CHARTING A SUSTAINABLE COURSE FOR INDIANA'S RURAL ROADS AND BRIDGES

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January 2025

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INTRODUCTION

In 2016 and 2017, the Indiana General Assembly enacted legislation that provided additional resources to local agencies through Motor Vehicle Highway (MVH) and Local Roads and Streets (LRS) distributions and the Community Crossings Matching Grant program. In addition, the legislation required asset management plans, including road inventory and conditions data, in order to apply for the matching grants.

Prior to 2016, little systematic, objective condition data was available for local roads. At that time, however, anecdotal information suggested that many local rural roads were in poor condition. Counties already were required to report bridge condition data regularly to the National Bridge Inventory (NBI).

During these and preceding years, several organizations—Indiana Local Technical Assistance Program (LTAP) at Purdue University,[1,2] the Indiana Metropolitan Planning Organization Council,[3] and the Indiana Soybean Alliance (ISA)[4]—commissioned or conducted studies of funding needs. In 2015–16, the Indiana Soybean Alliance and Indiana Corn Marketing Council (ICMC) commissioned a study of funding needs for rural roads and bridges.[5] These traditional needs studies were not resource constrained and estimated levels of funding that were largely unattainable.

ISA and ICMC have sponsored a series of research reports evaluating the condition of rural roads and bridges and tracking road and bridge funding and spending since 2018. The most recent report—*Rural Road and Bridge Needs 2023*—analyzed three years of data from county highway departments (excluding Marion County).[6] The research team concluded that with augmented investment, bridge conditions have improved modestly and average road conditions in many counties have stabilized or have begun to improve. Additionally, a substantial amount of road and bridge data has been collected from local asset management plans and annual operations reports—inventories, conditions, treatments, expenditures, and revenues—that provides a basis for completing more sophisticated, Indiana-specific analyses to inform state and local decision making.

To maintain the gains in pavement conditions, sustained investment will be needed to combat the inevitable cycle of pavement deterioration and improvement across such a large county road network. The research team proposes that policy makers consider, in addition to traditional needs estimates, resource-constrained scenarios and their likely effects on conditions. The data from asset management plans can be utilized for these analyses.

This report explores such an approach. First, the research team calculated average weighted ratings resulting from treatments and deterioration after treatment using 2021–23 county asset management plans. The incorporation of these impacts into each of the subsequent needs analyses allowed for the creation of more realistic estimates.

Next, the team conducted a traditional needs analysis for county roads and bridges without spending constraints. Road Scenario 1 estimates the cost to maintain all asphalt and chip seal pavements at least a rating of fair. Bridge needs estimates include the immediate costs to repair or replace all bridges that are failing or in imminent failure and repair of bridge components rated as poor.

Next, the team explored three road needs scenarios with resource constraints focused on asphalt and chip seal pavements and the resulting changes in pavement conditions. Road Scenario 2 maintains current county spending on asphalt and chip seal treatments. Road Scenario 3 increases spending on asphalt and chip seal treatments by 50%, and Road Scenario 4 increases

[1] Indiana Local Technical Assistance Program, 2024.
[2] Indiana Local Technical Assistance Program, 2009.
[3] Indiana Metropolitan Planning Organization Council, 2012.
[4] Strategic Marketing and Research, Inc., 2014.
[5] Palmer, McCullouch, Dumortier, Marron, & Ketzenberger, 2016.
[6] Marion County is excluded from the study due to its urban character.

spending on asphalt and chip seal treatments by 100%. Each scenario is adjusted for 3% annual inflation.

Because it is unlikely that counties will ever have the resources they need to maintain all assets in good condition, the research team also documented options for gaining additional local revenues and doing more to wring utility out of existing federal, state, and local funding.

METHODOLOGY (BRIEF)

Brief descriptions of the methodologies used by the research team to complete each of the analyses are provided below. Appendix A provides additional detail about the calculation of road needs and conditions.

Road and bridge data

The research team principally used data compiled by 91 county highway departments, including road inventory and conditions data from the 2021–23 local asset management plans and bridge inventories and conditions from the 2021 and 2023 National Bridge Inventory (downloaded October 2021 and October 2023). Team members also used spending and revenue data from the 2020–22 Annual Operational Reports for Local Roads and Bridges.[7] This data was compiled previously for the analyses in *Rural Road and Bridge Needs 2023*.

The research team also used unit costs for the pavement treatments reported by county highway departments in their asset management plans or through a survey conducted by the research team in mid-2024. The Indiana Department of Transportation (INDOT) provided unit costs for bridge repair and rehabilitation. Tables 1 and 2 summarize these unit costs for the repair and rehabilitation of roads and bridges, respectively.

Table 1. Average unit costs for the most-used pavement treatments

Treatment	Average unit cost per mile
Chip seal	$19,000
Patching/pothole filling	Not available
1.5" overlay	$150,000
2" overlay	$160,000
Crack seal	$11,000
Chip seal and fog seal	$28,000
Mill and 1.5" overlay	$150,000
Double chip seal	$29,000
Full-depth reclamation with asphalt	$240,000
3" overlay	$200,000
2.5" overlay	$190,000
Cold mix asphalt	$50,000
Pug mix asphalt	$50,000
Rejuvenator	$19,000
Mill and 2" overlay	$170,000
Triple chip Seal	$56,000
Mill and 3" overlay	$190,000
Blade mix with chip seal	$20,000

Sources: 2023 county asset management plans and 2024 survey of county highway departments.

Notes:

1. Patch/pothole filling is a common treatment used in all counties. The frequency of treatment and quantity of material used is unknown, making it difficult to calculate the cost of this treatment. For this reason, the treatment is excluded from the analysis.
2. Unit costs include the cost of materials and labor.

Table 2. Average unit prices for bridge repair and replacement

Bridge component	Average unit cost per square foot
Deck	$103
Superstructure	$163
Substructure	$73
Full bridge replacement	$242

Source: INDOT (2024).

Note: Unit costs include the cost of materials and labor.

[7] Local asset management plans and operational reports are submitted to the Indiana Local Technical Assistance Program Data Management Portal https://ltapdms.itap.purdue.edu/ltap

Roads needs

The research team calculated average weighted ratings resulting from treatments and deterioration following treatment using 2021–23 county asset management plans and developed four future spending scenarios. Road Scenario 1 estimates spending needs to keep asphalt and chip seal pavements at a minimum rating of fair without resource constraints. Road Scenarios 2–4 estimate needs and conditions with resource constraints. The elements of these analyses are described briefly below.

Pavement improvement and deterioration analysis

Treatment and deterioration affect pavement conditions. The research team estimated average changes due to improvements as the result of treatment and deterioration following treatment. First, the research team reviewed several deterioration models developed by state and local governments in the U.S. Next, the team compiled road segment data from the 2021–23 asset management plans from the 59 study counties using PASER ratings and with consistent road segment identifiers during the three-year period. These asset management plans include 2019–22 treatment data. The research team conducted pavement improvement and deterioration analyses by filtering this data. Table 3 shows the weighted rating changes calculated for the treatments reported most often by counties for treating asphalt and chip seal pavements. Table 4 shows weighted rating changes for asphalt and chip seal pavements that were treated in 2019 or 2020 with subsequent deterioration.

Table 3. Estimated rating improvements resulting from the most-used asphalt and chip seal treatments

Treatment type	Number of segments	Mileage	Estimated weighted PASER rating change
Asphalt			
Chip seal	290	213	1
1.5” overlay	207	88	5
2” overlay	156	69	6
Crack seal	62	28	0
Chip seal and fog	13	21	2
Mill and 1.5” overlay	191	57	4
Chip seal—double	33	25	2
Total	**952**	**501**	**N/A**
Chip seal			
Chip seal	430	318	3
1.5” overlay	34	23	5
2” overlay	0	0	Not available
Crack seal	13	12	6
Chip seal and fog	1	1	7
Mill and 1.5” overlay	32	17	3
Chip seal—double	64	44	2
Total	**574**	**415**	**N/A**

Sources: The estimated weighted rating changes were derived from 2021–23 county asset management plans.

Notes:

1. Patch/pothole filling is a common treatment used in all counties. The frequency of treatment and quantity of material used is unknown, making it difficult to calculate the cost of this treatment. For this reason, the treatment is excluded from the analysis.
2. There were insufficient observations to calculate an average weighted rating change for 2” overlay on chip seal.

Table 4. Estimated ratings as the result of the deterioration of asphalt and chip seal pavements with no treatment

Initial rating	Number of segments	Mileage	Estimated weighted PASER rating change
Asphalt			
5	7,452	2,282	-.5
6	8,149	2,610	-1
7	8,599	3,242	-1
8	6,317	2,553	-1
9	3,126	1,120	-1
10	620	173	-2
Total	**34,263**	**11,980**	**N/A**
Chip seal			
5	1,612	866	-.5
6	2,072	1,110	-.5
7	2,312	1,392	-.5
8	700	359	-1
9	728	439	-2
10	52	25	-2
Total	**7,476**	**4,191**	**N/A**

Sources: Estimated ratings derived from 2021–23 county asset management plans.

Note: There was insufficient data to calculate changes for pavements with initial PASER 1–5 ratings.

Needs scenarios

The research team developed four future spending needs scenarios. Road Scenario 1 estimates the cost to maintain asphalt and chip seal pavements above a PASER 5 rating over 10 years and the resulting pavement conditions. Road Scenario 2 shows the effect on asphalt and chip seal pavement conditions if counties continue spending on asphalt and chip seal pavements at the current level of spending over 15 years. Road Scenario 3 shows the effect on asphalt and chip seal pavement conditions if counties increase spending on asphalt and chip seal pavements by 50% over 15 years, and Road Scenario 4 shows the effect on asphalt and chip seal pavement conditions if counties increase spending on asphalt and chip seal pavements by 100%. A 3% annual inflation rate was applied to each scenario.

For each scenario, the research team followed a series of steps to calculate the costs of treatment as well as the resulting pavement ratings. Each analysis used the asphalt and chip seal segments and their corresponding ratings for all study counties reported in 2023. Selected road segments were treated, and the cost of treatment was calculated using mileage treated and average unit costs. The research team calculated the resulting ratings based on having received treatment or deterioration without treatment using the average changes shown above. This process was repeated for each two-year period using the resulting ratings from the previous period. Costs were then aggregated across the time horizon for each scenario.

Bridge needs

Immediate bridge spending needs include the cost to replace bridges that have failed or are in imminent failure and the cost to repair bridge components with poor ratings. To determine these costs, the research team first calculated the average bridge area for local bridges in the NBI. The average local bridge is 2,300 square feet. The research team then applied average repair and replacement costs (Table 2) to each of the bridges needing replacement and bridge components needing repair.

The research team was not able to estimate the repair costs associated with bridge deterioration over time. Unlike road rehabilitation, simple deterioration curves are not available for bridges. Bridge design varies more and depends on such factors as type, concrete or steel construction, and potential exposure to weather effects (e.g., erosion, flooding).

RESULTS

The research team's analyses and results are described below, including estimates of future spending needs for roads and bridges without any constraints and three scenarios for road needs with resource constraints.

Future road spending needs with no fiscal constraints

In 2023, the study counties reported 63,280 center line road miles in their asset management plans. These counties reported 35,438 miles of asphalt pavement and 15,797 miles of chip seal pavement representing 56% and 25% of the rural road inventory, respectively. Gravel roads comprised 18% of the inventory, and concrete, unimproved, and composite roads made up the remaining 1% of the rural road inventory.

Table 5 shows the mix of pavement ratings counties reported in the 2023 asset management plans for asphalt and chip seal pavements. The average PASER rating for asphalt surfaces was 6.1 and for chip seal surfaces was 5.7. Twenty-two percent of asphalt pavements were rated PASER 1–4, and 78% were rated PASER 5–10. Thirty percent of chip seal pavements had ratings of PASER 1–4, and 70% had ratings of PASER 5–10.

To explore future road needs, the research team set an initial condition goal to improve all asphalt and chip seal pavements to at least a minimum rating of PASER 5. A PASER 5 rating for asphalt is the upper rating in the fair category.[8] A PASER 5 rating for chip seal is the low end of the fair category.[9]

In Road Scenario 1, the research team estimated the spending required to improve asphalt and chip seal pavements to PASER 5 or higher, to build a typical number of miles of new roads annually,[10] and to conduct selected maintenance activities—gravel road maintenance and crack sealing. The time horizon for this initial scenario is 10 years. Because counties are required to rate pavement conditions only every two years, the team calculated spending needs iteratively every two years throughout the 10-year time horizon and applied a 3% annual inflation rate to subsequent periods.

Table 5. Rating mix for county asphalt and chip seal pavements—2023

PASER rating	Mileage	% of total
Asphalt		
1	351	1%
2	1,479	4%
3	2,862	8%
4	3,510	9%
5	4,294	12%
6	5,899	16%
7	7,223	20%
8	6,169	17%
9	4,034	11%
10	1,220	3%
Total	**37,041**	**100%**
Chip seal		
1	240	1%
2	1,239	8%
3	1,299	8%
4	2,239	14%
5	1,983	12%
6	2,369	15%
7	3,216	20%
8	1,751	11%
9	1,671	10%
10	279	2%
Total	**16,286**	**100%**

Sources: 2023 asset management plans.

Note: The sum of the individual percentages by pavement rating may add to more or less than 100% due to rounding.

Two potential approaches for network treatment are a worst-first approach or a network approach in which a mixture of treatments is used. A worst-first approach focuses on the management and assessment of individual pavement projects, while a network approach

[8] In Walker, Entine, & Kummer (2013), PASER ratings for asphalt were matched with conditions—1 (failed), 2 (very poor), 3 (poor), 4–5 (fair), 6–7 (good), 8 (very good), and 9–10 (excellent).
[9] In Center for Technology and Training (2022), PASER ratings for chip seal were matched with conditions—1–4 (poor), 5–7 (fair) and 8–10 (good).
[10] Collectively, all study counties reported about 10 miles of new road capacity each year in their 2021–23 asset management plans.

involves assessing the entire road network and aims to optimize pavement conditions and serviceability over time. The research team chose a network approach with treatments based generally on those the counties reported most often in their asset management plans. For example, if crack sealing is excluded, counties used asphalt overlays and chip seal surface treatments most often for asphalt pavements[11] and chip seal and fog seal most often for chip seal pavements. The estimates do not include the cost of patching/pothole filling due to the difficulty of estimating the materials needed and the corresponding costs.

Table 6 shows the costs of improving all asphalt and chip seal pavements to at least a PASER 5 rating and the resulting pavement conditions during the first two-year period. To calculate these costs, the research team utilized pavement miles by PASER rating, the appropriate treatment, the estimated change in pavement conditions with or without treatment, and per unit treatment costs. A 3% annual inflation rate was applied to the cost data. For this initial period, the cost of improving all asphalt and chip seal pavements to at least a PASER 5 rating is estimated to be $1.6 billion and $109 million for asphalt and chip seal pavements, respectively.

Table 6. Road Scenario 1—Year 0 spending needs

Year 0 initial PASER rating	Mileage	Treatment	Unit cost per mile	Year 0 cost	Year 2 initial PASER rating change	Year 2 PASER rating
Asphalt						
1	351	Reconstruction	$1,110,000	$389,368,012	9	10
2	1,479	2" overlay	$160,000	$236,674,861	6	8
3	2,862	1.5" overlay	$150,000	$429,306,083	5	8
4	3,510	1.5" overlay	$150,000	$526,480,864	5	9
5	4,294	No treatment	$0	$0	-1	4
6	5,899	No treatment	$0	$0	-1	5
7	7,223	No treatment	$0	$0	-1	6
8	6,169	No treatment	$0	$0	-1	7
9	4,034	No treatment	$0	$0	-1	8
10	1,220	No treatment	$0	$0	-1	8
Total Year 0	**37,041**	**N/A**	**N/A**	**$1,581,829,820**	**N/A**	**N/A**
Chip seal						
1	240	Chip seal and fog	$28,000	$6,728,660	7	8
2	1,239	Chip seal and fog	$28,000	$34,699,873	7	9
3	1,299	Chip seal	$19,000	$24,681,776	2	5
4	2,239	Chip seal	$19,000	$42,531,760	2	6
5	1,983	No treatment	$0	$0	-1	4
6	2,369	No treatment	$0	$0	-1	5
7	3,216	No treatment	$0	$0	-1	6
8	1,751	No treatment	$0	$0	-1	7
9	1,671	No treatment	$0	$0	-2	7
10	279	No treatment	$0	$0	-2	8
Total Year 0	**16,286**	**N/A**	**N/A**	**$108,642,069**	**N/A**	**N/A**

Sources: Year 0 costs and resulting ratings were derived using data from 2023 asset management plans and 2024 survey of county highway departments.

Note: Unit costs include materials and labor

[11] Chip seal surface treatments on an asphalt base are distinct from chip seal pavements on a gravel base.

In 2022, the study counties reported $800 million in road and bridge revenue. After excluding the approximately $100 million reported to have been spent on bridges, approximately $700 million is available for roads. The gap in annual spending for Year 0 would be about $1 billion.

Running the scenario iteratively every two years until Year 10 results in the estimated spending needs of $5.8 billion for asphalt and $357 million for chip seal (Table 7). The cost of maintaining gravel roads and building a modest amount of new capacity is $32 million initially and $210 million for 10 years. The full cost of this scenario over 10 years is $6.1 billion.

Table 7. Road Scenario 1—Estimated spending needs and resulting average PASER ratings over 10 years

Year	Cost	Average weighted rating
Asphalt		
0	$1,581.829,819	6.1
2	$682,722,519	7
4	$0	6.4
6	$944,217,460	5.6
8	$1,290,406,285	5.7
10	$1,238,328,046	6.1
Total	**$5,737,504,120**	**N/A**
Chip seal		
0	$108,642,069	5.7
2	$0	6.1
4	$39,943,811	5.5
6	$78,297,191	5.3
8	$0	5.3
10	130,423,788	4.8
Total	**$357,306,859**	**N/A**

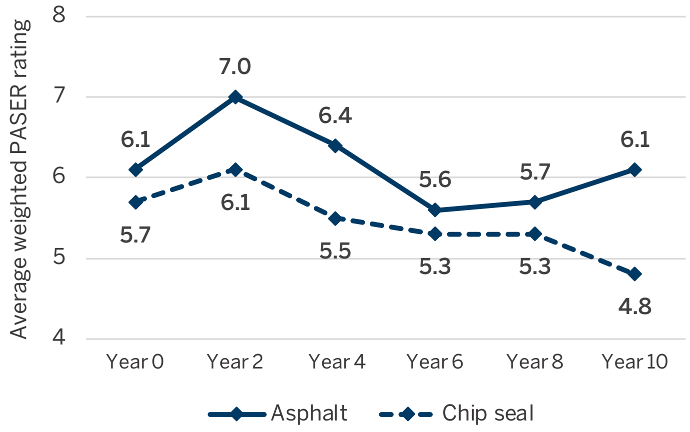
Sources: Costs and the resulting ratings were derived using data from the 2023 asset management plans and 2024 survey of county highway departments.

Note: In years when treatment cost is listed as $0, all pavements have a PASER 4 rating or above.

This approach results in the reconstruction and rehabilitation of all asphalt and chip seal pavement segments rated PASER 1–4 within the first two years. The initial investment in asphalt and chip seal pavements immediately increases the average weighted PASER ratings. The average ratings for asphalt then decline modestly until Year 6 and then improve modestly. The average ratings for chips seal decline modestly through Year 10. In Year 4, asphalt pavements do not need treatment because all segments are rated PASER 4 or above. Similarly, in Years 2 and 8, chip seal pavements need no treatment (Table 7 and Figure 1).

Pavement conditions are cyclical with ongoing deterioration and selective improvement. Asphalt road segments rated PASER 1–4 in Year 0 and treated to raise their ratings to PASER 5 or above will deteriorate over time and need rehabilitation around Year 10. Chip seal pavement conditions will follow a similar cycle and require rehabilitation around Year 14.

Figure 1. Average weighted PASER ratings for asphalt and chip seal for Road Scenario 1 by year



Sources: Ratings derived using data from the 2023 asset management plans.

Future bridge spending needs with no fiscal constraints

In 2023, counties reported 11,138 local bridges in the NBI. They rated 356 bridge decks as poor, 16 as failed, and 3 in imminent failure. In the same year, counties reported 488 bridge superstructures as poor, 22 as failed, and 8 in imminent failure. They also rated 397 bridge substructures as poor, 11 as failed, and 2 in imminent failure. Between 2021–23, the number of poor bridge decks, superstructures, and substructures declined by 5, 24, and 22, respectively. Over this same period, the number of bridge components that had failed or were in imminent failure remained the same or were reduced (Table 8). In 2023, 33 local bridges needed replacement across the state—23 failed bridges and 12 bridges in imminent failure.[12]

Immediate bridge spending needs include the cost to replace bridges that have failed or are in imminent failure and the cost to repair bridge components rated as poor. Table 9 shows the immediate cost to replace poor and failing bridges and bridge components. The estimated cost for full replacement of the 33 bridges that have failed or are in imminent failure is $18 million. The estimated cost to repair the 1,241 bridge elements rated poor is $334 million. The full immediate need is $352 million.

The cost to repair or replace bridge components during a 10-to 15-year time horizon would include bridge rehabilitation and replacement for the bridges rated as poor or worse and maintenance to address ongoing deterioration (Table 9). The research team was not able to estimate costs as the result of bridge deterioration. Unlike road rehabilitation, bridge deterioration is not as consistent as for roads. Bridge design varies more and depends on factors such as type, concrete or steel construction, and potential exposure to weather effects (e.g., erosion, flooding).

There is no estimate currently available for all bridge spending or activity. However, study counties reported spending at least $100 million from bridge-specific funds in 2022. This may underestimate actual spending because some funding sources such as Motor Vehicle Highway (MVH) and Local Roads and Streets (LRS) distributions can be used for both roads and bridges. If counties chose to address the full immediate need for bridge rehabilitation and replacement, they would have to spend about 250% more than reported in a typical year.

Table 8. Bridge conditions—2021 and 2023

Year	Total	Decks			Superstructures			Substructures		
		Poor	Failed	Imminent failure	Poor	Failed	Imminent failure	Poor	Failed	Imminent failure
2023	11,138	356	16	3	488	22	8	397	11	2
2021	11,152	361	16	4	512	23	8	419	13	4

Sources: 2021 and 2023 NBI (downloaded October 2021 and October 2023).

Table 9. Immediate spending needed to replace bridges or bridge components with failing or poor ratings

Bridge component	# rated poor or failing	Unit repair and replacement costs per square foot	Immediate need	Longer-term need (10–15 years)
Deck	356	$103	$84,336,400	$84,336,400 + deterioration
Superstructure	488	$163	$182,951,200	$182,951,200 + deterioration
Substructure	397	$73	$66,656,300	$66,656,300+ deterioration
Full bridge replacement	33	$242	$18,367,800	$18,367,800 + deterioration
Total	N/A	N/A	$352,311,700	$352,311,700 + deterioration

Sources: Immediate need was derived using data from the NBI (downloaded October 2023) and INDOT (2024).

12 Palmer, McCullouch, Chapple, & Ruess, 2024.

Future road spending needs with fiscal constraints

The additional spending needed to fully implement Road Scenario 1 is not realistic financially. The research team explored three additional scenarios for maintaining asphalt and chip seal pavements with constrained resources—continuing current spending on treatment of asphalt and chip seal pavements, increasing spending on treatment by 50%, and increasing treatment by 100%. The time horizons for these scenarios were extended to 15 years to cover approximately a full cycle of deterioration for both asphalt and chip seal pavements. Each of these scenarios incorporates 3% annual inflation.

The research team estimated the average annual spending for the treatment of asphalt and chip seal pavements using treatment data for 2019–22 in asset management plans and the average per mile costs of treatment. Using these calculations, the research team estimates that counties spend at least $220 million annually on treating asphalt and chip seal pavements. Each of the scenarios that follow starts from this base as Year 0.

The research team chose a network approach for each scenario to maximize pavement conditions with the available resources during the 15-year period. The team chose treatments based generally on those the counties reported most often in their asset management plans.

Scenario 2 shows that continued investment in asphalt and chip seal pavements at the current level with modest increases for inflation results in asphalt and chip seal ratings at or above a PASER 4 and PASER 5 over the next 15 years, respectively. Average asphalt ratings decline over the 15-year period, but conditions remain above the levels that were reported before the expansion of gas tax revenues and the creation of the Community Crossings Matching Grant. Because chip seal pavements are cheaper, those ratings increase and decline more modestly over the study period. With the investment of additional resources, Scenarios 3 and 4 result in modestly better average ratings than Scenario 1 for asphalt over the 15-year period and for chip seal over the first 10 years.

Road Scenario 2—Maintain current funding level for asphalt and chip seal pavements with inflation

Road Scenario 2 started with current annual spending for treating asphalt pavements at $200 million and chip seal pavements at $20 million with adjustments for inflation. For each two-year period, the spending is $400 million for asphalt and $40 million for chip seal with inflation. Over the 15-year period, the cost for the treatment of asphalt pavement is $3.9 billion, while the cost for chip seal pavement treatment is $252 million.

In this scenario, the treatment approach for asphalt pavements relies heavily on chip seal surface treatments at a ratio of 7:1 to asphalt overlays. A small proportion of pavements require reconstruction. All asphalt pavements rated 1–2 are rehabilitated within six years using reconstruction, chip seal surface treatments, and overlays. While this approach allows for the treatment of more road surface, it increases the proportion of asphalt pavements with a chip seal surface treatment to more than half the overall asphalt inventory. The average weighted rating begins at PASER 6.1 in Year 0 and declines steadily to PASER 3.9 in Year 12 after which it begins improving (Table 10 and Figure 2).

The treatment approach for chip seal pavements relies principally on chip seals and fog seals. In Road Scenario 2, this treatment approach results in the rehabilitation of all chip seal pavements rated PASER 1–4 by Year 8 (Table 11 and Figure 3). The average weighted rating for chip seal pavements fluctuates modestly throughout the 15-year period, but never falls below PASER 5.1.

Road Scenario 3—Increase current annual funding for asphalt and chip seal pavements by 50% with inflation

Road Scenario 3 starts with a 50% increase in the initial annual funding with $300 million allocated to treatment for asphalt pavements and $30 million allocated for treating chip seal pavements. For the 15-year period, the cost for the treatment of asphalt pavements is $5 billion, while the cost for chip seal pavement treatment is $236 million. For chip seal, the availability of more funds earlier in the process reduces treatment costs in the later years.

In this scenario, the research team uses chip seal surface treatments and asphalt overlays at about 50% each for asphalt pavements. A small proportion of pavements require reconstruction. All asphalt roads rated PASER 1 and 2 are rehabilitated within four years using reconstruction, chip seal surface treatments, and overlays. This strategy increases asphalt pavements with chip seal surface treatments by 50% over the current inventory, resulting in an equal inventory of asphalt and asphalt pavements with chip seal surface treatments. The average weighted rating for asphalt begins at PASER 6.1 and declines steadily to PASER 4.6 in Year 12 after which it begins improving (Table 10 and Figure 2).

Again, the treatment approach for chip seal pavements relies on chip seals and fog seals. This approach results in the rehabilitation of chip seal pavements rated PASER 1–4 by Year 8 (Table 11 and Figure 3). The average weighted rating for chip seal pavements fluctuates modestly throughout the 15-year period but never falls below PASER 5.1.

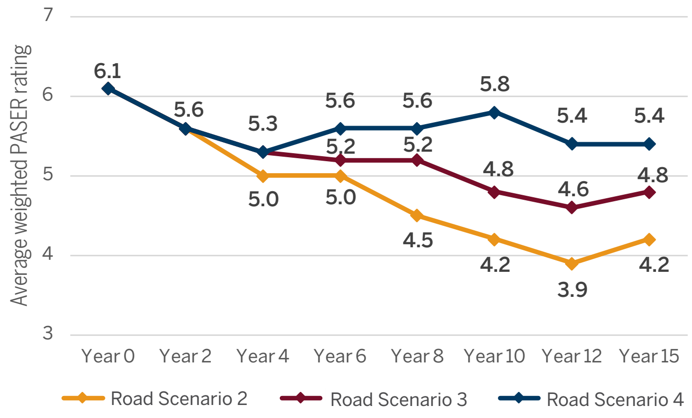
Road Scenario 4— Increase current annual funding for asphalt and chip seal pavements by 100% with inflation

Road Scenario 4 started with a 100% increase in the initial annual funding at $400 million for asphalt and $40 million for chip seal pavements. For the 15 years, the cost of the treatment of asphalt pavements is $8 billion, while the cost of the treatment for chip seal pavements is $290 million.

In this scenario, the treatment approach for asphalt uses overlays approximately two times more than chip seal surface treatments. A small proportion of pavements require reconstruction. All asphalt roads rated PASER 1 and 2 are rehabilitated within two years using reconstruction, overlays, and chip seal surface treatments. For the 15 years, this treatment approach maintains the asphalt pavement surface inventory at 2:1 over chip seal surface treatments. The average weighted rating for asphalt begins at PASER 6.1, declines to PASER 5.3 in Year 4, improves until Year 10, and declines again in Years 12 and 15 (Table 10 and Figure 2). The average weighted rating at Year 15 is PASER 5.4.

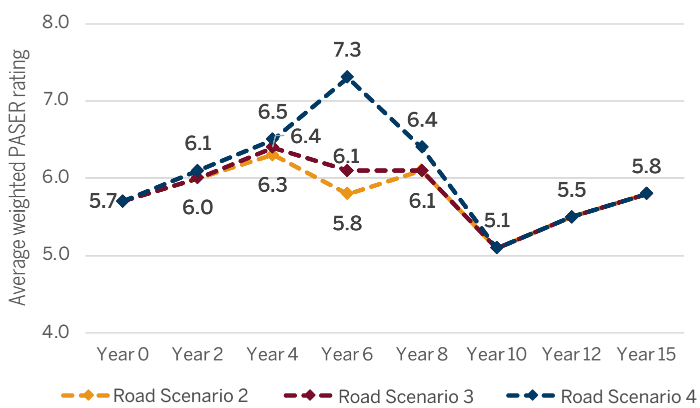
Again, the treatment approach for chip seal pavements relies on chip seals and fog seals. In this scenario, chip seal pavements rated PASER 1–4 are rehabilitated by Year 4. The average weighted rating improves until Year 6, declines to PASER 5.1 in Year 10, and then improves through Year 15 (Table 11 and Figure 3).

Figure 2. Average weighted PASER ratings for asphalt pavements by spending scenario and year



Sources: Ratings derived using from data from the 2023 asset management plans.

Figure 3. Average weighted PASER ratings for chip seal pavements by spending scenario and year



Sources: Ratings derived using from data from the 2023 asset management plans.

Table 10. Average weighted PASER ratings for asphalt pavements over 15 years by spending scenario

Scenario	Annual spending	Year 0 average rating	Year 2 average rating	Year 4 average rating	Year 6 average rating	Year 8 average rating	Year 10 average rating	Year 12 average rating	Year 15 average rating	Total spending	Results
2	$200 million	6.1	5.6	5.0	5.0	4.5	4.2	3.9	4.2	$3.9 billion	All pavements rated PASER 1 and 2 rehabilitated in 6 years. Inventory with chip seal surface treatments increases.
3	$300 million	6.1	5.6	5.3	5.2	5.2	4.8	4.6	4.8	$5.0 billion	All pavements rated PASER 1 and 2 rehabilitated in 4 years. Asphalt and chip seal surfaces are approximately 50% each of the asphalt inventory.
4	$400 million	6.1	5.6	5.3	5.6	5.6	5.8	5.4	5.4	$8.0 billion	All pavements rated PASER 1 and 2 rehabilitated in 2 years. Asphalt surfaces make up most of the asphalt inventory.

Sources: Ratings and spending derived using data from the 2023 asset management plans and the 2024 survey of county highway departments.

Table 11. Average weighted PASER ratings for chip seal pavements over 15 years by spending scenario

Scenario	Annual spending	Year 0 average rating	Year 2 average rating	Year 4 average rating	Year 6 average rating	Year 8 average rating	Year 10 average rating	Year 12 average rating	Year 15 average rating	Total spending	Results
2	$20 million	5.7	6.0	6.3	5.8	6.1	5.1	5.5	5.8	$252 million	All pavements rated PASER 1-4 rehabilitated by Year 8.
3	$30 million	5.7	6.0	6.4	6.1	6.1	5.1	5.5	5.8	$236 million	All pavements rated PASER 1-4 rehabilitated in Year 8. Increased treatment funding early in the cycle reduces later treatment costs.
4	$40 million	5.7	6.1	6.5	7.3	6.4	5.1	5.5	5.8	$290 million	All pavements rated PASER 1-4 rehabilitated by Year 4.

Sources: Ratings and spending derived using data from the 2023 asset management plans and the 2024 survey of county highway departments.

MAKING THE MOST OF CURRENT SPENDING

Over the last several years, the additional funding made available to counties have expanded county road spending and allowed many counties to stabilize and, in some cases, improve overall pavement conditions. These funds also have allowed improvements in the conditions of local bridges. The large inventory of local roads and bridges and the cyclical nature of improvement and deterioration suggest that sustained investment in the network will be needed to maintain this progress or to gain modest improvements. While modest increases in spending may be possible, substantial increases will be difficult in the current funding environment.

In light of these limitations, there is pressure for local governments to identify local resources and wring additional utility out of all available federal, state, and local dollars. A discussion of several local funding options and tools to increase the efficiency and effectiveness of existing resources is provided below.[13] Many of these strategies require having the appropriate expertise and staffing as well as a willingness to embrace change.

Local funding and financing strategies

The first group of tools addresses the identification of additional local financial resources including financing and cost-sharing mechanisms.

Adopt Local Option Highway User Tax (LOHUT)

Counties can adopt the Local Option Highway User Tax (LOHUT).[14] Local governments must adopt both components.

- Vehicle excise surtax: Paid at the time of vehicle registration, the surtax is applied to passenger cars, motorcycles, and trucks with a gross weight of 11,000 pounds or less, and trailers with a gross weight of 9,000 pounds or less. Counties can adopt a surtax of 2–10% of the excise tax or a flat fee. Counties may impose a fee between $7.50 and $25. With a transportation management plan, counties may impose a fee of up to $50.
- Wheel tax: The wheel tax is applied to all vehicles not subject to the surtax—e.g., buses, recreational vehicles, trailers, semi-trailers, larger trailers, and large trucks and tractors. Counties can adopt a tax that ranges between $5 and $40 per vehicle. With a county transportation management plan, it may be increased to $80. The adopted tax may differ within each vehicle category based on weight. Public entities and certain nonprofits are excluded.

For counties, either the county council or the county income tax council may adopt these taxes. In 2016 HEA 1001, the Indiana General Assembly expanded the maximum amounts that could be adopted using these fiscal tools for units with transportation asset management plans. These funds are allocated to each city, town, and county based on the LRS distribution formula. LOHUT may be used as matching funds for the Community Crossings Matching Grant Program.

For calendar year 2022, 55 counties had adopted LOHUT, and 37 had not.[15]

Utilize debt to complete additional current projects

Debt instruments provide access to additional funds in the short term that can be paid back with expected revenue over time. Most counties still employ a pay-as-you-go strategy, using current revenue or savings from the previous year's revenues to complete infrastructure replacement and rehabilitation. Debt can provide a method for amassing the resources necessary to make critical capital investments that could not be made otherwise. In a low-inflation economy, borrowing units also can benefit from the present value of future funding by buying infrastructure while costs are lower. Debt also allows the cost of infrastructure—principal and interest to be borne by the infrastructure users rather than previous users/taxpayers. All methods of debt are predicated on a unit's demonstrated ability to repay the debt.

[13] This research updates similar work that was published in Palmer., McCullouch., Dumortier, Marron, & Ketzenberger (2016).
[14] In the absence of the adoption of LOHUT by a county, cities have the ability to adopt these taxes.
[15] Indiana Legislative Services Agency, 2024.

In 2022, only 13 of the 91 study counties reported using bonds, notes, or loans to fund road and bridge construction, to buy vehicles, or to by construction equipment.[16]

Bonding

Tax-exempt municipal bonds are one form of available debt. Only a few counties currently use this option. With sufficient administrative and financial capacity, additional counties may benefit. This tool requires a financial advisor and bond counsel. These and other administrative costs make bonding most effective for large projects or bundles of projects. Bonding may not be prudent for counties with small populations and tax bases because bonding for small amounts under these circumstances is costly.[17,18]

Commercial lending

Counties may choose to use traditional lending. The availability of institutions willing to lend may vary. In some cases, community banks may be willing to make smaller loans. Interest rates are likely to be higher than for the other debt options.

Indiana Bond Bank

The Indiana Bond Bank[19] has several programs to help local governments. Two programs, may be particularly useful for road and bridge work. The Community Funding Resource (CFR) Program provides fixed-rate loans for public projects for terms up to 25 years. The simplicity of this option may be particularly advantageous for small counties. The Hoosier Equipment Lease Purchase (HELP) program assists local governments in purchasing equipment by collecting bids from commercial banks, including equipment for building or maintaining roads and bridges. This program eliminates the need to bid financing.

Cost sharing

Local governments have access to many funding options for road and bridge projects. However, these options do not guarantee a focus on specific farm-to-farm or farm-to-market roads and bridges. Without this focus, farm-to-farm and farm-to-market truck routes may be inefficient and include forced detours, increasing farmer costs and decreasing profits. In some cases, it may be helpful to offer cost-sharing arrangements in which landowners who benefit from particular infrastructure improvements contribute to the cost.[20] Presently, this cost sharing is accomplished by building relationships between local owners and officials on an ad-hoc basis. These arrangements could be made more formal by pursuing enabling legislation for special assessments like Economic Improvement Districts (IC 36-7-22).

Objective and overt local decision making

Maintaining road and bridge condition inventories and planning for anticipated improvements for multiple years can improve local decision making and increase the utility of transportation funding. Two tools, asset management and capital improvements planning, are presented here. The success of both tools depends on the collection of regular information on assets, conditions, traffic/trip patterns, and cost data.

Strengthen asset management

Asset management is a systemic, multi-year decision making approach that considers conditions across an agency's entire road and bridge network to distribute resources for network improvement. This approach utilizes a mix of treatments to optimize pavement and bridge conditions as well as available funding. Rather than a commonly practiced worst first approach, this strategy minimizes deterioration and treats pavements before they require rehabilitation or replacement.

Asset management planning includes quantifying the condition of assets and developing a multi-year treatment plan. More specifically, asset management plans (AMP) should include an inventory of assets with current conditions, establishing a level of service to which the community aspires, and the prioritization of projects.

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16 Palmer, McCullouch, Chapple, & Ruess, 2024.
17 Elmer, 2005a.
18 Hough, Smadi, & Bitzan, 1997.
19 For more information, consult the Indiana Bond Bank's website https://inbondbank.com/
20 Walzer & Chicoine, 1987–88.

2016 HEA 1001 requires Indiana local agencies to have asset management plans in order to apply for Community Crossings Matching Grant funds. For these pavement management plans, local agencies must develop a pavement inventory with conditions and a five-year treatment plan. Pavements must be rated every two years. Additional requirements include:

- Identifying the pavement rating system uses. Indiana agencies commonly use the PASER and PCI systems.
- Defining performance goals and expected levels of service.
- Developing and describing the process used to develop the treatment plan.
- Developing and describing the monitoring program.
- Describing drainage and rights-of-way conditions.
- Plans are submitted through the Indiana LTAP data portal.[21]

The requirements for bridge asset management plans are similar to those for pavements. They require a complete inventory with conditions data, including whether each bridge is functionally obsolete or structurally deficient. Bridges are inspected every two years and recorded in the NBI. The plan also must include planned projects, as well as their timing and estimated costs.

Capital improvement planning

Capital improvement planning (CIP) typically is a short-range plan—3 to 10 years—that selects and sequences local government capital projects and equipment purchases. CIP allows local governments to program local needs across multiple plans and infrastructure types. It allows agencies to anticipate needs rather than reacting to problems as they arise. It allows time to identify funding and the most economical construction methods. It also provides a process for planning, construction, and funding complex projects that may take three to five years from planning to completion. The development of a CIP involves the following steps, some shared with asset management planning:

1. Develop the planning process—criteria for qualifying as a capital project and for project evaluation and selection.
2. Create or update a list of capital assets, current conditions, and rehabilitation and repair needs. A regular system of adding or removing assets and evaluating asset conditions is important to effective capital improvement planning.
3. Conduct a fiscal analysis of available funding, including current fund balances, funding trends, and ongoing fixed costs such as bond payments and other debt service.
4. Review projects that have been previously approved, not yet implemented, or incomplete. Include these in the inventory of capital assets and needs and the fiscal analysis.
5. Review the capital needs reflected in the goals and recommendations established in local plans (comprehensive, economic development, and redevelopment plans, etc.).
6. Solicit proposals for projects for the period of the plan, including justification of need, relative urgency, estimated project costs, estimates of future operations and maintenance (O&M), the relationship to existing and proposed projects, proposed sources of funding, and a proposed implementation schedule.
7. Evaluate proposed projects against local goals and needs as well as fiscal goals and available resources.
8. Select projects each year from the plan.
9. The plan commission or county commissioners may formally adopt the plan, or particular agencies—such as the county engineer or highway department—can prepare and implement it informally.
10. The plan should be reviewed annually to confirm the next year's projects and funding in light of progress on previously selected projects and current circumstances.[22,23]

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21 The Indiana Local Technical Assistance Program data portal can be accessed at https://ltapdms.itap.purdue.edu/ltap
22 Elmer, 2005b.
23 Fillmore, 2014.

Joint purchasing and outsourcing

Local governments may be able to gain efficiencies by using joint purchasing and by outsourcing additional construction and maintenance.

Collaborate with other local governments on the purchase of road and bridge construction, maintenance, and materials

Joint purchasing of construction and maintenance materials or services is one way to expand or improve services and gain cost savings or efficiencies. The exact services and details will vary depending on the circumstances in particular counties.

Through these arrangements, participating units may also gain knowledge from the external expertise, access new best practices, reduce duplication and fully utilize personnel and equipment, and share risk. These arrangements require the buy-in of elected and appointed officials that may take time and effort to build. Local governments must also follow the public works statute (IC 36-1-12-3), which limits projects that can be accomplished with own-source labor and takes into account any relevant labor agreements. Organizations such as the Association of Indiana Counties, the Indiana Association of County Commissioners, and Indiana LTAP are sources of technical expertise for counties wishing to embark on collaborative arrangements.

A general step-by step process is described here:

1. Explore intra-organizational efficiencies that can be accomplished within the local government. Making changes internally is easier than managing a relationship with another local government. In some cases, such as the state's Quantity Purchasing Agreement (QPA) for road salt, can be accessed without the transaction costs of building and maintaining a new agreement.
2. Select services or materials for potential collaboration.
3. Agree on joint goals and objectives for the collaboration. If collaborating with another local government for the first time, consider starting small to build a working relationship and trust.
4. Evaluate collaborative options. Validate opportunities with supporting facts and figures. Consider carefully the business case for potential collaborations, including costs and benefits.
5. Negotiate details of the agreement, including duration, cost allocation, treatment of employees, facilities, vehicles, equipment, and other assets, ownership and insurance, an exit clause, and service levels
6. Create a transition plan.[24,25]

Outsource road and bridge construction and maintenance

Outsourcing road construction and maintenance to road and bridge contractors is another potential method for improving or expanding services and gaining cost savings and efficiencies. The exact services and details may vary. These arrangements may allow counties access to specialized personnel or equipment they cannot support individually.

Larger projects often require outsourcing. IC 36-1-12-3 sets forth specific requirements establishing when a county government is allowed to perform public works projects with its own workforce or is required to outsource projects. Small counties may struggle to have a critical mass of services needing outsourcing, making these arrangements less feasible and more expensive.

Local investment/disinvestment strategies

Considering limited resources, local agencies will need to make strategic decisions about which infrastructure is critical and how to focus resources. Several options are explored here: a fix-it-first strategy, selective reduction of the asset inventory, prioritizing farm-to-market routes, and aligning land use and transportation planning.

Fix-it first strategy

Application of a fix-it-first strategy at the local level involves prioritizing the rehabilitation and repair of existing infrastructure over new additions to the road and bridge network. This approach requires a good asset

[24] Howard, Fehrenbach, Malool, LaVenia, Mahr, Murphy, & Passanante, 2013.
[25] Murray, Rendell, Holland, & Locker, 2011.

inventory and use of an asset management approach. The most travelled assets receive rehabilitation and repair first. Additions to the network are evaluated using a rigorous cost-benefit analysis, including consideration of lifecycle costs. This approach is most applicable for counties that have an urban or suburban character or substantial population growth.

This strategy reduces infrastructure construction and maintenance costs. It also encourages development in existing centers and corridors. However, the focus on the most travelled roads and bridges may not prioritize agriculture-serving roads and bridges.[26,27]

Selective reduction of bridge inventory

Budget limitations have caused some local agencies to place load limits on structurally deficient bridges and to close functionally obsolete bridges. Bridges are closed when the load rating drops below three tons, or when the superstructure has deteriorated to a load rating that will not support typical traffic loads. Other factors that can cause a bridge closure include excessive substructure deterioration, foundation scouring, high-risk factors (e.g., structure type or land of load redundancy), or impact damage. After a bridge has closed for one of these reasons, it often remains closed due to a shortage of funding.

Eliminating low-value bridges allows limited resources to be spent on more strategic ones. Local agencies should consider several factors when exploring retiring bridges permanently, including the function classification of the adjacent roadway, average daily traffic volume, average daily truck traffic, economic development opportunities, agricultural use detour length, access to schools, and the relationship to school bus and emergency service routes.

Closing infrastructure can be controversial, particularly for users who may be affected. A clear understanding of public opinion and effective communication throughout the decision making process also are important considerations.[28,29]

Selective reduction of rural road inventory

As for bridges, eliminating low-value roads can allow limited resources to the more strategic ones. The considerations should be the same as for bridges. This strategy is likely to be more challenging than eliminating bridges because of the proliferation of non-farm scattered rural housing development. Again, these actions can be controversial for the affected stakeholders, and a clear understanding of public opinion and effective communication about decision making are critical. [30,31]

Returning paved infrastructure to gravel

In some cases, reverting poor pavements to gravel may be an option for managing the costs of low-value road segments. Poor pavement conditions and cost savings or avoidance often are overriding considerations for reverting roads to gravel, including the following:

- 30% of the surface areas have fallen below an acceptable PASER or PCI rating.
- PCI 1-13 ratings or PASER 1-2 ratings.
- Average annual daily traffic below 100.

When pavements are reverted to gravel, local agencies may save on annual maintenance costs. However, they must consider gravel reversions carefully because poor road conditions and severe weather impacts may compromise serviceability for agricultural and other purposes. Similar to assessing bridges for closure, decision making about reversions should include several factors: road condition; safety before and after conversion; the functional classification; the number of residents served by the road; traffic volume; vehicle types (trucks, motorcycles, trailers, and other vehicles with sensitive loads); the economics and practically of road treatment and maintenance; and environmental issues, including dust and erosion control. As with other decisions affecting residents and businesses,

[26] Braun & Shounce, 2011.
[27] Kahn & Levinson, 2011.
[28] Walzer & Chicoine, 1987–88.
[29] Hough, Smadi, & Bitzan, 1997.
[30] Walzer & Chicoine, 1987–88.
[31] Hough, Smadi, & Bitzan, 1997.

understanding public opinion and communicating effectively throughout the decision making process are particularly important.[32]

In 2023, counties reported that, on average, gravel roads were 18% of the pavement inventory. The proportion of gravel pavement varies across counties. Fountain, Pike, and Warren counties reported more than half of their pavement inventories as gravel. Eighteen counties reported 1% or less of their inventories as gravel.[33] County unit cost data revealed a large unit price variation for gravel road maintenance—from as low as $560 to $100,000 per mile—making the cost of reversion and maintenance difficult to predict.

Consider the adoption of cost-saving engineering measures for bridges

Local agencies can consider engineering practices that reduce replacement and repair costs. There are many resources counties can use to identify these measures, including the Indiana LTAP, professional associations, industry publications, and consulting engineers. The research team highlights a few of these opportunities below.

First, counties may consider using bridge load-testing technology to evaluate the load-carrying capacity of rural bridges, which is more accurate than traditional visual inspection and theoretical calculation. In some cases, using these engineering practices may allow local agencies to remove load limits placed previously on local bridges. This technology has been used in Michigan, Iowa, Nebraska, and South Dakota.[34,35,36,37] The technology also has been tested by the Boone County Highway Department in Indiana.[38]

Counties also may consider other cost-saving practices. For example, by adopting one or more of the 20 innovative measures developed by a committee of engineers convened by the Soybean Transportation Coalition in 2021. They identified 10 innovative practices each for bridge replacements and repair listed below with cost-saving estimates and supporting documentation.

<u>Bridge replacement innovations</u>

- Railroad flat car bridges
- Geosynthetic reinforced soil-Integrated bridge system
- Vibratory H-beam piling drivers
- Buried soil structures
- All steel piers
- Galvanized H-beam piling
- Press brake tub girders
- Galvanized steel beams
- Prestressed precast double tees
- Precast inverted tee slab span bridges

<u>Bridge repair innovations</u>

- Piling encasements
- Concrete pier piling repairs
- Driving piling through decks
- Epoxy deck injections
- Deck overlays with Type O concrete and plasticizers
- Deck patching
- Thin polymer concrete overlays
- Penetrating concrete sealers
- Spot cleaning painting steel beams
- Concrete overlay on adjacent box beams[39]

Prioritize and plan for local farm-to-market truck routes and/or selective strategic improvements

Prioritizing local farm-to-market truck routes for rehabilitation, upgraded capacity, or the removal of impediments is a possible strategy for focusing resources. Inefficient truck routes and forced detours can substantially affect farmer costs and profit. To evaluate the prudence of establishing these truck routes, counties should analyze truck trip patterns, truck traffic origins and destinations, road conditions, and trip

[32] Hough, Smadi, & Bitzan, 1997.
[33] Palmer, McCullouch, Chapple, & Ruess, 2024.
[34] Steenhoek, 2017
[35] Steenhoek, 2021, May 1.
[36] Steenhoek, 2021, January 22.
[37] Steenhoek & Harms, 2022.
[38] Indiana Soybean Alliance and Indiana Corn Marketing Council, 2016.
[39] Soybean Transportation Coalition, 2021.

impediments or barriers. Improvements can be scaled from removing specific impediments (bridge repairs, road or intersection upgrades, etc.) to a fully upgraded design to accommodate frequent truck traffic. A similar analysis could be completed to identify improvements to allow the movement of equipment from farm to farm.

Some states establish farm-to-market (or adequate truck route) infrastructure as a priority for funding. For example, in Iowa, a portion of the Road Use Tax is dedicated to its Farm-to-Market Road Fund.[40,41,42,43] Illinois has the Truck Access Route Program (TARP) to support local governments in upgrading roads to accommodate 80,000-pound truckloads.[44] Missouri has a system of farm-to-market roads—supplemental routes—the state government operates and previously had the Fixing Access to Rural Missouri (FARM) Bridge Program that focused on fixing rural bridges in northern Missouri.[45] Louisiana, Texas, and Ohio also have infrastructure designated to serve farm-to-market movements.

Aligning land use and transportation planning

To be effective, transportation and land use decisions should be synergistic. Changes in the location, type, and density of land uses change people's travel choices, thereby changing transportation patterns. "Transportation affects land uses by providing a means of moving goods [and people] from one place to another."[46] Often discussed in the context of urban and suburban places, these issues and dynamics are also important in the rural context because of the limited resources available for road and bridge infrastructure.

In rural Indiana, counties should plan proactively rather than reactively for both transportation and land use. By doing so, counties can maximize the utility of the transportation investments they make. This strategy requires planning for a longer time horizon and having local staff in place with expertise and time to coordinate efforts. The following actions should be considered:

- Ensure that the highway department, plan commission, and other county agencies participate in transportation, land use, and economic development planning processes to account fully for the effects of the decisions made for each.
- Establish land use regulations that support county road and bridge investments and the purpose of those investments. For instance, if a county invests in local farm-to-market truck routes, it may want to direct new housing development away from these areas. The addition of driveways and entering residential traffic reduces the utility of a corridor upgraded for moving products by truck to market. Similarly, land use regulations can guide development away from areas of the county not included in plans for improvements.
- Plan for land uses together. For example, if the county is planning for farm-to-market transportation and also desires an industrial park that will generate truck traffic, the location of the industrial park and the transportation improvements should be planned together.
- This strategy does not mitigate past land use decision making, although those details should be considered when planning for transportation improvements.
- Coordinate with other local governments in or near the county making transportation, water, and sewer infrastructure investments. County road networks connect to networks in cities, towns, and adjacent counties. While the county does not necessarily have control over those decisions, advanced knowledge allows those external investments to be considered in transportation planning. Counties can also mitigate the potential negative effects of these external investments through negotiation.[47,48,49]

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40 Stevenson, 2014.
41 Schroeder, 2015.
42 Iowa Department of Transportation, 2024.
43 Iowa Code 306.3.
44 Illinois Department of Transportation, 2024.
45 Missouri Department of Transportation, 2023.
46 Vijayan, no date.
47 ICF Consulting, 2005.
48 Smart Growth America, 2015.
49 Vijayan, no date.

CONCLUSION

Since the Indiana General Assembly passed road and bridge funding legislation in 2016 and 2017, the 91 study counties have done substantial work on local roads and bridges resulting in improved bridge conditions and stabilized or improved road conditions.

Counties have reported a growing amount of road asset management data and annual operational report revenue and spending data to the Indiana LTAP data portal including road inventories, pavement conditions, treatments used, and treatment cost data. Bridge data is reported to the NBI. This collection of data gives researchers, local agencies, and policy makers the data necessary to support more sophisticated local asset management planning and state-level analyses. The research team used this data to develop deterioration curves and to estimate resulting ratings associated with particular types of treatments.

The large inventory of local roads and bridges and the cyclical nature of improvement and deterioration will necessitate sustained investment in the network over time. Current and past studies—including this one (Road Scenario 1)—typically estimate needs based on a mid-range average pavement rating, the elimination of poor or failed roads and bridges, or some combination of goals. The outcomes often suggest the need for levels of additional resources that are likely unattainable.

The research team recommends that state policy makers consider various scenarios using attainable levels of investment and the resulting effects on pavement conditions. Road Scenarios 2–4 provide road condition data for three scenarios—maintaining current spending on the treatment of asphalt and chip seal pavements with modest annual price inflation over time, increasing that spending by 50% with modest annual price inflation, and increasing that spending by 100% with modest annual price inflation. These scenarios suggest that by taking an asset management approach and choosing treatments that maximize pavement conditions over time, Indiana's network can be maintained at an average PASER rating for asphalt at or above PASER 4 and the average chip seal pavement ratings at or above PASER 5. Each of these scenarios, including maintaining the current funding level with a modest increase for inflation, keep the average conditions of asphalt and chip seal pavements at a higher level than the poor conditions that existed in 2015–16 before the Indiana General Assembly expanded gas tax revenues and created the Community Crossings Matching Grant Program. Not surprisingly, the average ratings generally are modestly better with the investment of additional resources.

Given the limited nature of available state and local funding, the research team also provides a number of strategies that will either generate more local revenue or help local agencies wring more utility out of those limited resources, including bonding, engineering innovations, asset management and capital improvement planning, coordinating land use and transportation planning, interlocal cooperation on construction and purchasing, and investment and disinvestment strategies for high-value or low-value assets. Many of these strategies require having the appropriate expertise and staffing as well as a willingness to embrace change.

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APPENDIX A: COMPLETE METHODOLOGY—ROAD SPENDING NEEDS

The research team calculated average weighted pavement ratings resulting from treatments and deterioration after treatment using 2021–23 county asset management plans and developed four future spending scenarios. Road Scenario 1 estimates spending needs to keep asphalt and chip seal pavements at a minimum rating of fair without resource constraints. Road Scenarios 2–4 estimate needs and conditions with resource constraints.

Pavement improvement and deterioration analyses

To calculate pavement improvements resulting from treatments and deterioration following treatment, the research team compiled all road segment data from the 2021–23 county asset management plans for the 91 counties. The researcher team identified 32 counties as having inconsistent segment identifiers during the three-year period, making it difficult to match up segments without checking each one manually. The team excluded these segments and PCI-rated segments from the improvement and deterioration analyses, leaving 101,490 road segments in 59 counties for analysis.

The data fields in the master file include County, Designation, Roadway, From, To, Length in miles, Width in feet, Surface type, Rating 1, Date of rating 1, Rating 2, Date of rating 2, 2022 treatment, 2021 treatment, 2020 treatment, and 2019 treatment. Rating 1 for each segment was recorded most often in 2023, while Rating 2 was recorded most often in 2021. Pavement deterioration and treatment improvement analyses were conducted by filtering the data in the master file.

Table A1 shows the average annual mileage utilizing the 18 most-used treatments in the 91 study counties for 2019–22. The seven most-used treatments accounted for 86% of treated miles. The 10 remaining treatments accounted for 10% of treated miles and the 23 treatments not shown accounted for 4%.

Table A1. Annual average treated mileage—2019–22

Treatment	Average annual mileage treated
Chip seal	1,955
Patching/pothole filling*	413
1.5" overlay	384
2" overlay	260
Crack seal	237
Chip seal and fog seal	128
Mill and 1.5" overlay	108
Double chip seal	108
Full-depth reclamation with asphalt	58
3" overlay	56
2.5" overlay	51
Cold mix asphalt	48
Pug mix asphalt	44
Rejuvenator	42
Mill and 2" overlay	29
Triple chip Seal	28
Mill and 3" overlay	26
Blade mix with chip seal	26

Sources: 2021–23 county asset management plans.

Note: Patch/pothole filling is a common treatment used in all counties as indicated by the mileage shown. The frequency and quantity of material is unknown. Counties reported unit costs in tons of material. Since quantities are difficult to calculate this treatment type is excluded from the analysis.

To calculate rating improvements by treatment, the research team filtered road segments that met the following criteria—a rating recorded in 2021, followed by a treatment in 2022, and a subsequent rating recorded in 2023. The research team calculated improvement using the difference in rating directly before and after treatment. These individual rating changes by segment were then weighted based on segment length. Table A2 summarizes these improvements for the treatments used most for asphalt and chip seal pavements (Table A1).

It is important to note that the short time frame and small number of observations for these data limit accuracy. As more asset management data becomes available, calculations with enhanced accuracy can be made with more matching segments and a longer time horizon.

Table A2. Estimated rating improvements resulting from the most-used asphalt and chip seal treatments

Treatment type	Number of segments	Mileage	Mileage %	Estimated weighted PASER rating change
Asphalt				
Chip seal	290	213	42%	1
Overlay 1.5"	207	88	18%	5
Overlay 2"	156	69	14%	6
Crack seal	62	28	6%	0
Chip seal and fog	13	21	4%	2
Mill and 1.5" overlay	191	57	11%	4
Double chip seal	33	25	5%	2
Total	**952**	**501**	**100%**	**N/A**
Chip seal				
Chip seal	430	318	77%	3
Overlay 1.5"	34	23	6%	5
Overlay 2"	0	0	0%	Not available
Crack seal	13	12	3%	6
Chip seal and fog	1	1	0%	7
Mill and 1.5" overlay	32	17	4%	3
Double chip seal	64	44	10%	2
Total	**574**	**415**	**100%**	**N/A**

Sources: Estimated changes in weighted ratings were derived using data from 2021–23 county asset management plans.

Notes:

1. This table includes the data from Table 3 as well as additional data.
2. Patch/pothole filling is a common treatment used in all counties as indicated by the mileage shown. The frequency and quantity of material is unknown. Counties reported unit costs in tons of material. Since quantities are difficult to calculate this treatment type is excluded from the analysis.
3. There were insufficient observations to calculate an average weighted rating change for 2" overlay on chip seal.

To support the development of an Indiana-specific road deterioration model, the research team reviewed five deterioration models—Roadsoft;[50] Lincoln, California;[51] Lincoln, Nebraska;[52] Colorado Department of Transportation;[53] and Vermont Agency of Transportation.[54] All models have a similar deterioration curve.

To calculate deterioration by pavement type, the research team filtered segments that met the following criteria—treatment in 2019 or 2020, a rating in 2021, and a subsequent rating in 2023. The difference in the 2021 and 2023 ratings allows calculation of deterioration or the lasting effect of a treatment that occurred in 2019 or 2020. These individual rating changes by segment were then weighted based on segment length. Table A3 shows the bi-annual deterioration of asphalt and chip seal surfaces from initial rating post-treatment to subsequent rating post-treatment. As noted above, the short time frame for these data limits accuracy.

[50] Center for Technology and Training, 2010.
[51] Infrastructure Consulting Group, 2021.
[52] City of Lincoln, Nebraska, 2024.
[53] Saha, Ksaibati, & Atadero, 2017.
[54] Vermont Agency of Transportation, 2022.

Table A3. Estimated ratings as the result of the deterioration of asphalt and chip seal pavements with no treatment

Initial rating	Number of segments	Mileage	Estimated weighted PASER rating change
Asphalt			
5	7,452	2,282	-.5
6	8,149	2,610	-1
7	8,599	3,242	-1
8	6,317	2,553	-1
9	3,126	1,120	-1
10	620	173	-2
Total	**34,263**	**11,980**	**N/A**
Chip seal			
5	1,612	866	-.5
6	2,072	1,110	-.5
7	2,312	1,392	-.5
8	700	359	-1
9	728	439	-2
10	52	25	-2
Total	**7,476**	**4,191**	**N/A**

Sources: The changes in weighted ratings were derived using data from 2021–23 county asset management plans.

Notes:

1. This table duplicates Table 4.
2. Segments with PASER 1–4 are not included in this analysis due to the low number of matched segments.

Treatment costs

The research team collected unit costs for the pavement treatments from county highway departments. Two counties reported pavement unit costs in their 2023 county asset management plans. The research team surveyed the remaining counties to obtain additional local data. Thirteen additional counties responded to the survey. INDOT provided unit costs for bridge repair and rehabilitation. Table A4 summarizes these unit costs for road repair and rehabilitation. Table A5 summarizes unit costs for bridge replacement and repair.

Needs scenarios

In developing each of the spending needs scenarios, the research team followed a series of steps to calculate the cost of treatment and the resulting pavement ratings.

1. Inventoried 2023 asphalt and chip seal road segments and their corresponding ratings (1–10).
2. Applied treatments to selected road segments based on the scenario.
3. Calculated the aggregated cost of treatment using the mileage and treatment unit costs (Table A4).
4. Calculated conditions ratings—based on having received treatment or the deterioration projected to occur without treatment—from the expected rating changes shown in in Tables A2 and A3.
5. Repeated the process for each two-year period using the resulting ratings from the previous period.
6. Aggregated the costs across periods.

Road Scenario 1 estimates the initial cost to treat all pavements rated PASER 1–4 and the subsequent costs to treat deteriorating pavements falling below PASER 1–4 over 10 years using pavement unit costs with a 3% annual rate of inflation.

Road Scenarios 2–4 explores the effects of constrained resources on asphalt and chip seal pavements. Prior to implementing the steps described above, the research team estimated the spending for the treatment of asphalt and chip seal pavements from 2019–22 using mileage treated by type of treatment and pavement unit costs. The estimated average annual treatment cost for this period was $218 million (Table A6). The research team used $220 million as the base spending for the scenarios.

Table A4. Average unit costs for the most-used pavement treatments

Treatment	Unit cost per mile
Chip seal	$19,000
Patching/pothole filling	Not available
1.5" overlay	$113,000
2" overlay	$132,000
Crack seal	$11,000
Chip seal and fog seal	$28,000
Mill and 1.5" overlay	$150,000
Double chip seal	$29,000
Full-depth reclamation with asphalt	$240,000
3" overlay	$200,000
2.5" overlay	$190,000
Cold mix asphalt	$50,000
Pug mix asphalt	$50,000
Rejuvenator	$19,000
Mill and 2" overlay	$170,000
Triple chip Seal	$56,000
Mill and 3" overlay	$190,000
Blade mix with chip seal	$20,000

Sources: 2023 county asset management plans and 2024 survey of county highway departments.

Notes:

1. This table duplicates Table 1.
2. Patch/pothole filling is a common treatment used in all counties. The frequency of treatment and quantity of material used is unknown, making it difficult to calculate the cost of this treatment. For this reason, the treatment is excluded from the analysis.
3. Unit costs include the cost of materials and labor.

Table A5. Average unit prices for bridge repair and replacement

Bridge component	Average unit cost per square foot
Deck	$103
Superstructure	$163
Substructure	$73
Full bridge replacement	$242

Source: INDOT (2024).

Notes:

1. This table duplicates Table 2.
2. Unit costs include the cost of materials and labor.

The research team selected the relative mix of spending on asphalt and chip seal pavements based on the relative costs of the most common asphalt and chip seal treatments. For 2019–22, the most common treatment for asphalt pavements was 1.5" overlay, costing $150,000 per mile. The most common treatment of chip seal pavements was chip seal, costing $19,000 per mile. The relative cost of the most common asphalt and chip seal treatments is about 7:1.

For Road Scenario 2, the research team allocated $200 million to asphalt pavements and $20 million to chip seal pavements annually. Because counties are required to rate pavement conditions only every two years, initial spending for Scenario 2 was $400 million for asphalt pavements and $40 million for chip seal pavements for the first two years. A 3% annual increase was applied for subsequent years to account for inflation. Road Scenario 3 assumed a 50% increase in spending on asphalt and chip seal pavements with inflation. Road Scenario 4 assumed a 100% increase with inflation.

Two potential approaches for network treatment are a worst-first approach; or a network approach where a mixture of treatments is used. The research team chose a network approach for each scenario to maximize pavement conditions with the available resources during the 15-year period. Team members then applied treatments counties used most often in their asset management plans. For example, if crack sealing is excluded, asphalt overlays and chip seal surface treatments are the most often used treatments for asphalt pavements.[55] The treatments used most often for chip seal pavements are chip seal and fog seal.

[55] Chip seal surface treatments on an asphalt base are different than chip seal pavements on a gravel base.

Table A6. Average annual mileage treated and cost by treatment type

Treatment	2022	2021	2020	2019	Total 2019–22	Average annual mileage treated	Unit cost per mile	Average annual treatment cost
Mill and 1.5" overlay	159	95	96	83	433	108	$150,000	$16,237,500
Mill and 2" overlay	16	58	30	12	116	29	$170,000	$4,930,000
Mill and 2.5" overlay	16	6	17	17	56	14	$180,000	$2,520,000
Mill and 3" overlay	45	20	37	1	103	26	$190,000	$4,892,500
Mill and 4" overlay			4	15	19	5	$200,000	$950,000
1.5" overlay	296	474	364	400	1,534	384	$113,000	$43,335,500
2" overlay	230	292	263	253	1,038	260	$132,000	$34,254,000
2.5" overlay	89	61	37	16	203	51	$150,000	$7,612,500
3" overlay	71	13	72	68	224	56	$180,000	$10,080,000
4" overlay	2	1	1	5	9	2	$190,000	$427,500
Mill and chip seal		13			13	3	Not available	Not available
Chip seal	2,106	2,148	1,915	1,649	7,818	1,955	$19,000	$37,135,500
Double chip seal	107	98	126	100	431	108	$29,000	$3,124,750
Triple chip seal	23	42	25	20	110	28	$28,000	$770,000
Crack seal	222	231	217	277	947	237	$11,000	$2,604,250
Patching					0	0	Not available	Not available
Patching/pothole filling	377	401	393	479	1,650	413	Not available	Not available
Full-depth reclamation with asphalt	21	60	33	119	233	58	$240,000	$13,980,000
Full-depth reclamation with chip seal	6	6	46	29	87	22	Not available	Not available
New road construction	15	6	12	2	35	9	$2,300,000	$20,125,000
Asphalt reconstruction	20	12	20	4	56	14	$230,000	$3,220,000
Concrete reconstruction	4	2	1	4	11	3	Not available	Not available
Cape seal	0.5			1	2	0	Not available	Not available
Chip seal and fog seal	113	127	103	168	511	128	$28,000	$3,584,000
Fog seal		31	4	9	44	11	$2,300	$25,300
Slurry seal	2		3		5	1	Not available	Not available
Microsurface	11			3	14	4	Not available	Not available
Rejuvenator	33	45	61	30	169	42	$19,000	$802,750
Dust control		78		5	83	21	$5,000	$103,750
Gravel rehabilitation					0	0	Not available	Not available
Pug mix asphalt	44	44	31	57	176	44	$50,000	$2,200,000
Cold mix asphalt	27	32	75	57	191	48	$50,000	$2,387,500
Blade mix with chip seal	21	23	26	33	103	26	$20,000	$515,000
Chip seal patch and berming	18	70	5	2	95	24	$25,000	$593,750
Chip seal and 2.5" overlay	2				2	1	Not available	Not available
Crack seal and chip seal	1.5		3		5	1	Not available	Not available
Microseal	2				2	1	Not available	Not available
Microsurfacing and patching	6	51	3	17	77	19	$56,000	$1,078,000
Mill and chip seal	28		5	21	54	14	$25,000	$337,500
Horse trough paving	1	3			4	1	Not available	Not available
Liquid road		1	2		3	1	Not available	Not available
Total	**4,135**	**4,544**	**4,030**	**3,956**	**16,666**	**4,166**	**N/A**	**$217,827,550**

Sources: 2020–23 asset management plans and 2024 survey of county highway departments

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