North Dakota State University
Upper Great Plains Transportation Institute
Agency 627
Denver Tolliver, Director

House Bill 1020

Supplemental Information Concerning the Upper Great Plains Transportation Institute's 2019-2021 Biennial Budget Request

Submitted in response to questions from members of the Education and Environment Division and information requests from Chairman Monson

January 22, 2019

HIGHLIGHTS

The Upper Great Plains Transportation Institute's county and local road planning center will provide the North Dakota Legislature with timely information about road conditions and investment needs each biennium, answering two key questions: (1) what levels of road investment are warranted, and (2) where are investments most needed? In its biennial report, UGPTI will estimate road resurfacing, rehabilitation, and reconstruction costs for the next five biennia, by county. As shown in this paper, deferring a resurfacing improvement until rehabilitation is needed increases the capital cost by at least $400,000 per mile. If a road must be widened, rehabilitation could cost $1 million dollars per mile or more.

There are roughly 6,000 miles of paved county road in the state. Based on previous UGPTI studies, it is likely that 10% of these miles have Present Serviceability Ratings (PSR values) of less than 2.5. These segments are currently in need of resurfacing. Another 14% of paved county road-miles have PSR values ranging from 2.5 to less than 3.0. Pavements in this category can deteriorate quickly under truck traffic. These percentages could be understated because the latest condition assessment took place in 2016.

If UGPTI's request is funded, current condition assessments and investment needs will be estimated for the entire network each biennium. If, because of timely information, investments in only 500 miles of road with PSR values of less than 3.0 are optimized, UGPTI's requested program will save the state $200 million to $400 million in capital costs by avoiding rehabilitation. If investments in only 100 miles of paved county road are optimized, UGPTI's requested program will save the state $40 million to $80 million in capital cost each biennium. In this case, UGPTI's program will generate benefits 40 to 80 times greater than the requested $975,000 in state funds. If just one 5-mile segment of road is identified and improved in a timely manner each biennium so that rehabilitation is avoided, $2 million to $4 million will be saved, generating benefits more than twice the program cost.

INTRODUCTION

Chairman Monson and members of the Education and Environment Division of the House Appropriations Committee: my name is Denver Tolliver. I am director of North Dakota State University's Upper Great Plains Transportation Institute (UGPTI). During UGPTI's budget hearing (HB 1020) on January 11, 2019, I presented several examples of cost savings that could be generated from optimizing road investments and uniformly implementing asset management in the state. In my presentation, I noted that UGPTI's county and local road planning center would generate cost savings far greater than the $975,000 of base funding requested for the program. I was asked by the committee to document these efficiencies and demonstrate that the center will pay for itself in savings over time.

The expected benefits are illustrated in this document, which I am asking the committee to accept as an addendum to UGPTI's budget testimony (which was originally provided to the Education and Environment Division on January 11). In order to describe the benefits, it is necessary to introduce some background material on road condition ratings. Although savings in gravel road maintenance may be realized through UGPTI's program, the estimated cost savings presented in this addendum correspond to paved county roads.

COSTS OF DELAYED INVESTMENTS IN COUNTY AND LOCAL ROADS

Road Condition Rating

One of the indices used to measure the condition and quality of paved roads is the Present Serviceability Rating (PSR). As shown in Table 1, this index theoretically ranges from 0.0 to 5.0. However, measurements above 4.5 and below 1.0 are rare. The PSR after resurfacing is typically 4.2 to 4.5.

Types of Road Improvements

Thin Overlay. If funds are available, a road with sufficient traffic volume (or one that is essential to commerce) is typically *resurfaced* when the PSR drops to 2.5—i.e., the midpoint between fair and good. This practice reflects many years of experience and life-cycle analysis. At a PSR of 2.5, the existing surface layer is only moderately distressed (Table 1). Because the road is still in fair-to-good condition, an additional 15 to 20 years of service can be attained with a 2-inch overlay, which costs approximately $200,000 per mile (Table 2).

Thick Overlay. When the PSR drops to 2.0, the road's surface is marred with cracks, ruts, and other surface defects. Ride quality is noticeably worse. Because of accumulated distresses, a thin overlay will not yield a reasonable service life. Consequently, a thicker overlay is needed (e.g., 4 inches) at a higher cost (e.g., $375,000 per mile).

Rehabilitation. If the PSR deteriorates much further (e.g., to 1.8), large potholes, deep cracks, and ruts may cover 50% or more of the road's surface. Because of advanced deterioration, the existing surface layer will not perform adequately as a base layer in a resurfaced roadway. In

such cases, the most economical improvement is a mine-and-blend operation, in which the existing layers are taken up, recycled, and mixed with new material before being placed on the subgrade again. At a minimum, mine-and-blend improvements cost $600,000 per mile. In some cases, the road must be widened, which could increase the total cost to $1 million per mile or more (Table 2).

Table 1. Present Serviceability Rating for Paved Roads	
PSR Range	**Description**
4.0 - 5.0	Only new (or nearly new) pavements are likely to be smooth enough and distress free (e.g., sufficiently free of cracks and surface irregularities) to qualify for this category. Most pavements constructed or resurfaced during the year would be rated in this category.
3.0 - 4.0	Although not quite as smooth as those surfaces described above, pavements in this category give a first-class ride and exhibit few, if any, visible signs of surface deterioration. However, flexible pavements may show early evidence of rutting and fine random cracks.
2.0 - 3.0	The riding qualities of pavements in this category are noticeably inferior to those of new pavements and may be barely tolerable for high-speed traffic. Surface defects may include rutting, cracking, and extensive patching.
1.0 - 2.0	Pavements have deteriorated so much that the speed of free-flow traffic is affected. Flexible pavements may have large potholes and deep cracks. Distresses such as raveling, cracking, and rutting occur over 50% or more of the pavement's surface.
0.0 - 1.0	Pavements are in extremely deteriorated condition. The road is passable only at reduced speeds and with considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75% or more of the pavement's surface.
Source: U.S. Department of Transportation. *Status of the Nation's Highways, Bridges, and Transit: 2004 Conditions and Performance*. Exhibit 3-2.	

Table 2. Typical Improvements Based on Road Condition			
Improvement	**Thickness (inches)**	**PSR Threshold**	**Cost per Mile ($000)**
Thin Overlay	2	2.5	$200
Thick Overlay	4	2.0	$375
Rehabilitation	*	1.8	$600-$1,000
Reconstruction	*	1.5	$1,250
* The surface and base thicknesses are set to optimize their collective contributions, subject to cost constraints.			

Reconstruction. If the PSR drops to 1.5, all pavement layers (including the subgrade) are weakened and deformed. Consequently, the road must be fully reconstructed—i.e., rebuilt from

the ground up. Such improvements normally cost $1.25 million per mile (or more) for a two-lane road.

Incremental Capital Cost Due to Rehabilitation

There are roughly 6,000 miles of paved county road in North Dakota. Ideally, these roads should be resurfaced when the PSR reaches 2.5. However, this may not happen for several reasons, including: (1) The county does not have the funds to address all improvements in a timely manner. (2) Truck traffic on the road has increased and it has deteriorated quickly. Without UGPTI's biennial condition and investment needs study, road investments could be delayed (i.e., pushed into the future) with undesirable consequences. The cost of rehabilitating pavements is much greater than the cost of timely resurfacing improvements.

As shown in Table 2, deferring an investment until rehabilitation is needed increases the capital cost by at least $400,000 per mile. If the road must also be widened (because of the thicker surface and base layers), rehabilitation could cost much more—e.g., $1 million dollars per mile. If just one 5-mile segment is identified and improved in a timely manner and rehabilitation is avoided, $2 million to $4 million can be saved.

UGPTI's program will identify much more than just 5 miles of road that need timely investments. Current county road condition ratings do not exist. However, based on UGPTI's 2016 study, it is likely that 10% of paved county road-miles have PSR values of less than 2.5. These segments are currently in need of resurfacing. Another 14% of county road-miles have PSR values ranging from 2.5 to less than 3.0. If investments in just 100 miles of road with PSR values of less than 3.0 are optimized because of timely information, UGPTI's program will save the state $40 million to $80 million in capital costs. If investments in 500 miles of county road are optimized, UGPTI's program will save the state $200 million to $400 million in capital costs.

SAVINGS IN ROUTINE MAINTENANCE COST

Savings in capital cost are only one aspect of the potential benefits. As roads deteriorate, potholes, cracks, and raveling (e.g., the loss of asphalt and rocks from the surface) increase. Consequently, routine maintenance activities such as patching, crack sealing, and spot maintenance increase as the PSR drops. This effect is documented in Table 3. Routine maintenance costs do not include preservation treatments such as chip seals and microsurfacing treatments, which are also necessary.

The total impact depends on how much time each pavement spends in certain PSR ranges—e.g., how many years elapse between a PSR of 3.5 and 3.0, between a PSR of 3.0 and 2.5, etc. To simulate these effects, a light-duty road with modest truck traffic is allowed to deteriorate in a computer model as a result of environmental and traffic factors for 25 years without improvement (Figure 1).[1] The incremental maintenance cost as road condition deteriorates from

[1] The simulation assumes a structural number of 2.4 with good soil support and modest truck traffic—e.g., 50 trucks per day, loaded and empty. Deterioration from truck traffic is projected using the AASHTO-93 equations for flexible pavements. Environmental deterioration is accounted for through an exponential decay model, based on a

a PSR of 2.5 to the rehabilitation level (a PSR of 1.8) is approximately $10,000 per mile. Thus, if investments in just 100 miles of impacted county roads are optimized, UGPTI's program will save the state $1 million in routine maintenance cost. If investments in 500 miles of impacted county roads are optimized, UGPTI's program will save the state $5 million in routine maintenance cost.

Table 3. Routine Road Maintenance Cost per Mile at Various PSR Levels[2]	
PSR	**Cost per Mile**
4.0	$583
3.5	$2,019
3.0	$3,460
2.5	$4,893
2.0	$6,352
1.5	$7,783

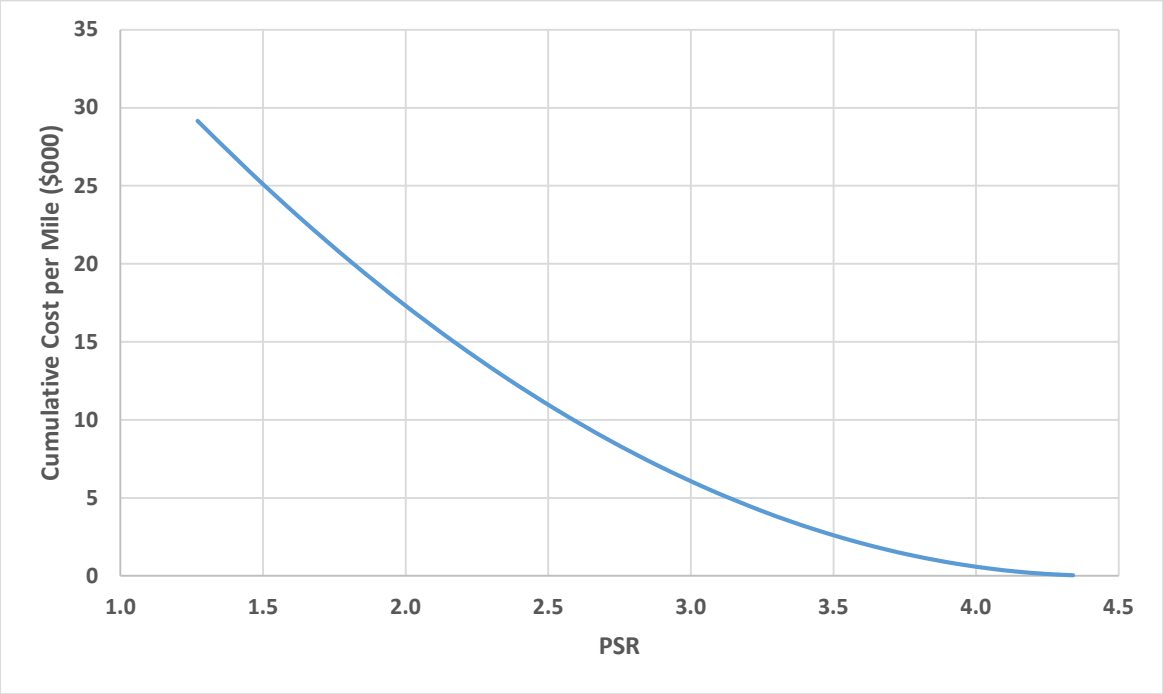

Figure 1 Routine Maintenance Cost for Light-Duty Pavement Over 25 Years without Resurfacing

maximum pavement life of 25 years in the absence of truck traffic. In the simulation, the road reaches a PSR of 2.5 in year 18, at which time it should be resurfaced. Without resurfacing, it continues to decline to a PSR of 1.8 in year 22 and 1.5 in year 24. As the simulation suggests, county roads with structural numbers < 2.5 can deteriorate quickly once the PSR drops below 2.5.

[2]U.S. Department of Transportation. *Highway Economic Requirements System: Technical Report, 2005*, Table 7-10. The original source is: Witczak, M. and G. Rada. *Microcomputer Solution of the Project Level PMS Life Cycle Cost Model*, University of Maryland, Department of Civil Engineering, 1984. The 1984 costs have been indexed through the end of 2017 using FHWA's construction prices indexes.

OTHER COST SAVINGS

As roads deteriorate, vehicle repair and maintenance costs increase from roughness. Travel speeds are less efficient because drivers must slow down for rough areas. As shown in Table 4, trucking costs increase by more than 35% when road condition deteriorates from good to very poor. These costs ripple throughout the economy, affecting merchandisers and producers. By identifying timely investment and maintenance opportunities, UGPTI's county and local road planning center (with its asset management program) will enable smoother roads for longer periods of time. Although these benefits are not estimated in this addendum, they are important to agricultural and energy producers and manufacturers in the state. Regardless of the distribution system, most freight shipments move the first and last miles in trucks.

Table 4. Trucking Cost as a Function of Road Condition

Road Condition	PSR	Cost Index
Good	4	0.93
Fair	3	1.00
Poor	2	1.14
Very Poor	1	1.26

Source: National Academies of Sciences. 1990. *New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal* – Special Report 227. Washington, DC.