Inventory-based Rating System™
for Gravel Roads

Training Manual

Acknowledgements

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Manual prepared by
Center for Technology & Training—Michigan Technological University
on behalf of the Michigan Transportation Asset Management Council

Introduction

The Inventory-based Rating (IBR) System™ is a visual survey method for evaluating the condition of unpaved roads. This method was developed by Michigan Technological University's Center for Technology & Training (also known as the CTT) to provide a simple, efficient, and consistent way for evaluating unpaved road condition. Michigan's Transportation Asset Management Council (TAMC) has adopted the IBR System™ for measuring statewide conditions of unpaved roads in addition to the Pavement Surface Education and Rating system for measuring pavement conditions of paved roads in Michigan. The TAMC requires data collection team members to attend annual trainings if they plan to submit data for the statewide, Act 51-mandated data submission (see *TAMC Data Collection Manual* for more information on the policies and procedures related to data collection efforts in Michigan; a link to this is provided in *Resources*).

This *Inventory-based Rating System™ for Gravel Roads Training Manual* describes the premise and data collection processes involved in the IBR System™. It explains concepts that form the foundation of the system, the road features assessed by the system, and the way in which ratings are calculated. The TAMC chose Roadsoft—a road management system used by Michigan's road-owning agencies—for collecting, storing, and analyzing condition data, and has detailed how Roadsoft can be used to do this in the *TAMC Data Collection Manual*. Roadsoft is the primary tool used for managing IBR System™ data. Roadsoft is funded through the Michigan Department of Transportation (MDOT) and developed, supported, and distributed by Michigan Technological University's Center for Technology & Training.

The development of the IBR System™ and this manual has been funded by the Michigan Transportation Asset Management Council and carried out by the Center for Technology & Training.

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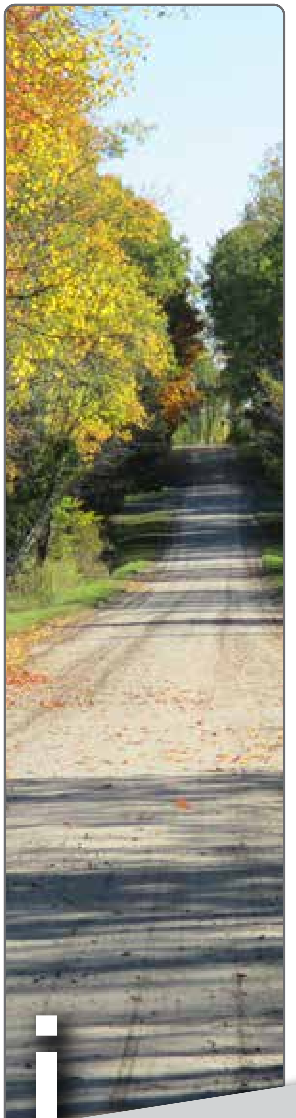


Premise Behind the Inventory-based Rating System™

Why Rate Roads

Michigan's Public Act (PA) 51 and its amendments PA 499 and PA 325 mandate the reporting of road conditions to the Michigan legislature. It created the Michigan Transportation Asset Management Council (TAMC) to facilitate collection of that data from road-owning agencies in Michigan. As such, the TAMC requires road-owning agencies to submit condition data, which the TAMC then reports to the legislature. For many years, the TAMC has had road-owning agencies collect and submit condition data on paved roads using the Pavement Surface Evaluation and Rating (PASER) system to fulfill the PA 51 requirements per the TAMC's *Policy for Collection of Roadway Surface Condition Data*. In 2017, the TAMC added a requirement for collecting and submitting data on unpaved roads using the Inventory-based Rating (IBR) System™ in order for agencies to comply with PA 51. Collecting condition data obliges road-owning agencies to rate their roads using one of these standardized systems.

Figure 1: The asset management cycle

PA 51 as amended also states that "[a]ll public roads in Michigan will be managed using the principles of asset management". It also defines asset management as the "ongoing process of maintaining, preserving, upgrading, and operating physical assets cost effectively, based on a continuous physical inventory and condition assessment and investment to achieve established performance goals" (PA 325). Condition data serves as the first step in identifying the state of one's assets and provides a way to track improvements made as well as necessary ongoing maintenance. It also enables agencies to forecast the right time and right place to apply improvements or maintenance techniques in a way that achieves optimal cost effectiveness. As an ongoing process, asset management relies on a continuous cycle of updating asset inventory, updating condition data including ratings, projecting future condition, updating management strategy, and again updating asset inventory (Figure 1). Asset management is a strategy that can be applied to preserving a critical component of Michigan's road network: unpaved roads.

Construction or maintenance on a road can have a drastic effect on its IBR number

Roads are left unpaved for many reasons. Unpaved roads may be a good choice for roads that serve a lower traffic volume, for roads where high-speed transit is not necessary, and for agencies that need a road option with low construction and maintenance costs. While unpaved roads are common in rural areas, they also exist in urban residential areas. These roads may even be critical links in some road networks, like those that serve farms or agricultural industries. By no means can an unpaved road be considered a “second-class” road.

One of the primary considerations influencing the construction of an unpaved road is how wide it should be. Deciding the width of the road largely depends on traffic volume. A road that serves only one or two properties is usually sufficient with a narrow width; but, roads serving agricultural industries require more width to facilitate the transport of agricultural equipment at optimal speeds. If, over time, a road’s need for width increases, it is a costly and extensive undertaking to perform a widening project.

In the construction of an unpaved road, drainage is critical to establishing a firm foundation (Figure 2). Water should drain away from the road structure; if it does not, water will saturate the road layers and layer mixing will occur. This over-saturation leads to distresses like rutting, potholes, washboarding, and gravel loss. To facilitate drainage, a road may be built with ditches, cross-slopes, culverts, and underdrains. Shape also enhances a road’s ability to drain (Figure 2). The shape created by a road’s outer edges being lower and the centerline being higher is called the “crown”. If the crown is too steep, the road itself will lose gravel, road users will drive down the center of the road when they can, and/or vehicles will easily slide off the road during icy conditions. If the crown is parabolic, water will sit near the crown and saturate the center of the road. And, if the crown is too flat, it will inhibit drainage.

Using quality construction material and creating road layers of optimal thicknesses influence an unpaved road resiliency to wet weather as well as dry seasons (Figure 2). An unpaved road depends upon its surface material’s aggregate—its angularity, its gradation of gravel to fines (small, dust-like particles), and its moisture content—to create interlock and to bind itself together. When an unpaved road surface relies on aggregate with good angularity and fines with good binding quality, the gravel/sand and the fines can work together to “lock” in place or “bond” together. This creates a crust, or layer, that prevents water penetration as well as the loss of fines in road dust. However, the ratio of gravel/sand to fines is important for drainage as well: if the entire road structure has an appropriate gradation from gravel/sands to fines, water will drain through

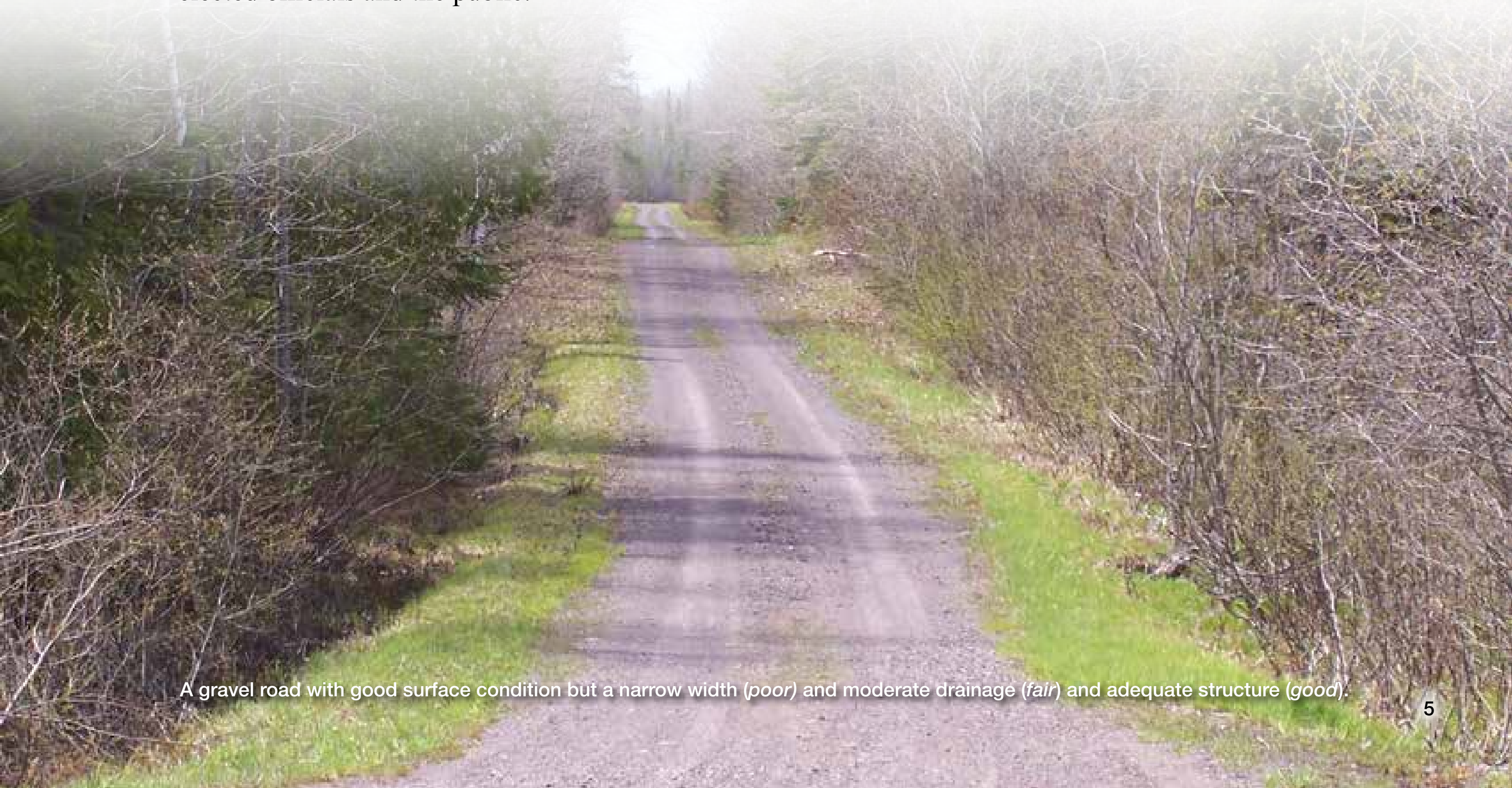
Grading is an inexpensive technique that can quickly, but temporarily, alter surface condition.

Figure 2: Drainage, shape, material quality, and material thickness are some key considerations when constructing unpaved roads.

it at an ideal rate. If there are not enough fines, water will transit through the road structure quickly, but the road structure will be too loose, not having enough of the binding matter to hold the aggregate in place and create that tight lock. On the other hand, having too much of the fines in the gradation prevents proper drainage, leaving the road structure in a more saturated state than the ideal after a rain event and inhibiting its drying out process.

Once built, a road owner must manage and maintain unpaved road assets in order for them to achieve their optimal usability and service lives at minimal costs. The first step to managing and maintaining unpaved road assets well is through rating, which gives road owners a clear picture of the current condition as well as the historic condition of the roads in their network. To manage a road network well, road owners should be able to project accurately where their roads will be in the future with scheduled maintenance alone or with the application of preventive maintenance or capital preventive maintenance treatments and if/when the road should be paved.

Collecting condition data on both paved and unpaved roads allows road owners to know the current status of their road network, and storing condition data allows them to see how quickly their network has been changing over time. Assessing condition data over time can yield information such as how effective past treatments have been and what the future condition of the network will be with scheduled maintenance alone as well as with treatments applied. Armed with condition data, road owners can best gauge where routine or preventive maintenance suffices, where improvements are needed, what improvements would be best, and when the optimal time to make those improvements would be, and they can use the data to justify their decisions to elected officials and the public.



A gravel road with good surface condition but a narrow width (*poor*) and moderate drainage (*fair*) and adequate structure (*good*).

Furthermore, collecting condition data for unpaved roads allows road owners to compare the road's current condition to a baseline condition. This enables road owners to see the status of road conditions so they know where to target future improvements or maintenance. Monitoring unpaved road conditions over time at a network level also provides measures that can be used to illustrate the impact of investments on the unpaved road network. Unpaved roads make up half of the non-Federal-aid network and approximately one third of Michigan's entire road network. The fact that unpaved roads constitute such a large portion of Michigan's road network shows the importance of having accurate data regarding their condition. Without relevant unpaved condition data, it is impossible to have a clear picture of the quality of Michigan's roads overall. However, condition assessment systems based on surface condition are problematic when they are applied to unpaved roads and can lead to inaccurate data.

Limitations of Existing Assessment Systems for Unpaved Roads

While many condition assessment systems exist for unpaved roads, most of them evolved from paved road assessment systems. Consequently, assessment of road condition according to these systems relies heavily on surface distresses. Surface condition is a primary factor that impacts use of a paved road by motorists and is directly related to the life of the most expensive layer of the pavement, which is the surface layer, that typically drives major improvement work on a paved road network. Focusing on surface distress as a measure of quality works well for paved roads because surface distresses change slowly—making the distresses relatively static over the course of a year—and require a significant effort to repair. This slow rate of change allows a single rating event every one to two years to provide a sufficient level of data for management purposes on paved roads.

Unpaved roads, on the other hand, can have significant changes in surface condition over a matter of days or weeks (see pages 6 and 7 footer images). Rating systems based on surface conditions are difficult to apply as a network-level measure to unpaved roads since road condition in terms of its surface may be highly variable during the year as distresses appear and short-term maintenance activity, such as grading, is completed. For example, an unpaved road's surface might become severely deteriorated following a rain event due to distresses like gravel loss, dust loss, and saturated gravel (i.e., weakened base structure). These distresses

This is a road in the fall season with no surface distresses.

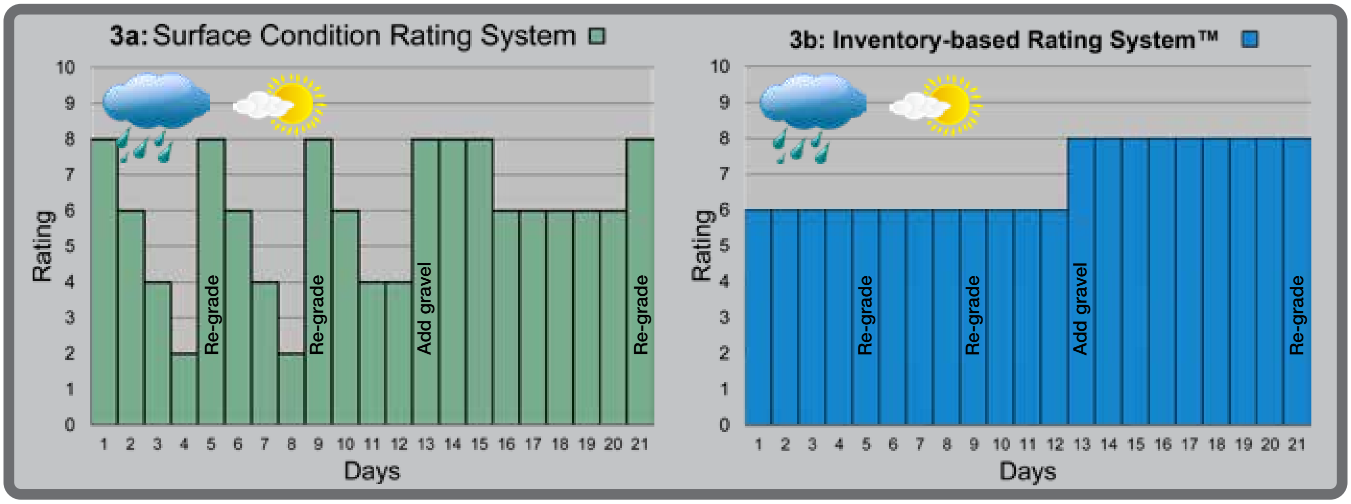


Figure 3: These two charts compare unpaved road rating systems that rely on surface condition with the IBR System™, which relies on other road elements. The IBR System™ provides more accurate and consistent results.

Figure 4: Even if an unpaved road appears to have good surface condition, it is still likely to perform poorly without proper drainage.

can be quickly corrected by shaping and adding proper material to rectify the immediate issue. Nonetheless, a subsequent rain event or traffic use can cause the road to deteriorate again. Thus, assessment based on surface condition, which could be called a maintenance-based feature (i.e., one that is easily changed through maintenance projects), results in a network-level metric that can vary greatly from week to week depending on when ratings were collected (Figure 3a). Therefore, using condition assessment metrics based on needing major improvement to effect change yields a more stable assessment of an unpaved road's overall condition. If an unpaved road is assessed based on its major-improvement-based features like its surface width, drainage adequacy, and structural adequacy rather than its maintenance-based features (e.g., surface condition), what one finds is the unpaved road rating actually possesses a more stable

This is the same road as the left photo but in the spring. The surface condition of a road can change drastically from day to day, week to week, or season to season.

condition over time, and the unpaved road needs extensive and costly changes made to its major-improvement-based rated features if and when agency resources allow (Figure 3b).

Figure 5: The width of a road can have a big effect even if the other factors are good.

Unlike paved roads, many other factors unrelated to surface condition can influence the functionality of unpaved roads. Unpaved roads are highly variable in their design, construction, use, and upkeep when compared with paved roads. Many unpaved roads do not contain basic inventory elements common to most paved roads, which makes the exclusive focus on surface condition problematic. Differences in inventory elements can adversely influence the use of the road and may have more of an impact on users than poor surface conditions. For example, road users may consider ruts or potholes on an unpaved road a secondary inconvenience if the unpaved road is only nine-feet wide and the limited surface width will not allow the operation of two-way vehicle traffic at any significant speed (Figure 4). In this case, surface condition may not be very important to users. Similarly, an unpaved road without proper drainage is likely to perform poorly for any traffic volume regardless of the current surface condition (Figure 5). Poor unpaved road surface condition does not always relate to the life of the surfacing layer and more typically may be rectified by low-cost grading.

Thus, assessment systems based on surface condition are problematic for unpaved roads.

A gravel road with good surface condition but moderate width (*fair*), adequate drainage (*good*), and adequate structure (*good*)

Overview of the Inventory-based Rating System™

The Inventory-based Rating (IBR) System™ was developed to rectify the problems associated with many unpaved road condition assessment systems by providing a rating system specifically designed for unpaved roads—a rating system that does not exclusively focus on surface condition but, rather, those features that change the value of the road in terms of its usability. The IBR System™ is a visual survey method that provides a simple, efficient, and consistent method for evaluating the condition of unpaved or gravel roads.

Road Features Assessed as Part of the IBR System™

The IBR System™ assesses conditions for three characteristic elements—Surface Width, Drainage Adequacy, and Structural Adequacy—of unpaved roads (see page 11 footer image). These "IBR elements" relate to the considerations involved in effecting improvement on unpaved roads. They were specifically selected based on their impact on road use and based on the level of investment required to bring them to a baseline, or good, condition. Each element's baseline condition is determined by characteristics that are considered acceptable for the majority of road users with guidance from design standards.

Since these IBR elements do not change rapidly, a rating only requires updates when construction activities occur or when lack of maintenance leads to loss or degradation of a road feature. But, when these features do degrade, they require significant construction or maintenance efforts to improve.

Good, Fair, Poor Assessments

The baseline of what is acceptable to most road users and what adheres to industry recommendations is a *good* assessment in the IBR System™. Not meeting the baseline condition results in a lower assessment. Each of the three IBR elements have three ranges of classification—*good*, *fair*, and *poor*—based on ranges of physical characteristics (Figure 6 and see Figures 8, 9, and 10). IBR elements are apparent enough to be evaluated from a moving vehicle and typically only require hand measurement to orient users for making evaluations from the vehicle.

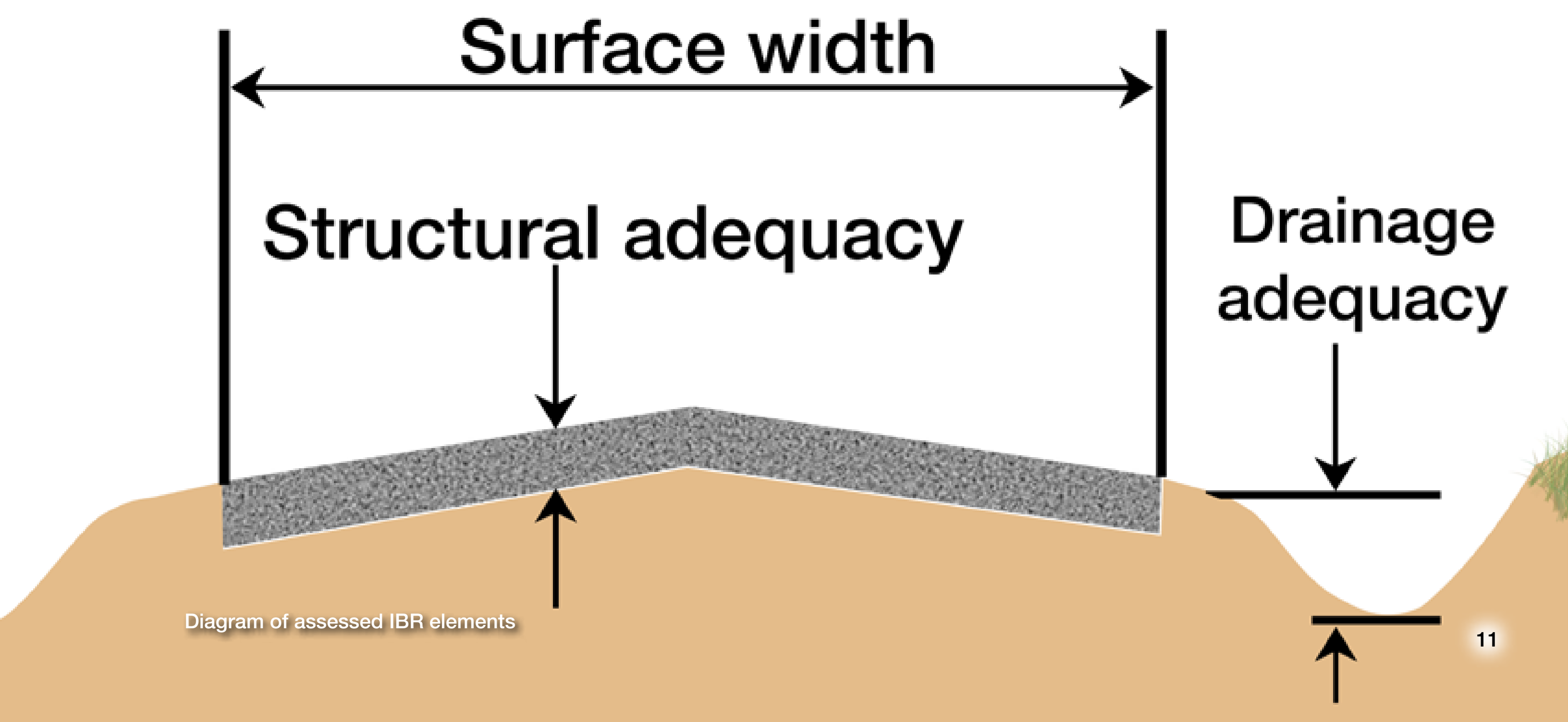


Diagram of assessed IBR elements

The *good*, *fair*, and *poor* assessments for each of the three IBR elements are used to accrue up to nine points in the IBR number system. For each element being assessed on a road segment, criteria that meet the baseline condition (considered *good*) generate more points. An additional IBR number of 10 is reserved for newly-constructed roads less than one year old that are built with *good* surface width, *good* drainage adequacy, and *good* structural adequacy. Thus, the IBR System™ forms a 10-point scale that can match the scales used for the TAMC's paved road condition assessment.

One problem IBR System™ raters and data handlers encounter is associating *good* unpaved roads with "superb" or newly-paved roads and *poor* unpaved roads with "shabby" or completely-deteriorated paved roads. With the IBR System™, an element's assessment reflects that feature's alignment with a baseline condition rather than a quality that influences management and maintenance decisions. Having unpaved roads with poor assessments does not mean the road-owning agency is mis-managing their unpaved road network; the agency may still be managing these assets well based on the service these roads provide in the context of the agency's entire network.

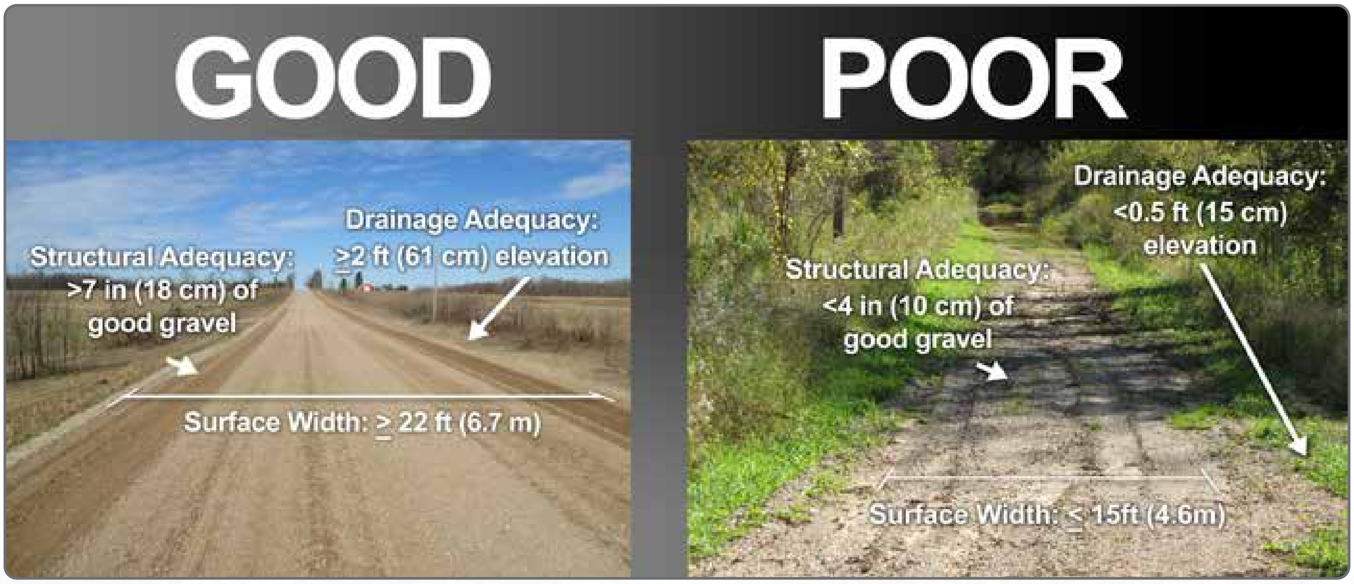


Figure 6: Example of good criteria for the IBR elements (left) and poor criteria (right).

Trees and foliage close to the side of the road can make it more challenging to estimate surface width accurately.

Rather, the IBR System's™ *good*, *fair*, and *poor* assessments can be interpreted as *at* baseline, *moderately below* baseline, or *significantly below* baseline. The baseline for unpaved roads are the expectations that most road users have for its surface width, drainage adequacy, and structural adequacy. A *good* unpaved road—one that is at baseline—can satisfy most road users in terms of the passing ability, speed, and usability; conversely a *poor* unpaved road—one that is significantly below baseline—cannot satisfy most road users in terms of passing ability, speed, and usability. Each case may be appropriate depending on the context of the road. In other words, users of unpaved roads that support agricultural industry might be satisfied with *good* elements facilitating passing and high-speed travel, and users of unpaved roads that allow access to seasonal residences might be equally satisfied with *poor* elements that limit traffic and, consequently, road noise. An agency that spends the money to widen, ditch, or re-gravel those roads providing access to agricultural industries while leaving the seasonal roads to camps and cottages narrow and with little structure can be said to be managing those unpaved road assets well. The IBR System™ does not translate *good* or *poor* assessments into types of repairs or upgrades needed but, rather, serves to identify where upgrades could occur in the network should agency resources and public needs allow.

Grading can correct surface condition defects.

Did you know?

The Center for Technology & Training conducted a pilot study on IBR System™ data collection (see page 29). As part of the study, the project team collected gravel measurements using core drills and demolition hammers in order to determine the accuracy of the structural adequacy assessments made by agency staff in the pilot counties. What they found was that agency staff were correct in their assessments 79.6% of the time (Figure 7). This demonstrates just how well local agencies know the structure of their unpaved roads!

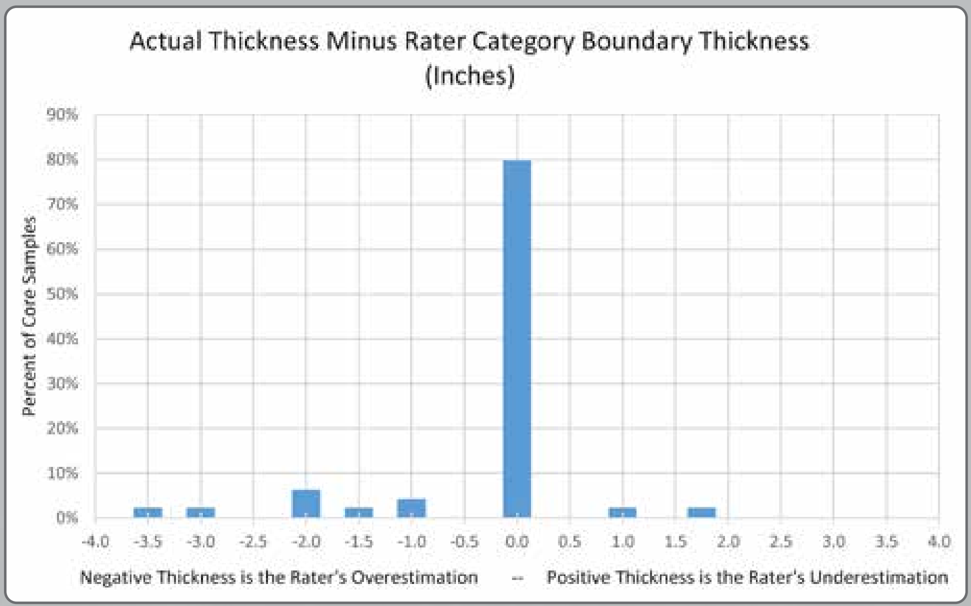
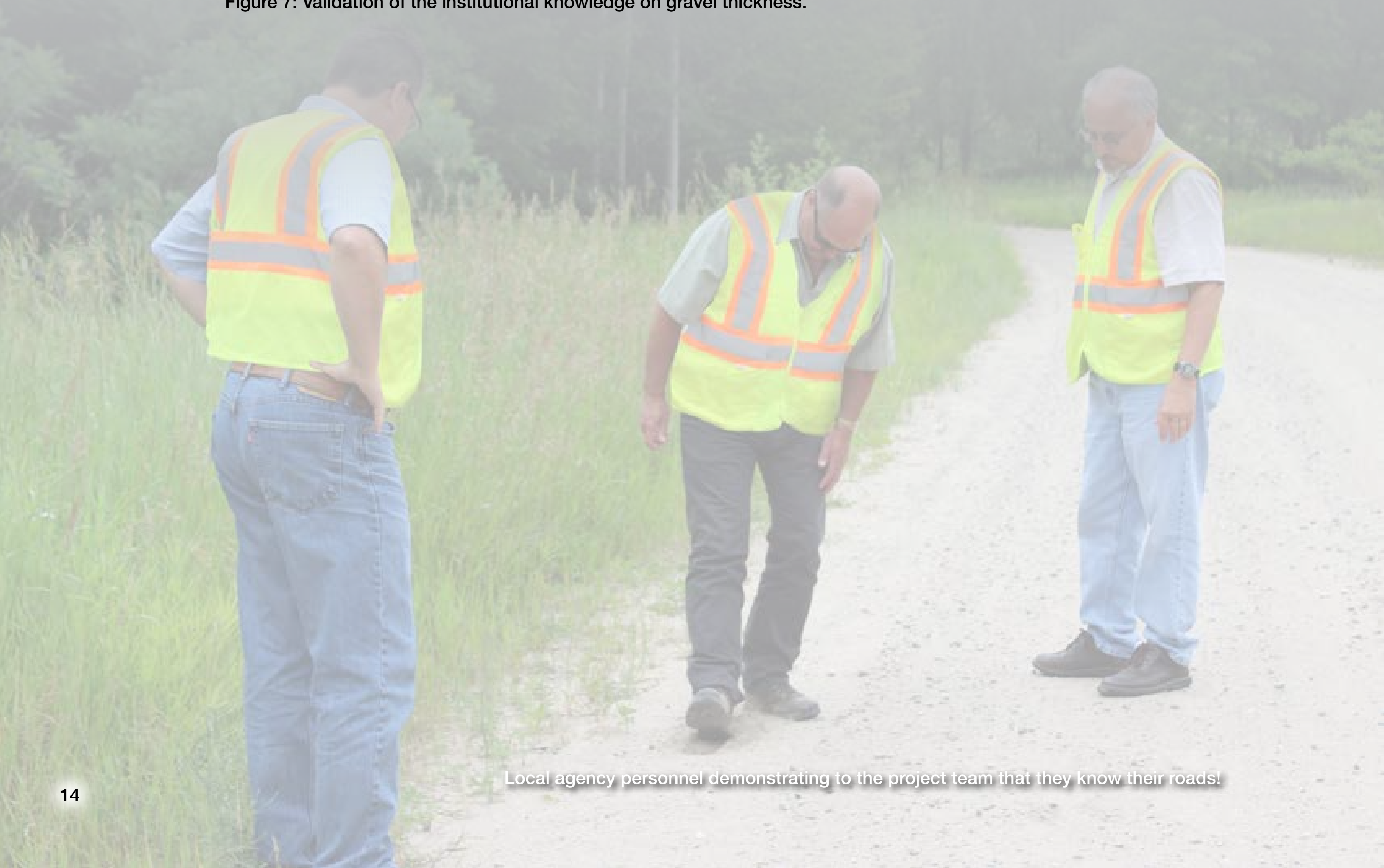


Figure 7: Validation of the institutional knowledge on gravel thickness.



Local agency personnel demonstrating to the project team that they know their roads!

IBR System™
Assessment Criteria

Surface Width

Surface width is assessed by estimating the width of the travelled portion of the road (or travel lanes; also called the roadway) and any travel-suitable shoulder.

Good

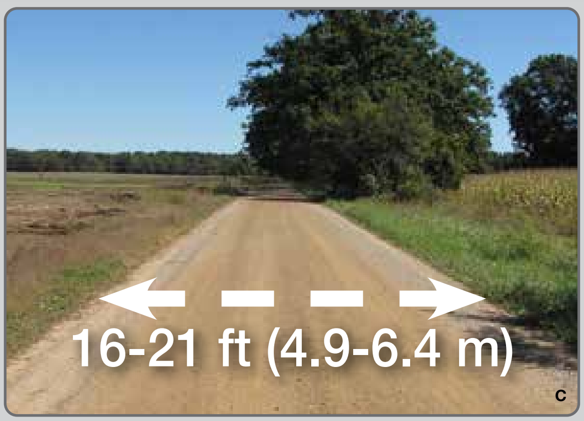
22 feet (6.7 meters) wide or more

a

b

Fair

16 to 21 feet (4.9 to 6.4 meters) wide



c

d

Poor

15 feet (4.6 meters) wide or less

e

f

Figure 8

Tips for Assessing Surface Width

1

Include any shoulder in the width that is suitable for travel

2

Orient yourself by physically measuring the width until you are comfortable making accurate estimates from your vehicle

3

Be aware of trees and slopes that may influence your width perception

Drainage Adequacy

Drainage adequacy is assessed by, first, estimating the difference in elevation between the ditch's flow line or level of standing water (if present) and the top edge of the shoulder and, second, evaluating any secondary ditches that are present since they have the ability to retain surface water (Figure 9a). Secondary ditches should only be considered when they are over six inches tall.

Ditches can vary greatly between the left and right shoulders as well as along the entire length of a road. Therefore, the assessment for Drainage Adequacy should always reflect the worst side of the road (Figure 9b) and should always reflect the condition typical of the entire segment.

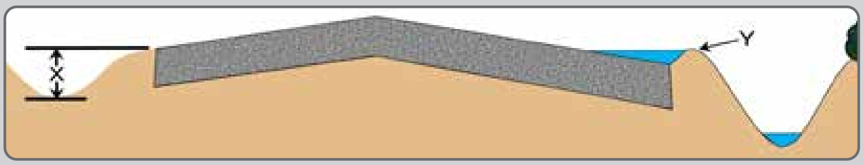


Figure 9a: Diagram illustrating the difference in elevation between the edge of the shoulder and the ditch flow line—identified as "x"—and the presence of a secondary ditch—identified as "y".

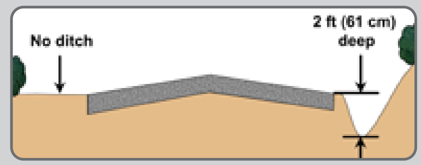
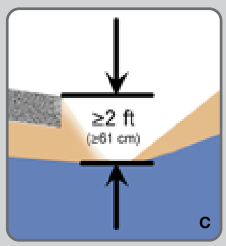


Figure 9b: Rate the worst side for drainage

Good

Two feet (61 centimeters) or more of difference in elevation

No secondary ditches (Y) greater than 6" tall are present

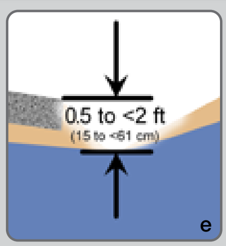


Fair

From 0.5 to less than 2 feet (15 to < 61 centimeters) of difference in elevation

OR

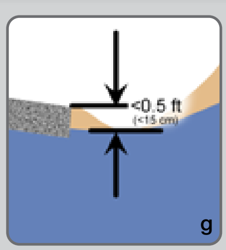
Secondary ditches are present AND there is two feet (61 centimeters) or more of difference in elevation



Poor

Less than 0.5 feet (15 centimeters) of difference in elevation

Secondary ditches may or may not be present



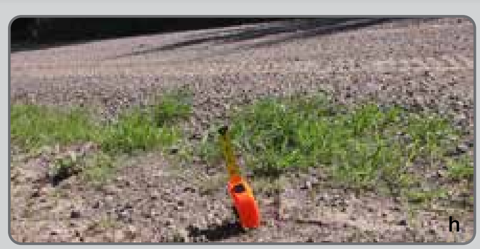


Figure 9

Tips for Assessing Drainage Adequacy

1

Orient yourself by measuring the actual ditch depth until you are comfortable estimating accurately from your vehicle

2

Note whether driveway culverts are present; if they are, then drainage is most likely good or fair

3

Be aware of tall grass hiding ditches

4

Be aware of conditions that would not warrant ditching (i.e., tops of hills) that may influence your perception of ditches

Structural Adequacy

Structural adequacy is assessed by estimating the thickness of good quality gravel (crushed and dense graded; Figure 10a). This assessment relies on local institutional knowledge and should not require involved testing or probing of existing conditions. A further gauge is that a *fair* structure would benefit from the placement of 1 to 4 inches (2.5 to 10 centimeters) of good quality gravel and a *poor* structure would benefit from the placement of 5 to 8 inches (13 to 20 centimeters). Placing this gravel would bring the road's structure to its baseline, or *good* condition.

Figure 10a: Good gravel

Structural Distresses

If gravel thickness is not known, structural adequacy assessment can then rely on the prevalence and substantiality of structural distresses that require emergency maintenance to make the road passable during either wet periods or the entire year. Structural adequacy and, consequently, the IBR number may shift if **ruts are equal to or greater than 1 inch (2.5 centimeters) in depth** and/or **potholes are equal to or greater than 3 feet (0.9 meters) in width or length** (Figure 10b). Therefore, in the absence of institutional knowledge about gravel thickness, roads with *good* structure tend to experience no ruts or potholes exceeding these baseline measurements. Roads with *fair* structure tend to experience some structural distresses exceeding the baseline measurements during wet periods whereas roads with *poor* structure tend to experience more frequent structural distresses throughout the entire year.

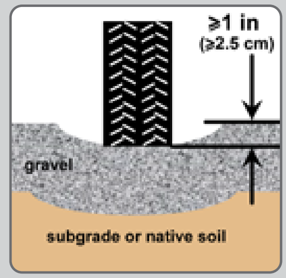
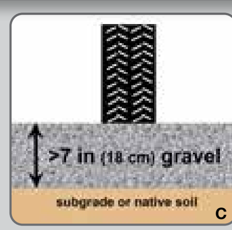


Figure 10b: Rutting on an unpaved road

Good

More than 7 inches (18 centimeters) of good gravel



Fair

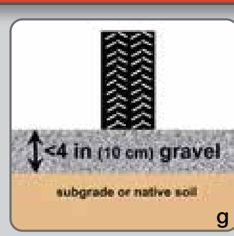
4-7 inches (10 to 18 centimeters) of good gravel

(needs placement of 1-4 inches [2.5 to 10 centimeters] to meet baseline)

Poor

Less than 4 inches (10 centimeters) of good gravel

(needs placement of 5-8 inches [13 to 20 centimeters] to meet baseline)

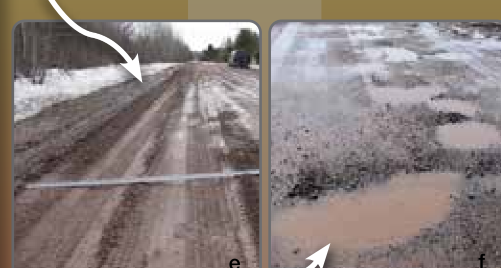


IF THICKNESS IS NOT KNOWN:

NO STRUCTURAL DISTRESSES

FAIR: SOME | DURING WET PERIODS

RUTS: Prevalent, substantial, and ≥ 1-inch deep



POTHOLES: Prevalent, substantial, and ≥ 3-feet wide

POOR: MANY | THROUGHOUT THE ENTIRE YEAR

Figure 10

Tips for Assessing Structural Adequacy

1

When rating by *Historical Measure*: If you do not know the history of a segment, ask someone who does; otherwise, rate during thaw or very wet periods and during dry periods to determine when the road is not passable and when ruts and potholes are present.

2

Look into what is causing structural problems; more gravel is not a good remedy for bad cross-slope drainage

e-

IBR System™
Rating Lookup Chart

IBR System™ evaluation places a feature on a *good-fair-poor* gradient; while *good*, *fair*, and *poor* are simple designators, they do not relate the quality of the road feature to the road's intended use but, instead, to the baseline condition of the feature itself. This evaluation is applied to three distinct unpaved road features that weight the road's overall rating by the cost to get the features to baseline, or *good*, condition.

To obtain the IBR number, each of three elements—surface width, drainage adequacy, and structural adequacy—are given an assessment of their alignment to the baseline. When these three elements all have *good* assessments, these elements function in concert to satisfy the needs of most road users in terms of, for example, passing ability, speed, and usability. Therefore, roads that have *good* baselines for all three elements may achieve an IBR number of 9 or, if the road is less than one year old, an IBR number of 10, which is the highest number. If one or all of these elements have *fair* or *poor* assessments, these elements function in concert to satisfy a smaller niche of road users' needs in terms of passing ability, speed, and usability. Thus, roads with varying baselines for all three elements achieve an IBR number of 9 or less.

Assessment combinations for all three elements create a matrix. The IBR number relates to that matrix. Higher IBR numbers correlate with *good* assessments for those elements that are more costly or intensive to enhance. Lower IBR numbers correlate with *fair* and *poor* assessments for the elements that are more costly or intensive to enhance although they may still have *good* assessments for elements that are less costly or intensive to enhance. For example, changing the surface width of a unpaved road would be many times more costly than changing the structure, which can be achieved by simply adding more gravel or grading. A road with *good* surface width, *good* drainage, and *poor* structure would have an IBR number of 7; at the same time, a road with *poor* surface width, *good* drainage, and *good* structure would only have an IBR number of 5.

Road with an IBR number of 8, having *fair* surface width, *good* drainage adequacy, and *good* structural adequacy

Road Examples of IBR Numbers

9

IBR NUMBER 9

Surface Width: Good

Drainage Adequacy: Fair

Structural Adequacy: Good

8

IBR NUMBER 8

Surface Width: Fair

Drainage Adequacy: Good

Structural Adequacy: Good

5

IBR NUMBER 5

Surface Width: Good

Drainage Adequacy: Poor

Structural Adequacy: Poor

5

IBR NUMBER 5

Surface Width: Poor

Drainage Adequacy: Good

Structural Adequacy: Good

IBR Number Look-up Chart

Surface Width	Drainage Adequacy	Structural Adequacy	IBR Number
Good	Good	Good	10*
Good	Good	Good	9
Good	Good	Fair	8
Good	Good	Poor	7
Good	Fair	Good	9
Good	Fair	Fair	8
Good	Fair	Poor	6
Good	Poor	Good	7
Good	Poor	Fair	6
Good	Poor	Poor	5
Fair	Good	Good	8
Fair	Good	Fair	7
Fair	Good	Poor	6
Fair	Fair	Good	7
Fair	Fair	Fair	6
Fair	Fair	Poor	5
Fair	Poor	Good	6
Fair	Poor	Fair	5
Fair	Poor	Poor	4
Poor	Good	Good	5
Poor	Good	Fair	4
Poor	Good	Poor	3
Poor	Fair	Good	4
Poor	Fair	Fair	3
Poor	Fair	Poor	2
Poor	Poor	Good	3
Poor	Poor	Fair	2
Poor	Poor	Poor	1

* Segment is less than one year old

Unpaved road in Gogebic County

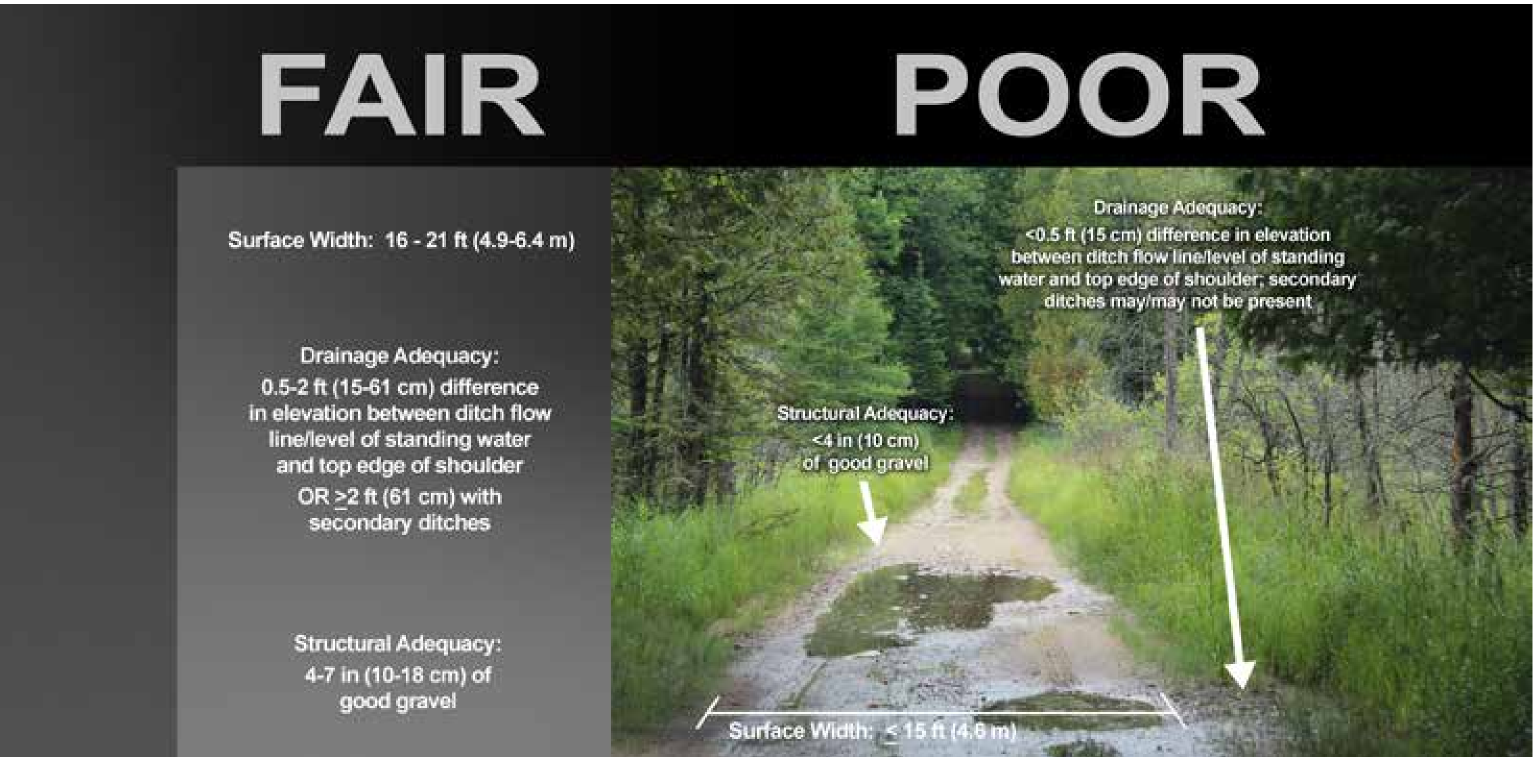
IBR System™ in Practice

Figure 11: IBR System™ elements and assessment criteria

Michigan's unpaved roads vary greatly. Therefore, a pilot study applied the IBR System™ to evaluate rating parameters and data collection feasibility for Michigan's road networks (Figure 11). The pilot study project team defined three classifications of road networks: Low Volume Terminal Branch Networks (contain many "ends" of road systems where traffic volumes are low and few properties accessed), Agricultural Grid Networks (provide year-round regular access to farm fields and residents, support higher traffic volumes and larger truck loads), and Suburban Residential Networks (provide local access to rural residential properties located near urban centers, support primarily passenger vehicle traffic).

A sampling of five counties chosen for the pilot test reflected each of the different road network classifications. Data collection events in each of the counties included collecting IBR data and rating productivity

Unpaved roads such as this one in Huron County are classified as part of an Agricultural Grid Network



measures, ascertaining gravel thickness by randomly performed measurements, and jointly collecting IBR data for unpaved roads and PASER data for paved roads. Data collection tools were Roadsoft and the Roadsoft Laptop Data Collector (Figure 12).

In general, the pilot study found that:

- Low Volume Terminal Branch Network roads exhibited narrow surface widths, minimal drainage adequacy, and minimal structural gravel leading to overall low IBR numbers (see page 32 footer image)
- Agricultural Grid Network roads typically had *good* to *fair* surface widths, *good* to *fair*

drainage adequacy, and *good* structural gravel leading to overall high or moderately high IBR numbers (see page 30-31 footer image)

- Suburban Residential Network roads had moderately low IBR numbers (see page 33 footer image)

Rating productivity ranged from 6.3 miles per hour (10.1 km/hr) for the low-IBR-number Low Volume Terminal Branch Networks, which often had lakes and streams dividing the road network and/or contained many ends of the road network, to 28.3 miles per hour (45.5 km/hr) for good Agricultural Grid Networks, which featured roads in mile-long-section-line interconnected grid patterns; the average rating productivity was 12.3 miles per hour (19.8 km/hr). From the rating productivity captured by the study, researchers estimated a statewide collection of IBR would require between 3,200 and 4,300 total hours, or an average of 39 to 52 hours per county.

Combined collection of IBR and PASER data in one county (Baraga) demonstrated a higher rate of data collection at 20.9 miles per hour (33.6 km/hr) in comparison to IBR collection only at 8.8 miles per hour (14.2 km/hr) or PASER collection only at 14.8 miles per hour (23.8 km/hr). The reason for this higher rate is a reduction in time traveled without rating. Therefore, a statewide data collection that gathers IBR and PASER data at the same time would require reduced total hours and average per-county hours.

Figure 12: Rating in action

The IBR System™ had a high degree of accuracy: 72.2 percent of "blind" ratings were exact matches with "ground truth" and 92.9 percent were within a tolerance of plus/minus one rating point. Institutional-knowledge-based assess-

Baraga County is an example of a Low Volume Terminal Branch Network.

ments of structural adequacy had a 79.6-percent match with the *good*, *fair*, and *poor* bin ranges, as established by actual measurements. These matches indicate repeatability in the use of the system.

The article *Inventory Based Rating System: A Stable and Implementable Method of Condition Assessment for Unpaved Roads*, by Tim Colling, John Kiefer, and Pete Torola, details these analyses of the IBR System™ (see https://ctt.mtu.edu/inventory-based-rating-system). This article and an original version of Figure 11 in this manual were published as part of the Transportation Review Board's 2017 compendium of conference papers and poster presentations, respectively.

Kalamazoo County has gravel roads such as this one in their Suburban Residential Network.

Glossary

Aggregate: a mixture of gravel-, sand- and fine-sized rock particles (also commonly called "gravel")

Agricultural grid network: unpaved roads that support local agricultural economy by providing regular access to farms. They experience seasonally higher volumes of traffic and larger truck loads and are generally maintained all year in order to serve both residents and agricultural industries.

Angularity: shape of an individual aggregate particle. A more angular aggregate has more fractured and jagged faces and less rounded faces.

Asset management: a process that uses data to manage and track road assets in a cost-effective manner using a combination of engineering and business principles. Public Act 325 of 2018 provides the legal definition of: "an ongoing process of maintaining, preserving, upgrading, and operating physical assets cost effectively, based on a continuous physical inventory and condition assessment and investment to achieve established performance goals".

Base: layer beneath a road surface; usually composed of large-sized aggregate and drainable

Baseline condition: condition that satisfies most road users in terms of the passing ability, speed, and usability

Capital preventive maintenance: also known as CPM, planned set of cost-effective treatments for "fair" roads that corrects pavement defects, slows further deterioration, and maintains the functional condition without increasing structural capacity

Center for Technology & Training: also known as the CTT, a center at Michigan Technological University that houses the Michigan Local Technical Assistance Program (LTAP) as well as other programs, including, Roadsoft, the Michigan Engineers' Resource Library, Bridge Load Rating, and the Great Lakes Environmen-

tal Infrastructure Program. Michigan Technological University was designated as a Rural Technical Assistance Program Technology Transfer Center on April 18, 1985. This center initially changed its name to the Michigan LTAP, but with the expansion and growth with the additional programs, the center again changed its name to the CTT to better reflect the multiple areas of service. The Michigan LTAP provides transportation-related information and training to rural and urban governmental agencies (e.g., county road commissions, cities, villages, townships, regional and metropolitan planning organizations, and law enforcement) within Michigan. Funding for the program is provided through the Michigan Department of Transportation with matching funds from Michigan Technological University, and federal funds distributed from the U.S. Department of Transportation Federal Highway Administration Center for Local Aid Support.

Cross-slope: a drainage gradient used to channel water on the road surface to a ditch

Crown: shape of a road by which the outer edges are lower than the centerline, allowing water to drain

Crust: hard, compacted layer that forms at the top of an unpaved road's surface layer

Culvert: pipe or structure used to convey ditch water under driveways or roads to convey cross-road drainage to allow traffic to pass without impedance

Condition data: quantitative numbers derived from assessment of road segments; for unpaved roads, assessments are made of IBR elements, which identify a road's alignment with a baseline condition and indicate areas where improvements or upgrades can be made as resources allow

Ditch flow line: lowest elevation in a ditch cross-section where water is concentrated

Ditch: road feature that is designed to convey water away from the road structure

Drainage Adequacy: existence and functionality of ditches or other drainage features

Drainage: conveyance of water. For roads, this may include ditches, cross-slopes, drains, culverts, and underdrains

Driveway culvert: pipe or structure used under driveways to convey ditch water across driveways to allow traffic to pass without impedance

Dust control (and stabilization): application of a chemical product or other material to an unpaved road's surface layer for the purpose of reducing dust loss and/or strengthening the road

Fair assessment: moderately below the baseline condition

Federal-aid network: portion of road network that is considered Federal-aid routes. According to Title 23 of the United States Code, Federal-aid-eligible roads are "highways on the Federal-aid highway systems and all other public roads not classified as local roads or rural minor collectors".

Fines: very small aggregate particles that help lock larger aggregate particles in place. Individual fine particles are not visible to the naked eye.

Flat crown: road shape that has the same elevation at the center and edges. Water cannot be conveyed off a roadway with a flat crown

Good assessment: at the baseline condition

Good gravel: gravel that consists of the correct amount of angularity, gradation, and moisture content for the intended use

Gradation: distribution of large- and small-sized aggregate in a sample of gravel

Grading: gravel road maintenance activity consisting of short-term, low-cost, quick-fix surface blading to slightly-longer-lasting, higher-cost reshaping of road crown

Gravel loss: displacement of aggregate into road ditches or air due to rain, traffic, wind, or snow plowing

Historical measure: using the institutional local agency knowledge of road repair history to assess the structural adequacy when thickness is not known

IBR element: feature used in the IBR System™ for assessing the condition of roads. The system has three elements: surface width, drainage adequacy, and structural adequacy.

IBR number: the 1-10 rating determined from assessments of the weighted IBR elements. The weighting relates to the intensity of the major improvement projects needed to improve or enhance the IBR element category.

Institutional knowledge: knowledge possessed by staff members of a local agency that is neither documented on paper nor stored electronically

Interlock: the orientating of aggregate particles in a way that they are not easily moved by traffic, wind, rain, and snow plowing

Inventory-based Rating System™: also known as IBR System™, a stable and implementable method of condition assessment for unpaved roads

Laptop Data Collector: also known as the LDC, a data collection utility designed specifically for field collection and data entry for Roadsoft. The LDC allows data on pavement, signs, and other asset information to be captured from the passenger seat of a vehicle.

Low-volume terminal branch network: unpaved roads that serve low traffic volumes, provide access to only a few properties, are primarily the "ends" of the road system, and are often seasonal roads. Road networks in the Upper Peninsula and northern Lower Michigan generally fall into this category.

Michigan Transportation Asset Management Council: also known as the TAMC, a council comprised of professionals from county road commissions, cities, a county commissioner, a township official, regional and metropolitan planning organizations, and state transportation department personnel. The council reports directly to the Michigan Infrastructure Council.

Network classifications: a grouping of road networks by similar function and quality. For the IBR System™ pilot study, three network classifications were defined: Low Volume Terminal Branch Networks, Agricultural Grid Networks, and Suburban Residential Networks.

Network-level metric: analyzing a road network by a specific network-wide feature of the roads in the network

Non-Federal-aid network: a portion of a road network that is made up of non-Federal-aid routes (see Federal-aid network)

Parabolic crown: a road crown that has become rounded in shape

Pavement Surface Evaluation and Rating system: also known as the PASER system, the PASER system,

developed by the University of Wisconsin Transportation Information Center, is a visual survey rating system that provides a simple, efficient, and consistent method for evaluating the condition of paved roads

Poor assessment: significantly below the baseline condition

Pothole: a defect in a road that is a localized depression, which causes vehicles to jolt down and up when a tire passes over it

Preventive maintenance: are “planned strategy[ies] of cost-effective treatments to an existing roadway system and its appurtenances that preserve assets by retarding deterioration and maintaining functional condition without significantly increasing structural capacity” [Public Act 51 of 1951, 247.660c Definitions]

Proactive preventive maintenance: also known as PPM, a method of performing CPM treatments very early in a pavement’s life, often, before it exhibits signs of pavement defects

Project-level metric: analyzing a road segment or project by a specific feature of the particular road

Public Act 325: Michigan public act of 2018 that modified PA 51 of 1951 in regards to asset management in Michigan, specifically 1) re-designating the TAMC under Michigan Infrastructure Council (MIC); 2) promoting and overseeing the implementation of recommendations from the regional infrastructure asset management pilot program; 3) requiring local road three-year asset management plans beginning October 1, 2020; 4) adding asset classes that impact system performance, safety or risk management, including culverts and signals; 5) allowing MDOT to withhold funds if no asset management plan submitted; and 6) prohibiting shifting funds from a county primary to a county local, or from a city major to a city minor if no progress toward achieving the condition goals described in its asset plan.

Public Act 499: Michigan public act of 2002 that modified PA 51 of 1951 in regards to asset management in Michigan. The act defined asset management, established the TAMC, and was superseded by PA 325 of 2018.

Public Act 51: Michigan public act of 1951 that served as the foundation for establishing a road funding structure by creating transportation funding distribution method and means. It has been amended many times.

Rating productivity: number of miles of roadway ratings collected compared to total vehicle miles driven

Road: the area consisting of the roadway (i.e., the traveled way or the portion of the road on which vehicles are intended to drive), shoulders, ditches, and areas of the right of way containing signage

Road layer: one of the material layers composing a road; for unpaved roads, layers commonly include the surface, the sub-base (optional layer composed of smaller-sized, permeable aggregate and typically constructed thicker than base or surface layers), and the sub-grade

Roadsoft: roadway asset management system for collecting, storing, and analyzing data associated with transportation infrastructure. Built on an optimum combination of database engine and GIS mapping tools, Roadsoft provides a quick, smooth user experience and almost unlimited data handling capabilities.

Roadway: the area consisting of the traveled way (portion of the road on which vehicles are intended to drive) exclusive of shoulder and areas of the right of way containing signage

Rural area: an area that is less populated. For the IBR System™ pilot study, this was defined as a county with less than 100,000 people.

Rutting: permanent depression in a roadway surface concentrated under wheel paths that run parallel to traffic on the roadway

Saturated gravel: gravel layers that remain intermittently or permanently saturated by sub-surface water

Scheduled maintenance: low-cost, day-to-day activities applied to roads to prevent water or debris intrusion for paved roads or that involve surface blading or dust control application for unpaved roads

Secondary ditch: also known as a high shoulder, a condition of gravel cast off from unpaved roads forming into berms that prevent water from leaving a road's traveled way

Service life: the time from when a road or treatment is first constructed to when it reaches a point where the distresses present change from age-related to structural related (also known as the critical distress point)

Shape: lines and grades of the top surface of a roadway driving surface, shoulders, ditches, and/or slopes

Shoulder: outside edges of a roadway's driving surface that is not used for typical driving but can be. Shoulders are used for safety (pulling over and not driving into ditch) and mobility (area of refuge when passing

oncoming traffic), and are often made of a lesser thickness then the road itself.

Slope: percent or ratio of vertical change to horizontal change between two points on a straight line. Road surface slopes are expressed as percentages (e.g., 4%) and ditch slopes are expressed as ratios (e.g., 1V:4H)

Structural Adequacy: ability of the primary surface to support design loads; this is a function of the type and thickness of material used to construct the roads and the vehicles that use the road

Subgrade: also considered native soil, the lowest layer of the road

Suburban residential network: unpaved roads that enable year-round local access to rural residential properties located near urban centers. These roads serve predominantly passenger vehicle traffic. Road networks near urban centers and typically located in the population belt between Grand Rapids and Detroit may fall into this category.

Surface condition: roadway element that comprises of lines and grades of the driving surface and any distresses that may be present

Surface distress: defect on the driving surface of the road

Surface width: travel lane width and the shoulder width

Traffic volume: number of vehicles using a road over a specific length of time, often measured as average daily traffic (ADT; amount of cars that pass a road point in a 24-hour period with data collected over a less-than-one-year time period) or annual average daily traffic (AADT; amount of cars that pass a road point in a 24-hour period with data collected over a one-year time period and divided by number of days per year)

Underdrain: underground pipes that convey water away that has entered the roadway structure

Unpaved road: Road with a gravel or earthen surface instead of a stabilized surface like asphalt or concrete

Urban area: an area that is more populated. For the IBR System™ pilot study, this was defined as a county with more than 100,000 people.

Washboard: ripples that are on the roadway surface and perpendicular to the direction of travel

Resources

Inventory-based Rating System™

- https://ctt.mtu.edu/inventory-based-rating-system

Inventory-based Rating System™ Asset Management Training Resources

- http://ctt.mtu.edu/asset-management-resources

TAMC Data Collection Manual

- http://ctt.mtu.edu/sites/default/files/resources/paser/tamc-data-collection-manual.pdf

Michigan LTAP Motor Grader Manual

- https://michiganltap.org/sites/ltap/files/publications/technical/motor-grader-manual.pdf

Gravel Roads Construction & Maintenance Guide

- https://www.fhwa.dot.gov/construction/pubs/ots15002.pdf

At the Crossroads

- https://www.pavementpreservation.org/wp-content/uploads/2011/12/crossroads.pdf

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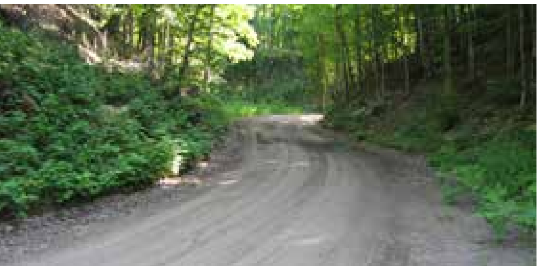
About the Center for Technology & Training

Michigan Technological University was designated as the site of the Rural Technical Assistance Program Technology Transfer Center on April 18, 1985. Now called the Local Technical Assistance Program (LTAP), the Michigan LTAP resides in the University's Center for Technology & Training (CTT). The Michigan LTAP provides transportation-related information and training to rural and urban governmental agencies (e.g., county road agencies, cities, villages, townships, regional and metropolitan planning organizations, and law enforcement) within Michigan. Funding for the program is provided through a combination of funds administered by the Michigan Department of Transportation (MDOT), matching funds from Michigan Technological University, and federal funds distributed from the Federal Highway Administration (FHWA) Center for Local Aid Support in Washington, D.C.

The CTT, which is part of the University's Civil and Environmental Engineering department, focuses its efforts specifically on projects that relate to local government agencies and transportation. As such, the CTT also houses other programs and projects that are funded by MDOT, the FHWA, and public agencies. These programs and projects include Roadsoft, Michigan Engineer's Resource Library (MERL), the Michigan Transportation Asset Management Council's asset management training program, the Bridge Load Rating Program, and other research and development projects. In addition, the CTT is home of the Great Lakes Environmental Infrastructure Center (GLEIC), which is the Environmental Protection Agency's Region 5 environmental finance center.



Center for Technology & Training

TAMC Michigan Transportation Asset Management Council