RESEARCH & DEVELOPMENT

# Identifying Bridges Critical to North Carolina Agriculture and Commerce

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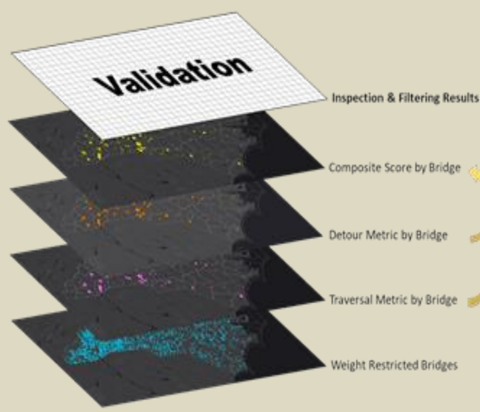


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16. Abstract

Current legislation in North Carolina restricts the use of State bridge funds to Functionally Obsolete or Structurally Deficient bridges. Meanwhile, weight-restricted bridges (only allowed to transport vehicles or trucks of limited weights) do not meet the requirements for being categorized as Functionally Obsolete or Structurally Deficient. Additionally, North Carolina funding targeted for improving weight and clearance restrictions is currently limited to higher traffic volume routes. This combination of occurrences makes it possible for bridges restrictive to heavy loads to fail to qualify for State bridge improvement programs and funding targeted for improving weight and clearance restrictions. As a result, bridges that are critical nodes in North Carolina's agricultural freight network are unable to receive dedicated sources of funding for improvements or long-term viability.

North Carolina has almost 3,000 bridges classified as weight restricted spread across the state, some of which could have significant economic value if improved. Bridges heavily traversed for agricultural and commerce purposes that do not have many convenient alternative routes that would make the bridge redundant are considered to be important bridges. However, if the bridge has a weight restriction, agricultural and commerce freight vehicles may be forced to take longer alternative routes, costing farms and businesses potential significant time costs.

The final, ranked list of weight restricted bridges was developed through a Geographic Information System (GIS) process that expressed bridge criticality as a score derived from a comprehensive and systematic travel model to consider the frequency of demand across weight-restricted bridges (traversals) and the necessary detour to avoid the weight-restricted bridge. This process offers a system-wide, objective evaluation of weight-restricted bridges. Based on the funding availability to improve or replace the bridges with the highest composite scores, a validation of the scores should be considered based on local input and confirmation of the importance of the bridge for local, impacted businesses.


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# Executive Summary

Current legislation in North Carolina restricts the use of State bridge funds to Functionally Obsolete or Structurally Deficient bridges. Meanwhile, weight-restricted bridges (only allowed to transport vehicles or trucks of limited weights) do not meet the requirements for being categorized as Functionally Obsolete or Structurally Deficient. Additionally, North Carolina funding targeted for improving weight and clearance restrictions is currently limited to higher traffic volume routes. This combination of occurrences makes it possible for bridges restrictive to heavy loads to fail to qualify for State bridge improvement programs and funding targeted for improving weight and clearance restrictions. As a result, bridges that are critical nodes in North Carolina's agricultural freight network are unable to receive dedicated sources of funding for improvements or long-term viability.

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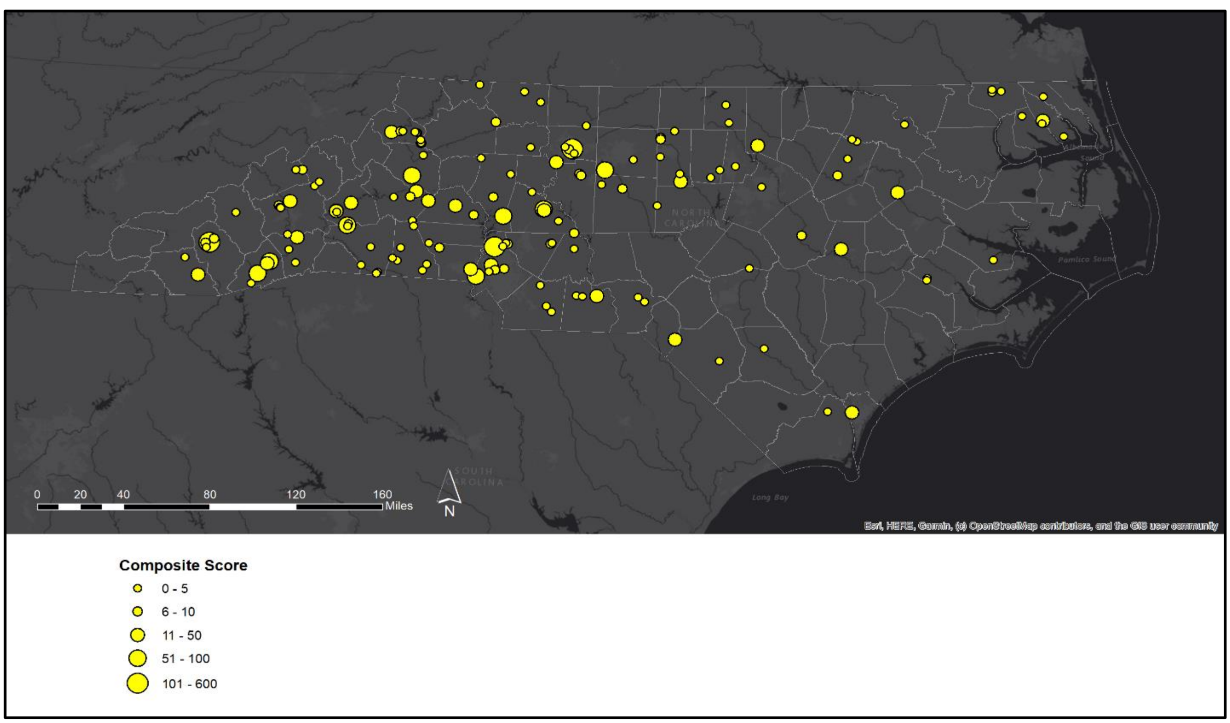
The prioritized set of weight restricted bridges (shown below) was developed through a Geographic Information System (GIS) process that expressed bridge criticality as a score derived from a comprehensive and systematic travel model to consider the frequency of demand across weight-restricted bridges (traversals) and the necessary detour to avoid the weight-restricted bridge. This process offers a system-wide, objective evaluation of weight-restricted bridges. Based on the funding availability to improve or replace the bridges with the highest composite scores, a validation of the scores should be considered based on local input and confirmation of the importance of the bridge for local, impacted businesses.



# Table of Contents

## Introduction

Current legislation in North Carolina restricts the use of State bridge funds to Functionally Obsolete or Structurally Deficient bridges. Meanwhile, weight-restricted bridges (only allowed to transport vehicles or trucks of limited weights) do not meet the requirements for being categorized as Functionally Obsolete or Structurally Deficient. Additionally, North Carolina funding targeted for improving weight and clearance restrictions is currently limited to higher traffic volume routes. This combination of occurrences makes it possible for bridges restrictive to heavy loads to fail to qualify for State bridge improvement programs and funding targeted for improving weight and clearance restrictions. As a result, bridges that are critical nodes in North Carolina's agricultural freight network are unable to receive dedicated sources of funding for improvements or long-term viability.

In 2014, the North Carolina Department of Agriculture provided NCDOT with a tiered list and corresponding map of bridges that were critical to the agricultural industry. NCDOT has used this list to identify bridges that are an impediment to agriculture but do not qualify for other programs because they are not Structurally Deficient or Functionally Obsolete, nor do they reside along a high traffic volume route. The purpose of this project was to create a methodology to update the tiered list of bridges vital to North Carolina's agricultural industry and more generally, commerce. The project team created a methodology that targeted weight restricted bridges that pose the greatest impediment to agriculture and commerce.

North Carolina has almost 3,000 bridges classified as weight restricted spread across the state, some of which could have significant economic value if improved. Bridges heavily traversed for agricultural and commerce purposes that do not have many convenient alternative routes that would make the bridge redundant are considered to be important bridges. However, if the bridge has a weight restriction, agricultural and commerce freight vehicles may be forced to take longer alternative routes, costing farms and businesses significant time costs.

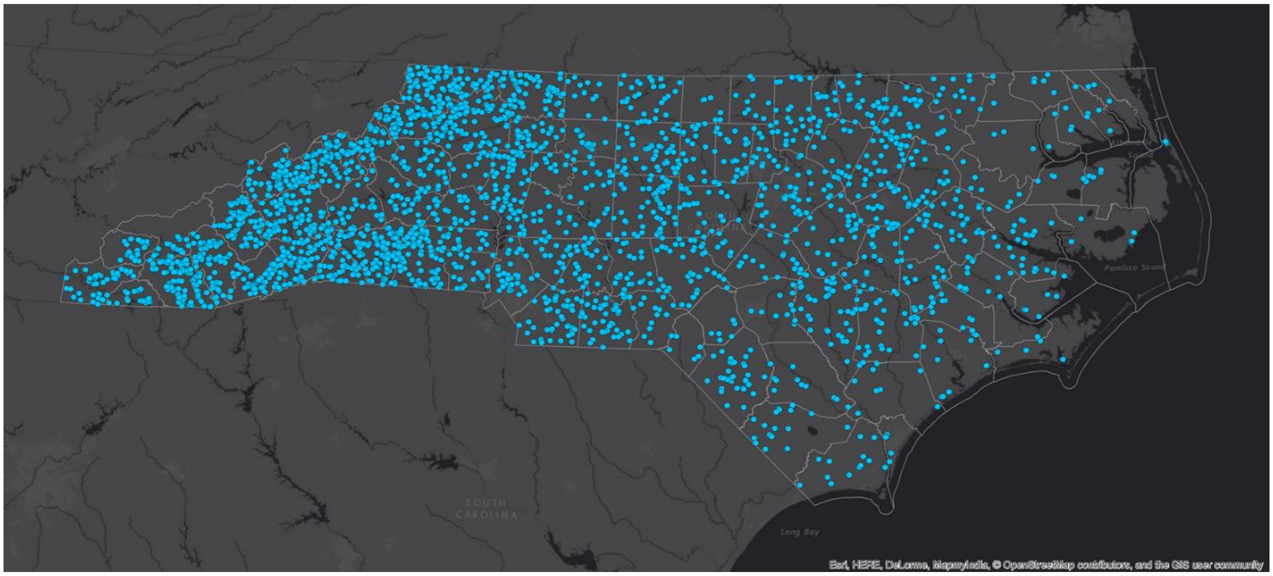



*Figure 1. NCDOT Weight Restricted Bridges (2,879 Bridges)*

# Background and Literature Review

The NCDOT is responsible for the maintenance of 13,500 bridges in North Carolina (NCDOT 2020). These bridges make up part of North Carolina's infrastructure system that supports the movement of goods and people. Of the 13,500 bridges in North Carolina, roughly 14% are considered structurally deficient with a cost of $3.8 billion needed to repair them to standard. In addition to the structurally deficient bridges, over 2,800 bridges are posted with weight restrictions. Bridges with posted weight restrictions can create vulnerabilities, bottlenecks, or suboptimal inefficiencies in the freight transportation system, preventing industries from being as competitive as they could be at a national or global level. Many of these posted bridges are not considered structurally deficient or functionally obsolete and are likely not located on heavy passenger vehicle traffic routes. This combination of occurrences makes it possible for bridges restrictive to heavy loads to fail to qualify for State bridge improvement programs. As a result, bridges vital to some businesses have the possibility of only receiving limited, ad-hoc funding.

Several previous studies informed the methodology development of this paper. Particular focus was given to studies that focused on various prioritization schemes for bridges. Zhang and Alipour (2020) developed a process for prioritizing bridge replacements based on the benefits from accelerated bridge construction. Their process includes a determination of a bridge's criticality and an optimization of the appropriate accelerated bridge construction techniques that could be applied to the bridge. The various construction techniques were evaluated based on the construction costs and impacts on travelers during a bridge's closure period. Liu and Frangopol (2005) developed a procedure to prioritize the maintenance of reinforced concrete bridge crossheads. Bocchini and Frangopol (2012) evaluated resiliency and cost to prioritize bridge improvements in response to disruptive events. Whelan et al. (2019) developed two indices considering various performance measures to prioritize bridge replacement projects.

This research project compliments the existing literature in bridge improvement prioritization by focusing on a subset of bridge types, weight-restricted bridges, and their potential to reduce industry transportation costs. Specific evaluation metrics in this research concentrate on the potential for heavy traffic, spurred by local businesses, to traverse each weight-restricted bridge and the resulting travel time savings relative to the available network.

## Methodology

To determine the importance of a bridge, two different factors were considered: 1) the use of the bridge for agricultural and commerce purposes and 2) the circuity costs of having to take an alternative route if the bridge did not exist. These two factors work in tandem. For example, a bridge heavily used by agricultural and commerce freight but having a detour route that only adds a short distance to the trip, or a bridge having a detour route that adds over ten miles to the travel distance but not used by any agricultural or commerce freight would not be considered important bridges. To be considered an important bridge, the bridge must be used by agricultural and/or commerce freight and have a significant detour penalty if the bridge did not exist. To capture both factors, the research team developed a multi-step methodology shown in Figure 2. The approach builds upon business and bridge data to develop an overall composite score for each bridge.

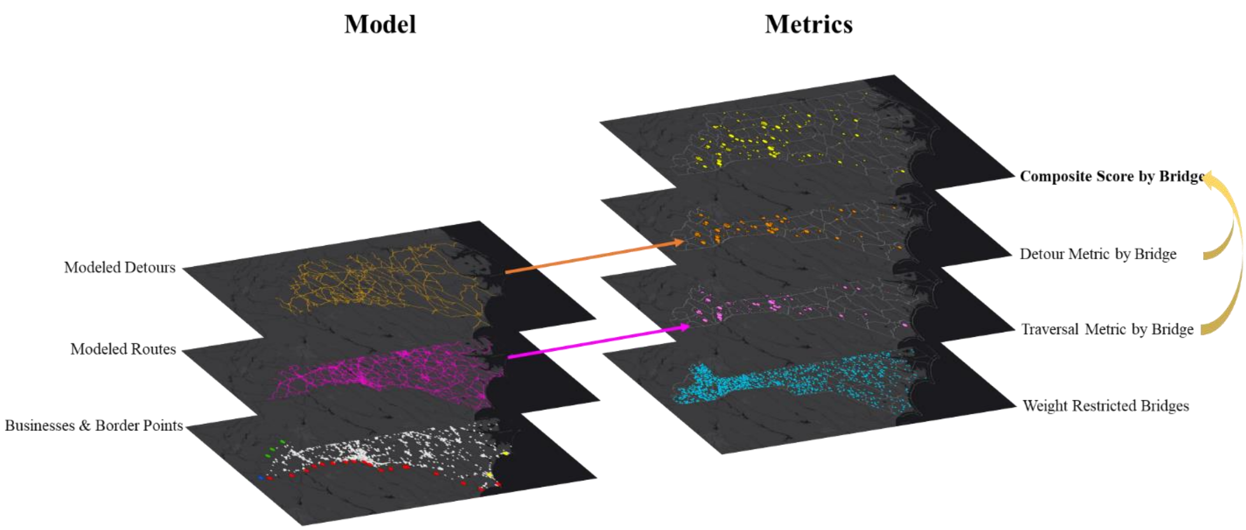



*Figure 2. Analysis Methodology*

### GIS Process

This study used a Geographic Information Systems (GIS)-based approach to model agriculture- and commerce-related truck demand throughout North Carolina and evaluate the criticality of existing weight-restricted bridges to those routes. Weight-restricted bridge criticality is evaluated with a combination of two metrics: (i) a weighted *traversal* value, calculated from the count of crossings for a given weight-restricted bridge, and (ii), a weighted *detour* value, calculated from the time required to circumvent a given weight-restricted bridge. The overall workflow is summarized in Figure 3. These multiple perspectives of criticality account for the variable density of trucking-dependent businesses and weight-restricted bridges throughout the state. Weighting for both metrics is a function of the trucking intensity (which is a function of the business size and trucking demand) of the modeled routes and the distance of a given weight-restricted bridge from route origins, as discussed below. A final "composite score" was created from the sum of weighted traversal and weighted detour values and was used to rank weight-restricted bridges by criticality.

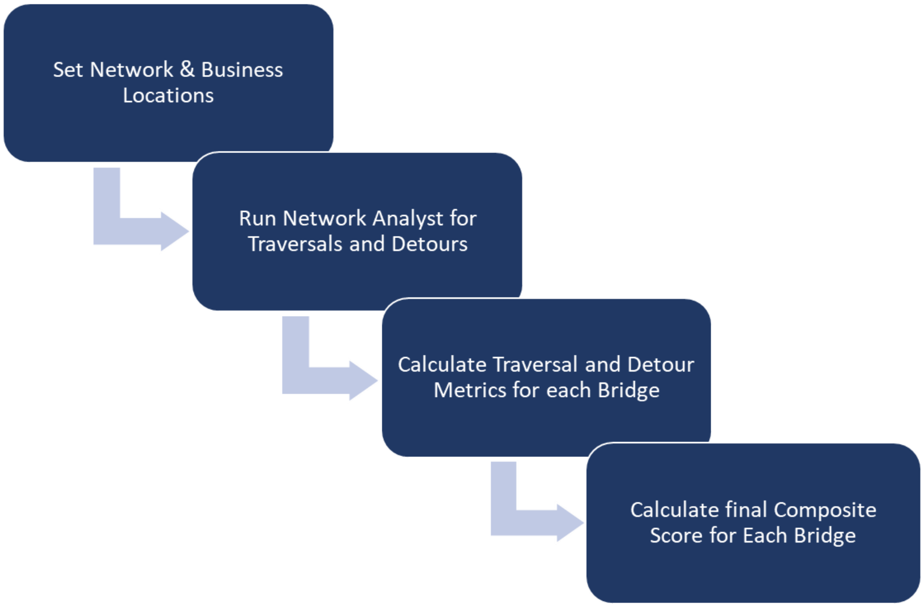



*Figure 3. Analysis Workflow for Developing Composite Score for Bridge*

An important methodological consideration for the design of the travel model used in this study is that the specific trucking routes used by trucking-dependent businesses across weight-restricted bridges is unknown. This is because large trucks should be avoiding these bridges, depending on their specific load and the given limit for the bridge. The model applied in this study accounts for this unknown by systematically modeling routes from trucking-dependent businesses in multiple directions, generating one route for each trucking-dependent business for each direction (see "Trucking Intensity of Businesses" below for the approach used to determine truck-dependency). Trucking-dependent businesses are treated as route origins, and a destination in each direction is automatically selected from a set of points where major road network segments intersect the state border (referred to here as *border points*). In this study, we use four sets of border points that correspond to the northern, eastern, southern, and western borders of the state (see Figure 4). Traversal and detour scores for bridges reflect the aggregation of modeled routes for all directions.

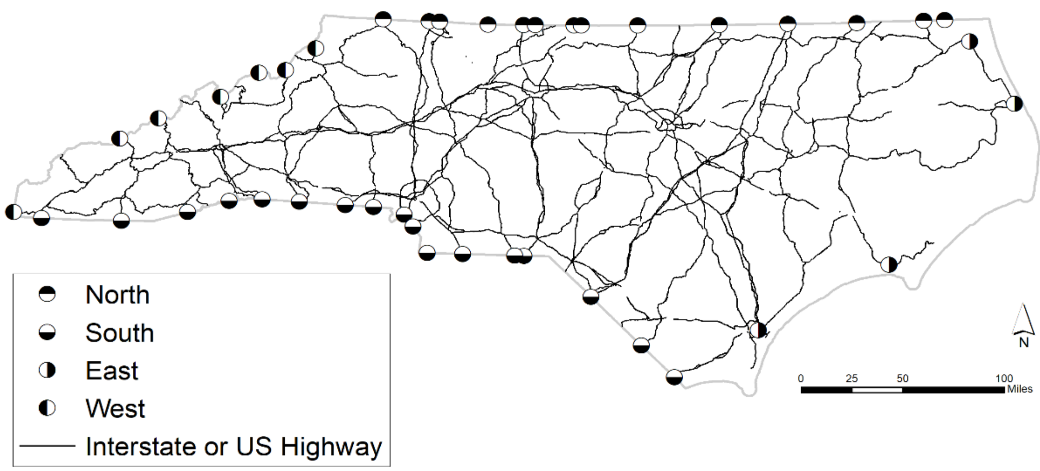



*Figure 4: Locations of Border Points*

**Trucking Intensity of Businesses**

A measure of the intensity of trucking activity associated with business locations was used to weight modeled routes and narrow the universe of businesses included in the study. To determine trucking intensity, the project team analyzed industry linkages within the Impact Analysis for Planning (IMPLAN) economic input-output platform for North Carolina. IMPLAN contains interindustry linkages for 546 industrial sectors within North Carolina. The project team evaluated how each of these industrial sectors rely on sector 417, Truck Transportation, as a factor of production. To understand the magnitude of trucking dependency, the research team evaluated the use and make tables of the Social Accounting Matrices (SAMs) within IMPLAN. These tables provide the input commodities and goods and services by industry required to produce an industry's output. Thus, industries that had higher trucking dependence had higher use table values for 417, Truck Transportation. The research team then used a North American Industry Classification System (NAICS) and IMPLAN crosswalk to bridge the 546 IMPLAN sectors to NAICS designations. Next, the research team used this information to assess trucking dependence for business establishments in North Carolina.

The research team used ArcGIS Business Analyst, which contains a database of over 13 million U.S. businesses by NAICS designation, to locate businesses by NAICS within the state. Using business establishments within the database and use table values extracted from IMPLAN’s social accounting matrices, the research team conducted its assignment of trucking dependency. Businesses with a trucking intensity of at least 1.0 were defined as “trucking-dependent” (n=5400) and included in the study. The calculated trucking intensity of each trucking-dependent business was used to weight its associated routes. The location of all businesses in North Carolina, along with the business sector and the number of jobs at the business were obtained using ArcGIS Business Analyst. The research team augmented the Business Analyst dataset with business location and employment data for the meatpacking sector developed by the North Carolina Department of Agriculture and Consumer Services. Trucking intensity was calculated using the same methodology for businesses with available employment information in this ancillary meatpacking dataset. The estimated trucking intensity for each business was calculated for each business as the product of the number of jobs and the trucking/freight intensity of the business sector (obtained from IMPLAN Sector Analysis) for each business.

**Network Dataset**

The travel model used to generate scores for weight-restricted bridges employed a statewide road network model to perform network analysis and generate routes for trucking-dependent businesses. The network model is composed of road segment features and a set of rules stored as an ArcGIS Network Dataset. The speed limit of each network segment was used to calculate a traversal time for each network segment, which serves as a cost attribute when calculating routes. In the interest of modelling truck navigation on the network realistically, the network dataset includes a connectivity policy, route hierarchy, and route type preference. The connectivity policy ensures access to limited-access network segments is only permitted at ramps and highway endpoints. The hierarchy constraint requires continuous travel on primary routes (defined as Interstate, US, and NC highways) once they are reached, thereby reducing shortcuts on secondary routes. The route-type preference is used to further encourage travel on primary routes rather than on secondary routes.

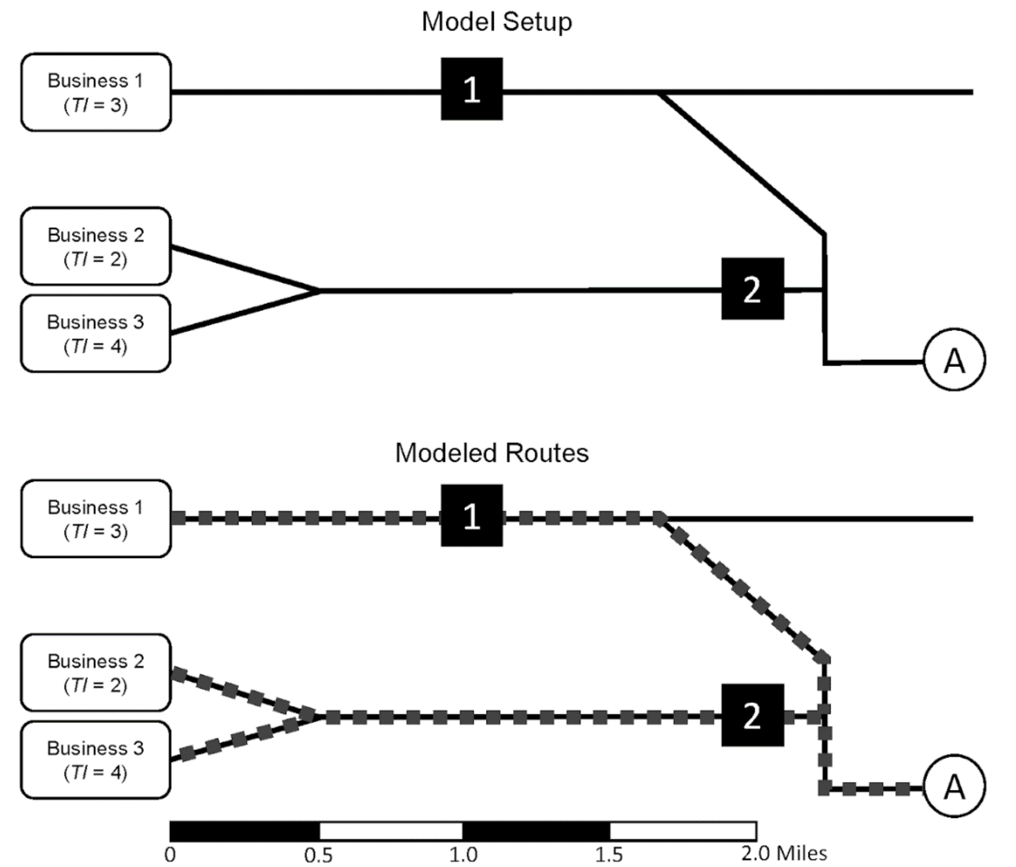
**Travel Model**

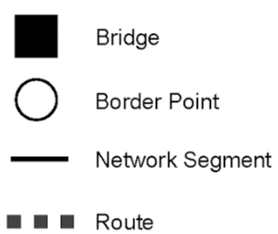
Truck routes are modeled in a two-step process using ArcGIS Network Analyst and the Closest Facility Tool. The Closest Facility Tool facilitates automatic destination selection and permits preservation of the “true shape” of routes, which is necessary for spatially joining route characteristics to bridges. The same Network Dataset was used to model routes in both steps.

In the first step, the Closest Facility Tool was run once for each set of border points, generating four unique routes for each trucking-dependent business. In each of the four runs, trucking-dependent businesses were loaded into the tool as "Incidents," and a set of border points corresponding to the direction of analysis were loaded as "Facilities." The specific border point to which a trucking-dependent business was routed was automatically chosen by the tool to provide the least-time route. After routes were generated, route features were spatially joined with weight-restricted bridges to yield a set of traversed bridges. Each traversal was weighted by the trucking intensity of the route and the inverse of the Euclidean distance from the weight-restricted bridge to the trucking-dependent business generating the route. The resulting weighted traversal values were summed by weight-restricted bridges for all routes and all directions to produce the weighted traversal score.

In the second step, the Closest Facility Tool was run again for trucking-dependent businesses that generated routes with weight-restricted bridge traversals in the previous step. The Closest Facility Tool was run individually for each trucking-dependent business, with the business loaded as an "Incident," the border points for the recorded direction of the traversal loaded as "Facilities," and the traversed weight-restricted bridge loaded as a "Barrier." When the tool was rerun, routes were not permitted to traverse Barriers. The route generated is therefore the next-shortest route from the trucking-dependent business to a border point in a given direction that does not include the weight-restricted bridge traversal found in the previous step. The difference in the route time calculated for the trucking-dependent businesses in this step, and the previous step is stored as the detour value for each pair of weight-restricted bridges and traversed bridges. Detour values were weighted in the same way as traversals, with the inverse of the Euclidean distance from the weight-restricted bridge to the trucking-dependent business generating the route. The resulting weighted detour values were summed by weight-restricted bridges for all routes and all directions to produce the weighted traversal score. The process is summarized in Figure 5. The composite score of bridge criticality was calculated as a simple sum of the total weighted traversal value and the total weighted detour value for each bridge. The final, ranked list of weight restricted bridges should be visually inspected against aerial imagery and further vetted by local experts to confirm the results of the travel model.

The stakeholder feedback process described below produced a list of 30 additional weight-restricted bridges that were not included in initial set of bridges scored automatically in the GIS process described above. The research team analyzed each of these additional bridges for likely traversals by agricultural and business users, for whether or not those users were included in the trucking-dependent set employed in the study, and for the availability of acceptable detours (defined as fewer than five minutes). From the list of 30 bridges, 11 were selected for inclusion in the final scored set of bridges based on this analysis. These additional bridges share a common feature of apparent importance to agricultural uses not recorded in the final trucking-dependent businesses dataset employed in the travel model. The research team manually applied the travel model to these bridges by measuring the approximate agricultural acreage (measured to the nearest 250 acres) affected by the bridge and applying an agricultural land trucking intensity to enable manual scoring. The results presented here include the manually-derived scores for those bridges.




Calculation of Results

| | Modeled Traversals | Weighted Modeled Traversals |
|---|---|---|
| Bridge 1 | 1 | $\frac{3\ TI}{1\ \text{mi}} = 3$ |
| Bridge 2 | 2 | $\frac{2\ TI}{2\ \text{mi}} + \frac{4\ TI}{2\ \text{mi}} = 3$ |

*Figure 5. Illustration of weighted traversal value calculation. "TI" refers to trucking intensity.*

## Results

The GIS process expresses bridge criticality as a score derived from a comprehensive and systematic travel model. As noted in this report, the model results should be analyzed alongside local stakeholder expertise. This section reports the results of both the model and local office comments and presents an analysis of these results as they pertain to prioritizing bridge replacement.

### Model Results

A total of 158 weight-restricted bridges received at least one traversal in the travel model and therefore have composite scores greater than zero. The 158 bridges with modeled traversals represent 5.5% of the 2,879 weight restricted bridges in the study. The final sorted results (see Appendix A Table A1) show a relatively large range in composite score values, with a median value of 2.89 and a maximum value of 538.46. The large range in scoring is not surprising given the high variation in underlying bridge, roadway network, local economic, and business characteristics. The research team classified the final list of 158 bridges with modeled traversals into three replacement priority levels, with the highest-scoring 20% of bridges designated as high priority, the next-highest scoring 30% of bridges designated as medium priority, and the lowest-scoring 50% of bridges designated as low priority. These classifications are summarized in Table 2 and mapped in Figure 6 (by priority and replacement status) and Figure 7 (by composite score excluding replaced or planned for replacement). Table 1 lists the 28 high priority bridges based on the modeled composite scores (excluding bridges that have been replaced or have replacement plans).

Following the review of the State Transportation Improvement Program (STIP) and comments from NCDOT Divisions and Cooperative Extension Offices, the research team identified 31 bridges from the final list of 158 scored bridges that have already been replaced (including those with improvements currently under construction) or that are planned to be replaced in the next ten years. These bridges represent 19.6% of scored bridges (Table 1).

Final composite scores for all bridges are a sum of weighted traversal values and weighted detour values. The relationship between these values for scored bridges (Figure 8) indicates correlation but not collinearity. The traversal count plays a significant role in driving both weighted traversal values and weighted detour values because every traversal also generates a detour. However, the additional weighting variables (detour time, trucking intensity, and business-to-bridge distance) contribute unique information to the detour score, as is indicated by the non-collinearity of these variables. The model therefore appears to effectively incorporate the dual factors of use and circuity in its measurement of bridge criticality.

The final scoring and priority classifications derived from the GIS travel model can be interpreted as a measure of probability that a bridge is critical to agriculture and commerce based on the assumptions in the model. Given that the model's set of traversed bridges is a small fraction of the full set of bridges in the study, gathering local expert comment for all bridges with modeled traversals is a practicable task. Local expert feedback provides a second perspective on bridge prioritization that can validate the GIS model and provide a more complete picture of the potential impacts of the bridge.

*Table 1. High Priority Bridges (Excluding those with Replacement Plans)*

| Bridge Number | Feature Crossing | Route | County | NCDOT Division | Modeled Composite Score |
|---|---|---|---|---|---|
| 330386 | Fifth Street | Vine Street | Forsyth | 9 | 158.4 |
| 590109 | Torrence Creek | SR2138 | Mecklenburg | 10 | 115.9 |
| 130353 | Lower Creek | Complex Rd | Caldwell | 11 | 86.7 |
| 870207 | Lamb Creek | SR1592 | Transylvania | 14 | 79.0 |
| 800252 | Greasy Creek | SR1001 | Rutherford | 13 | 70.5 |
| 480473 | Southern R.R. | SR2398 | Iredell | 12 | 64.3 |
| 870222 | Morgan Mill Creek | SR1388 | Transylvania | 14 | 61.1 |
| 400289 | Branch of Richland Creek | SR1300 | Guilford | 7 | 57.1 |
| 790393 | Norfolk Southern Rr. | North Ellis St | Rowan | 9 | 54.3 |
| 590441 | CSX Rr | Hovis Rd | Mecklenburg | 10 | 45.4 |
| 030288 | Flat Fork Creek | SR1650 | Anson | 10 | 42.6 |
| 440237 | Southern Railroad | SR1545 | Henderson | 14 | 33.5 |
| 550193 | Cullasaja River | SR1677 | Macon | 14 | 32.2 |
| 580025 | Catawba Rvr & Private Rd | SR1221 | McDowell | 13 | 29.8 |
| 380002 | Ledge Creek | NC56 | Granville | 5 | 25.9 |
| 640036 | Abandoned Rr | Front St | New Hanover | 3 | 25.3 |
| 100224 | Reems Creek | SR1003 | Buncombe | 13 | 18.5 |
| 000114 | South Fork Cane Creek | SR1003 | Alamance | 7 | 18.2 |
| 870102 | Kings Creek | Railroad Ave | Transylvania | 14 | 16.0 |
| 110302 | Southern Railway | SR1628 | Burke | 13 | 15.1 |
| 690026 | Canal | SR 1144 | Pasquotank | 1 | 14.0 |
| 820025 | Shoe Heel Creek | SR1369 | Scotland | 8 | 13.8 |
| 350007 | Ut To S Fork Catawba Rivr | SR2014 | Gaston | 12 | 13.5 |
| 170086 | McLin Creek | SR1739 | Catawba | 12 | 13.0 |
| 580269 | Mill Creek | SR1103 | McDowell | 13 | 12.7 |
| 790138 | Norfolk Southern Rr. | East Fisher St | Rowan | 9 | 12.6 |
| 580268 | Mill Creek | SR1103 | McDowell | 13 | 12.1 |
| 950039 | Little River Overflow | NC581 | Wayne | 4 | 11.3 |

*Table 2. Bridge Priority Classification based on Modeled Composite Score*

| Modeled Priority | Total Bridges | Replacement Planned | Replaced or In Progress of Replacement | Total Bridges without Planned or Executed Replacement |
|---|---|---|---|---|
| Low (50%) | 79 | 11 | 5 | 63 |
| Medium (30%) | 47 | 5 | 6 | 36 |
| High (20%) | 32 | 4 | 0 | 28 |
| *Total* | 158 | *20* | *11* | *127* |

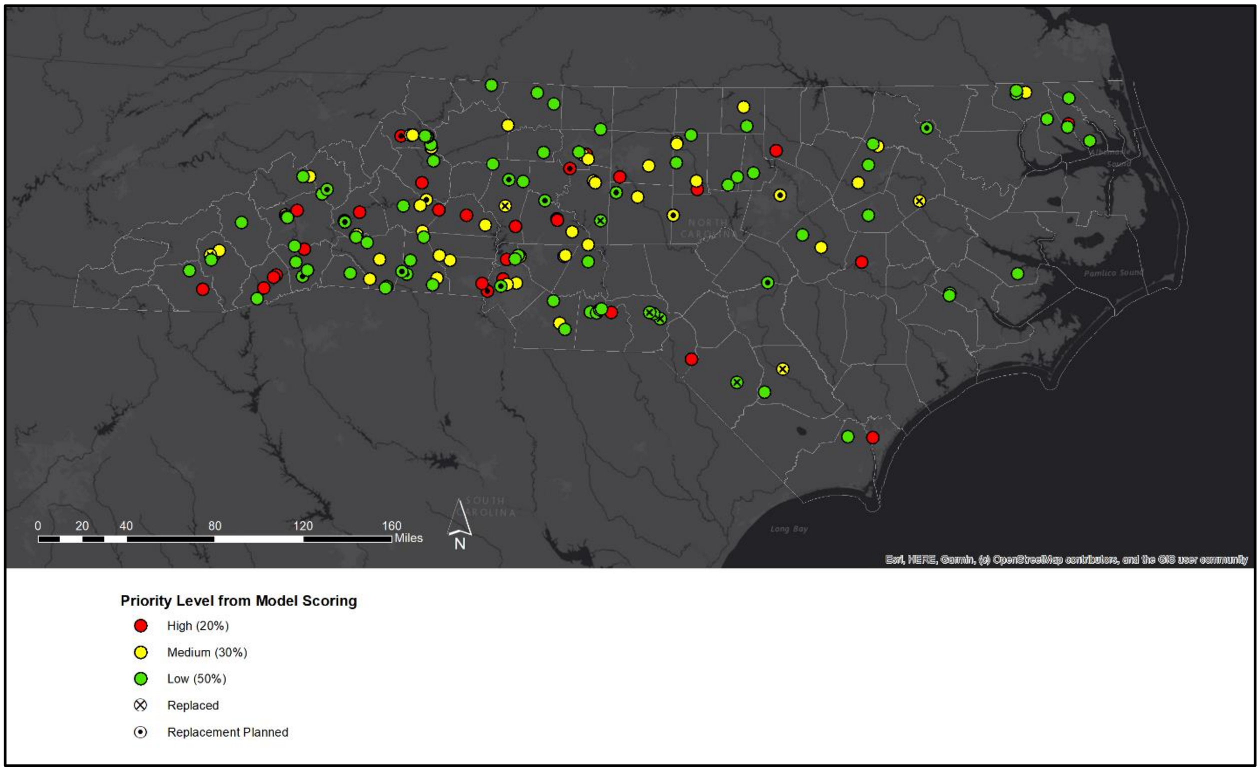



*Figure 6. Map of Scored Bridges with Model-Based Priority Classification*

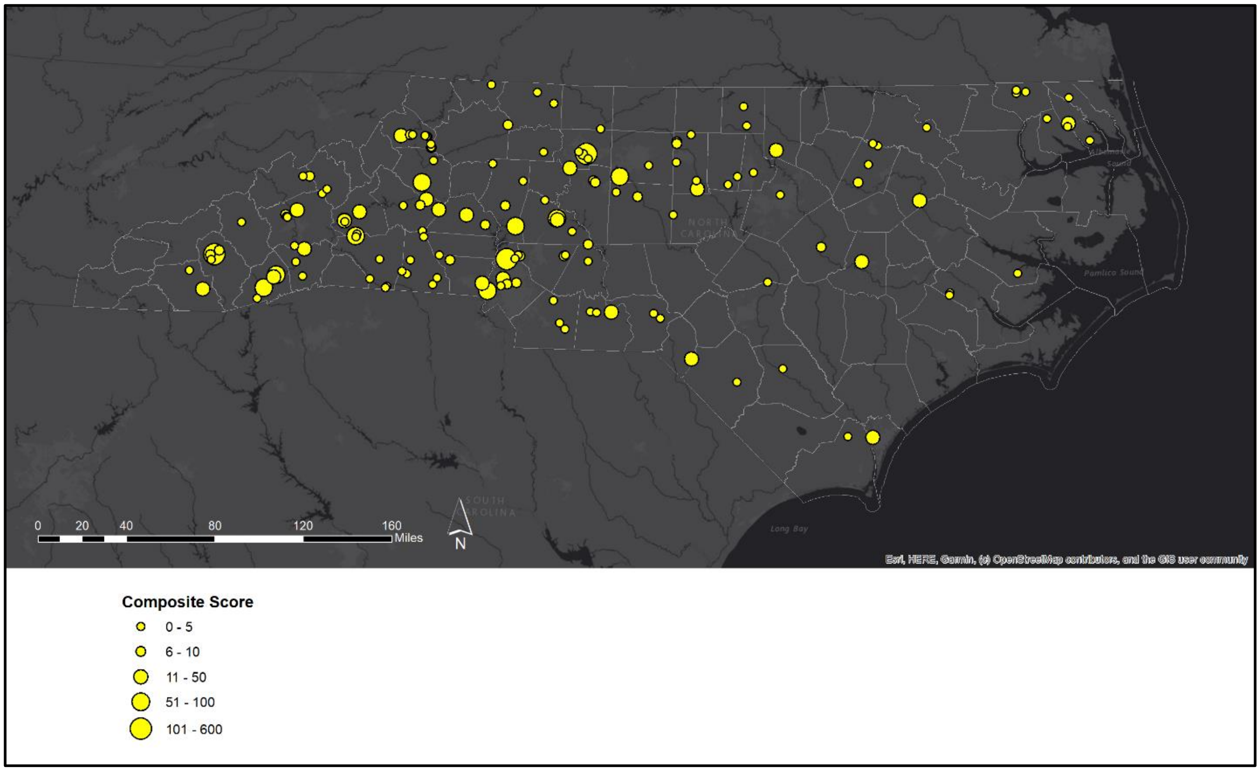



*Figure 7. Composite Score for Scored Bridges*

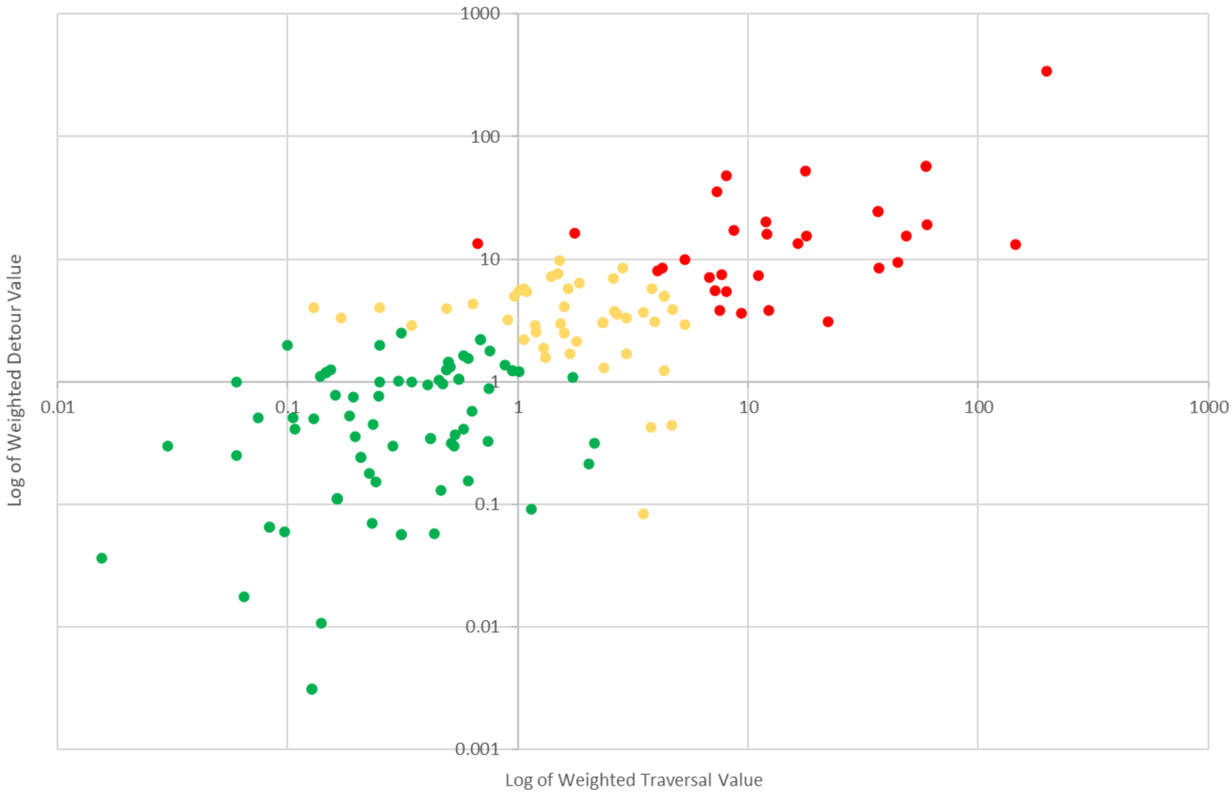



*Figure 8. Relationship of Weighted Traversal and Weighted Detour Values among Scored Bridges.*

## Stakeholder Feedback

The research team solicited feedback from NCDOT Division bridge professionals and local Cooperative Extension offices to comment on known bridge replacement projects, to assign replacement priority classifications (low, medium, and high) to any of the 158 traversed weight-restricted bridges within their districts, and to identify any additional critical weight-restricted bridges in their area not represented in the final model results. Modeled bridge scores and classifications designated by the research team were not disclosed to respondents. Of the 158 weight restricted bridges with modeled traversals, 55 bridges not yet replaced or planned for replacement received prioritization assignments from local comments (see Table 3). Results of the comments from the local stakeholders are mapped in Figure 9.

*Table 3. Bridge Priority Classification Based on Stakeholder Feedback*

| Priority Level from Stakeholder | Total Bridges | Average Modeled Traversals | Average Composite Score |
|---|---|---|---|
| Low | 17 | 3.2 | 10.7 |
| Medium | 6 | 8.5 | 16.4 |
| High | 32 | 3.7 | 6.1 |
| *Total* | *55* | *4.1* | *8.6* |

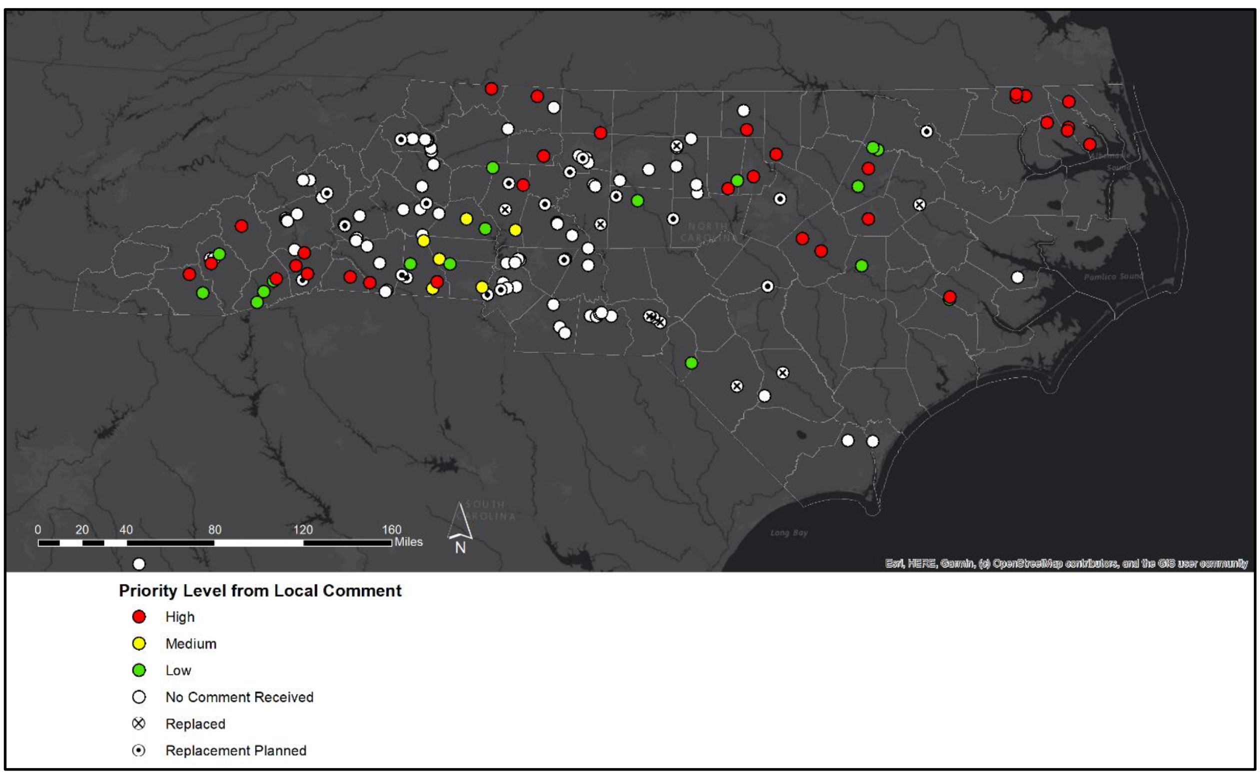



*Figure 9. Map of Scored Bridges with Comment-Based Priority Classification*

Priority levels assigned from these comments gravitate to the high and low extremes, with few bridges assigned a priority level of medium. The average number of modeled traversals for bridges assigned a priority level of medium or high by a local comment is higher on average than bridges assigned a priority level of low. The average composite score for bridges assigned a priority level of medium or high is not higher on average than bridges assigned a priority level of low. This difference between priority levels from comments and priority levels from the classified model results shows the importance of a multi-perspective approach to criticality. In these cases, local stakeholders may have special knowledge or experience that is not considered by the travel model. Conversely, the travel model may incorporate systematic weighting that is not accounted for by the local comments.

## Recommendations

The final, ranked list of weight restricted bridges was developed through a GIS process that expressed bridge criticality as a score derived from a comprehensive and systematic travel model to consider the frequency of demand across weight-restricted bridges (traversals) and the necessary detour to avoid the weight-restricted bridge. This process offers a system-wide, objective evaluation of weight-restricted bridges. The recommended methodology developed in this study is summarized in Figure 12. An important final step, similar to soliciting stakeholder feedback in this study, is the validation process. Based on the funding availability to improve or replace the bridges with the highest composite scores, a validation of the scores should be considered based on local input and confirmation of the importance of the bridge for local, impacted businesses. For instance, the current posted weight restriction should be considered based on this stakeholder input. If a posted weight limit is above the weight of heavy vehicles generated by the proximate businesses and no desire for carrying heavier loads exists, the bridge may not be a prime candidate for improvement funds. Additionally, visual inspections of each bridge should be performed to assess the potential for inaccuracies in the travel model or business information (e.g., incorrect business address, driveway connections on a different, adjacent roadway, and others).

Future research efforts could involve updates to the travel modeling and business input data. Specifically, some heavy vehicle generating land uses (such as agricultural activities located separately from the farm headquarters) may not be present in traditional business listing databases. More thorough information about truck traffic generation would improve this method's ability to adequately prioritize bridges.

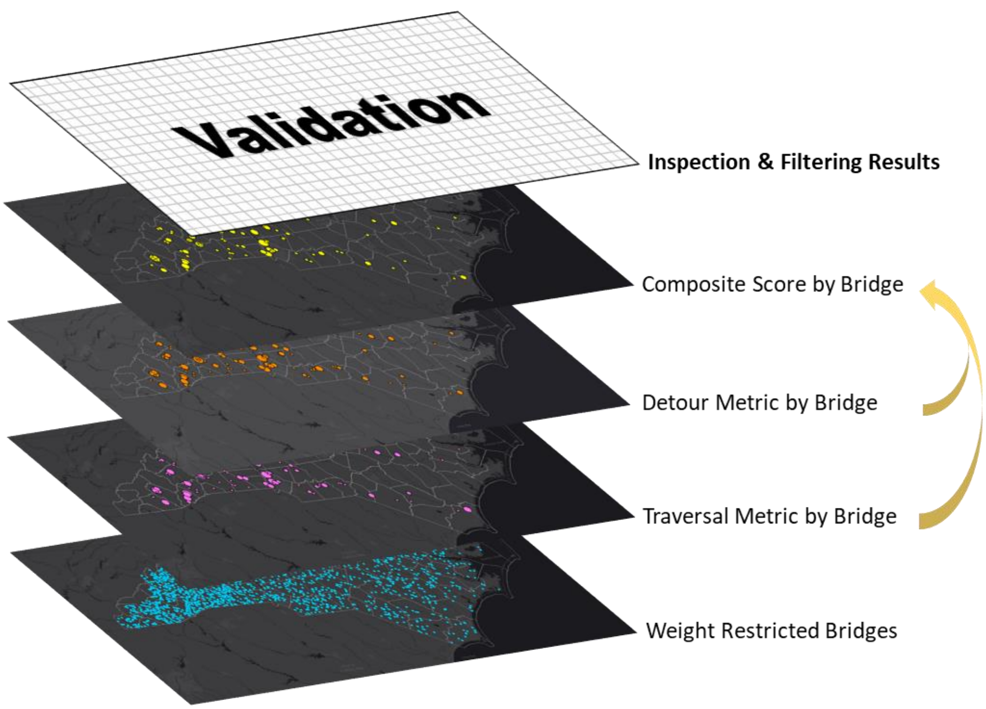



Figure 12. Recommended Methodology for Scoring Weight-Restricted Bridges

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# Appendix A – Full Model Results

*Table A1. Final Model Results Sorted by Modeled Composite Score*

| Bridge | Feature Crossing | Route | County | Div. | Struc. Def. | Func. Obs. | Posted SV Weight | Posted TTS Weight | Weighted Trav | Weighted Det* | Comp Score | Score Rank | Priority Class from Model | Repl. Status | Manual Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 490077 | Scott Creek | US23BUS. | Jackson | 14 | N | FO | 24 | 32 | 198.4 | 340.0 | 538.5 | **1** | High | Planned | |
| 330386 | Fifth Street | Vine St | Forsyth | 9 | N | FO | 30 | 30 | 145.3 | 13.1 | 158.4 | **2** | High | | |
| 590109 | Torrence Creek | SR2138 | Mecklenburg | 10 | N | FO | 38 | 99 | 59.1 | 56.9 | 115.9 | **3** | High | | |
| 130353 | Lower Creek | Complex Rd | Caldwell | 11 | N | N | 39 | 42 | 86.7 | None Found | 86.7 | **4** | High | | |
| 870207 | Lamb Creek | SR1592 | Transylvania | 14 | N | FO | 24 | 32 | 59.8 | 19.2 | 79.0 | **5** | High | | |
| 800252 | Greasy Creek | SR1001 | Rutherford | 13 | N | FO | 21 | 28 | 17.7 | 52.8 | 70.5 | **6** | High | | |
| 480473 | Southern R.R. | SR2398 | Iredell | 12 | N | FO | 22 | 31 | 48.8 | 15.5 | 64.3 | **7** | High | | |
| 870222 | Morgan Mill Creek | SR1388 | Transylvania | 14 | N | N | 20 | 28 | 36.5 | 24.5 | 61.1 | **8** | High | | |
| 400289 | Branch Of Richland Creek | SR1300 | Guilford | 7 | N | N | 20 | 28 | 57.1 | None Found | 57.1 | **9** | High | | |
| 350022 | Duke Power Feeder | NC273 | Gaston | 12 | N | FO | 26 | 39 | 8.0 | 48.1 | 56.1 | **10** | High | Planned | |
| 790393 | Norfolk Southern Rr. | North Ellis St | Rowan | 9 | SD | FO | 5 | 0 | 44.9 | 9.4 | 54.3 | **11** | High | | |
| 590441 | Csx Rr | Hovis Rd | Mecklenburg | 10 | N | FO | 34 | 37 | 36.9 | 8.5 | 45.4 | **12** | High | | |
| 030288 | Flat Fork Creek | SR1650 | Anson | 10 | SD | FO | 19 | 28 | 7.3 | 35.3 | 42.6 | **13** | High | | |
| 440237 | Southern Railroad | SR1545 | Henderson | 14 | N | FO | 31 | 36 | 18.0 | 15.5 | 33.5 | **14** | High | | |
| 550193 | Cullasaja River | SR1677 | Macon | 14 | N | N | 34 | 40 | 11.9 | 20.3 | 32.2 | **15** | High | | |
| 580025 | Catawba Rvr & Private Rd | SR1221 | McDowell | 13 | N | FO | 31 | 35 | 16.4 | 13.3 | 29.8 | **16** | High | | |
| 330109 | Southern Railroad | SR2999 | Forsyth | 9 | N | FO | 20 | 27 | 12.0 | 15.9 | 27.9 | **17** | High | Planned | |
| 380002 | Ledge Creek | NC56 | Granville | 5 | N | FO | 38 | 38 | 8.6 | 17.3 | 25.9 | **18** | High | | |
| 640036 | Abandoned Rr | Front St | New Hanover | 3 | N | FO | 34 | 34 | 22.2 | 3.1 | 25.3 | **19** | High | | |
| 100224 | Reems Creek | SR1003 | Buncombe | 13 | N | FO | 32 | 35 | 11.1 | 7.4 | 18.5 | **20** | High | | |
| 000114 | South Fork Cane Creek | SR1003 | Alamance | 7 | N | N | 39 | 43 | 1.8 | 16.4 | 18.2 | **21** | High | | |
| 870102 | Kings Creek | Railroad Ave | Transylvania | 14 | SD | FO | 10 | 14 | 12.3 | 3.8 | 16.0 | **22** | High | | |
| 940005 | Watauga River | NC105 | Watauga | 11 | SD | N | 30 | 30 | 5.3 | 9.9 | 15.2 | **23** | High | Planned | |
| 110302 | Southern Railway | SR1628 | Burke | 13 | N | FO | 23 | 31 | 7.7 | 7.4 | 15.1 | **24** | High | | |
| 690026 | Canal | SR 1144 | Pasquotank | 1 | N | N | 38 | 44 | 0.7 | 13.3 | 14.0 | **25** | High | | Y |
| 820025 | Shoe Heel Creek | SR1369 | Scotland | 8 | N | N | 38 | 99 | 6.8 | 7.0 | 13.8 | **26** | High | | |
| 350007 | Ut To S Fork Catawba Rivr | SR2014 | Gaston | 12 | N | FO | 32 | 37 | 8.0 | 5.4 | 13.5 | **27** | High | | |
| 170086 | Mclin Creek | SR1739 | Catawba | 12 | N | N | 34 | 38 | 9.4 | 3.6 | 13.0 | **28** | High | | |
| 580269 | Mill Creek | SR1103 | McDowell | 13 | N | FO | 39 | 39 | 4.2 | 8.5 | 12.7 | **29** | High | | |
| 790138 | Norfolk Southern Rr. | East Fisher St | Rowan | 9 | SD | FO | 10 | 13 | 7.2 | 5.5 | 12.6 | **30** | High | | |
| 580268 | Mill Creek | SR1103 | McDowell | 13 | N | FO | 39 | 99 | 4.0 | 8.1 | 12.1 | **31** | High | | |
| 950039 | Little River Overflow | NC581 | Wayne | 4 | N | FO | 39 | 99 | 7.5 | 3.8 | 11.3 | **32** | High | | |
| 110010 | Rhodhiss Lake | SR1001 | Burke | 13 | SD | FO | 16 | 19 | 2.9 | 8.4 | 11.2 | **33** | Medium | Planned | |
| 320028 | Tar River | NC42 | Edgecombe | 4 | N | N | 29 | 29 | 1.5 | 9.7 | 11.2 | **34** | Medium | Repl./Active | |
| 490317 | Scott Creek | SR1432 | Jackson | 14 | N | N | 25 | 37 | 3.8 | 5.8 | 9.6 | **35** | Medium | | |

| Bridge | Feature Crossing | Route | County | Div. | Struc. Def. | Func. Obs. | Posted SV Weight | Posted TTS Weight | Weighted Trav | Weighted Det* | Comp Score | Score Rank | Priority Class from Model | Repl. Status | Manual Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 630090 | Henry Branch | SR1919 | Nash | 4 | N | N | 20 | 29 | 2.6 | 7.0 | 9.5 | **36** | Medium | | |
| 000119 | Haw River | NC87 | Alamance | 7 | SD | FO | 22 | 26 | 4.3 | 5.0 | 9.3 | **37** | Medium | Repl./Active | |
| 000126 | Mill Race | NC87 | Alamance | 7 | N | FO | 39 | 44 | 4.3 | 4.9 | 9.3 | **38** | Medium | Repl./Active | |
| 280099 | Brushy Fork Creek | SR1810 | Davidson | 9 | SD | N | 19 | 24 | 1.5 | 7.6 | 9.1 | **39** | Medium | | |
| 110304 | Southern Rr | SR1730 | Burke | 13 | N | FO | 24 | 30 | 9.1 | -4.5 | 9.1 | **40** | Medium | | |
| 590239 | A,C & Western Railroad | SR2975 | Mecklenburg | 10 | N | N | 31 | 35 | 1.4 | 7.2 | 8.6 | **41** | Medium | | |
| 000112 | Reedy Fork Creek | NC87 | Alamance | 7 | SD | FO | 31 | 35 | 4.7 | 3.9 | 8.6 | **42** | Medium | | |
| 280100 | Abbotts Creek | SR1810 | Davidson | 9 | SD | FO | 19 | 25 | 1.9 | 6.4 | 8.3 | **43** | Medium | | |
| 330296 | Norfolk S. Railroad | West First St | Forsyth | 9 | SD | FO | 17 | 22 | 5.3 | 2.9 | 8.3 | **44** | Medium | Planned | |
| 790108 | Riles Crk Royals Crk | SR1004 | Rowan | 9 | SD | N | 24 | 29 | 1.7 | 5.8 | 7.4 | **45** | Medium | | |
| 490027 | Scott Cr.,Sou.Rr | US23 BUS. | Jackson | 14 | SD | FO | 30 | 31 | 3.5 | 3.7 | 7.2 | **46** | Medium | Repl./Active | |
| 590386 | Pedestrian Footpath | Tuckaseegee Rd | Mecklenburg | 10 | N | N | 32 | 36 | 3.9 | 3.1 | 7.0 | **47** | Medium | | |
| 120103 | Dutch Buffalo Creek | NC49 | Cabarrus | 10 | SD | FO | 24 | 30 | 1.1 | 5.7 | 6.8 | **48** | Medium | Planned | |
| 990269 | Bald Creek | SR1421 | Yancey | 13 | N | FO | 22 | 30 | 1.0 | 5.5 | 6.5 | **49** | Medium | | |
| 590096 | Ramah Creek | SR2426 | Mecklenburg | 10 | N | FO | 39 | 43 | 1.1 | 5.4 | 6.5 | **50** | Medium | | |
| 500105 | I95 | SR1007 | Johnston | 4 | N | FO | 39 | 42 | 2.6 | 3.8 | 6.4 | **51** | Medium | | |
| 750230 | I73, Us220 | SR1952 | Randolph | 8 | N | FO | 39 | 42 | 3.0 | 3.3 | 6.3 | **52** | Medium | | |
| 350116 | Beaverdam Creek | SR1627 | Gaston | 12 | SD | FO | 6 | 0 | 2.7 | 3.5 | 6.2 | **53** | Medium | | |
| 960389 | Elk Creek | SR1162 | Wilkes | 11 | SD | N | 24 | 31 | 1.0 | 4.9 | 5.9 | **54** | Medium | | |
| 100017 | Newfound Creek | SR1607 | Buncombe | 13 | N | N | 33 | 37 | 1.6 | 4.1 | 5.7 | **55** | Medium | | |
| 940098 | Hodges Creek | SR1547 | Watauga | 11 | N | N | 25 | 33 | 4.3 | 1.2 | 5.5 | **56** | Medium | | |
| 960239 | Elkin Creek | SR2044 | Wilkes | 11 | SD | N | 18 | 22 | 2.3 | 3.0 | 5.4 | **57** | Medium | | |
| 480038 | Third Creek | US21 | Iredell | 12 | SD | FO | 24 | 28 | 5.1 | -3.2 | 5.1 | **58** | Medium | Repl./Active | |
| 170158 | N. Fork Mountain Creek | SR1817 | Catawba | 12 | N | FO | 25 | 38 | 4.7 | 0.4 | 5.1 | **59** | Medium | | |
| 800563 | Cathey'S Creek | SR1510 | Rutherford | 13 | N | FO | 23 | 27 | 0.6 | 4.3 | 4.9 | **60** | Medium | | |
| 350092 | Ut To Mill Creek | NC274 | Gaston | 12 | N | N | 26 | 31 | 2.9 | 1.7 | 4.6 | **61** | Medium | | |
| 410003 | Little Fishing Creek | SR1343 | Halifax | 4 | N | N | 35 | 44 | 1.5 | 3.0 | 4.5 | **62** | Medium | | |
| 960620 | Elk Creek | SR1166 | Wilkes | 11 | N | N | 38 | 42 | 0.5 | 4.0 | 4.5 | **63** | Medium | | |
| 740087 | Broad River | SR1004 | Polk | 14 | N | N | 30 | 30 | 0.3 | 4.0 | 4.3 | **64** | Medium | | Y |
| 910494 | Crabtree Creek | SR1670 | Wake | 5 | N | N | 41 | 41 | 3.8 | 0.4 | 4.2 | **65** | Medium | Planned | |
| 360022 | Middle Swamp | SR 1312 | Gates | 1 | N | N | 32 | 37 | 0.1 | 4.0 | 4.1 | **66** | Medium | | Y |
| 940173 | Winkler Creek | State Farm Rd | Watauga | 11 | N | FO | 21 | 28 | 1.6 | 2.5 | 4.1 | **67** | Medium | | |
| 110305 | Camp Creek | SR1924 | Burke | 13 | N | FO | 37 | 99 | 0.9 | 3.2 | 4.1 | **68** | Medium | | |
| 120118 | Little Buffalo Creek | NC49 | Cabarrus | 10 | N | FO | 40 | 43 | 1.2 | 2.9 | 4.1 | **69** | Medium | | |
| 080011 | Ellis Creek | NC53 | Bladen | 6 | N | FO | 38 | 99 | 1.8 | 2.1 | 3.9 | **70** | Medium | Repl./Active | |
| 000098 | Mary'S Creek | SR1003 | Alamance | 7 | N | N | 38 | 44 | 1.2 | 2.6 | 3.8 | **71** | Medium | | |
| 890066 | Branch Of Meadow Creek | SR1002 | Union | 10 | N | FO | 26 | 38 | 2.4 | 1.3 | 3.6 | **72** | Medium | | |
| 330134 | Wssb Railroad | Sprague St | Forsyth | 9 | N | FO | 16 | 22 | 3.5 | 0.1 | 3.6 | **73** | Medium | | |
| 220040 | Potts Creek | SR 1001 | Cleveland | 12 | SD | FO | 15 | 21 | 0.2 | 3.3 | 3.5 | **74** | Medium | | Y |
| 400238 | Little Alamance Creek | SR1005 | Guilford | 7 | SD | FO | 41 | 44 | 1.7 | 1.7 | 3.4 | **75** | Medium | | |
| 580247 | Frasheur Creek | SR1140 | McDowell | 13 | N | FO | 16 | 23 | 1.1 | 2.2 | 3.3 | **76** | Medium | | |
| 790141 | High Rock Lake | SR1004 | Rowan | 9 | SD | FO | 22 | 22 | 0.3 | 2.9 | 3.2 | **77** | Medium | | |
| 180252 | Blood Run Creek | SR1127 | Chatham | 8 | N | FO | 20 | 25 | 1.3 | 1.9 | 3.2 | **78** | Medium | Planned | |
| 720184 | Marlowe'S Creek | SR1532 | Person | 5 | N | FO | 34 | 39 | 1.3 | 1.6 | 2.9 | **79** | Medium | | |

| Bridge | Feature Crossing | Route | County | Div. | Struc. Def. | Func. Obs. | Posted SV Weight | Posted TTS Weight | Weighted Trav | Weighted Det* | Comp Score | Score Rank | Priority Class from Model | Repl. Status | Manual Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 840176 | Lick Creek | SR1926 | Stokes | 9 | SD | N | 35 | 38 | 0.7 | 2.2 | 2.9 | **80** | Low | | |
| 590097 | Ramah Creek | SR2425 | Mecklenburg | 10 | N | N | 20 | 26 | 2.9 | -0.4 | 2.9 | **81** | Low | | |
| 940210 | Elk Creek | SR1508 | Watauga | 11 | N | N | 38 | 38 | 0.3 | 2.5 | 2.8 | **82** | Low | | |
| 140014 | Dismal Swamp Canal | US17B | Camden | 1 | N | FO | 25 | 38 | 1.7 | 1.1 | 2.8 | **83** | Low | | |
| 760057 | Hitchcock Creek | SR1487 | Richmond | 8 | SD | N | 15 | 20 | 0.8 | 1.8 | 2.5 | **84** | Low | Repl./Active | |
| 110084 | Silver Creek | US70 | Burke | 13 | N | N | 39 | 43 | 2.2 | 0.3 | 2.5 | **85** | Low | | |
| 480338 | Kinder Creek | SR 2139 | Iredell | 12 | SD | FO | 10 | 15 | 0.3 | 2.0 | 2.3 | **86** | Low | | Y |
| 060048 | South Creek | NC33 | Beaufort | 2 | N | N | 35 | 43 | 0.9 | 1.4 | 2.2 | **87** | Low | | |
| 310044 | Nc55 | Pettigrew St | Durham | 5 | N | FO | 39 | 99 | 2.0 | 0.2 | 2.2 | **88** | Low | | |
| 410093 | Conoconnara Swamp | NC561 | Halifax | 4 | SD | N | 30 | 30 | 0.6 | 1.6 | 2.2 | **89** | Low | Planned | |
| 870139 | Taxaway Creek | SR1139 | Transylvania | 14 | SD | FO | 14 | 18 | 1.0 | 1.2 | 2.2 | **90** | Low | | |
| 250060 | Lower Little River | US401 | Cumberland | 6 | SD | FO | 41 | 41 | 0.9 | 1.2 | 2.2 | **91** | Low | Planned | |
| 030084 | Lanes Creek | NC742 | Anson | 10 | SD | N | 34 | 38 | 2.2 | -0.3 | 2.2 | **92** | Low | | |
| 100016 | Dix Creek | SR1607 | Buncombe | 13 | N | FO | 20 | 24 | 0.6 | 1.6 | 2.2 | **93** | Low | | |
| 710029 | Perquimans River | SR 1200 | Perquimans | 1 | SD | N | 7 | 0 | 0.1 | 2.0 | 2.1 | **94** | Low | | Y |
| 000173 | Back Creek | SR1149 | Alamance | 7 | SD | FO | 26 | 99 | 0.5 | 1.4 | 1.9 | **95** | Low | | |
| 800254 | Cove Creek | SR1328 | Rutherford | 13 | N | FO | 38 | 41 | 1.9 | -1.0 | 1.9 | **96** | Low | | |
| 220039 | Knob Creek | NC10 | Cleveland | 12 | N | FO | 12 | 15 | 0.5 | 1.3 | 1.8 | **97** | Low | | |
| 100648 | Ut To Dix Creek | SR1002 | Buncombe | 13 | SD | N | 16 | 24 | 0.5 | 1.3 | 1.7 | **98** | Low | | |
| 830167 | Town Creek | SR1421 | Stanly | 10 | SD | FO | 12 | 17 | 1.6 | -1.5 | 1.6 | **99** | Low | | |
| 590443 | Southern Railroad | Morris Field Dr | Mecklenburg | 10 | N | FO | 23 | 27 | 0.7 | 0.9 | 1.6 | **100** | Low | Planned | |
| 590090 | S.Prong Of Clark'S Creek | SR2442 | Mecklenburg | 10 | SD | FO | 25 | 38 | 0.6 | 1.0 | 1.6 | **101** | Low | | |
| 750054 | Creek | SR1557 | Randolph | 8 | SD | FO | 14 | 18 | 1.6 | -0.2 | 1.6 | **102** | Low | Planned | |
| 020021 | Little River | NC18 | Alleghany | 11 | SD | FO | 32 | 36 | 0.5 | 1.0 | 1.5 | **103** | Low | | |
| 670086 | University Lake | SR1005 | Orange | 7 | SD | FO | 35 | 40 | 0.5 | 1.0 | 1.4 | **104** | Low | | |
| 940205 | Elk Creek | SR1508 | Watauga | 11 | N | N | 31 | 35 | 0.2 | 1.2 | 1.4 | **105** | Low | | |
| 220070 | Beasons Creek | SR2238 | Cleveland | 12 | N | FO | 38 | 41 | 0.4 | 0.9 | 1.3 | **106** | Low | | |
| 850113 | Flat Shoal Creek | SR1827 | Surry | 11 | N | FO | 18 | 24 | 0.3 | 1.0 | 1.3 | **107** | Low | | |
| 940204 | Elk Creek | SR1508 | Watauga | 11 | N | N | 41 | 44 | 0.1 | 1.2 | 1.3 | **108** | Low | | |
| 480510 | Dishman Creek | SR1599 | Iredell | 12 | SD | FO | 22 | 28 | 1.3 | -0.7 | 1.3 | **109** | Low | | |
| 790061 | Fourth Creek | NC801 | Rowan | 9 | SD | FO | 40 | 43 | 0.3 | 1.0 | 1.3 | **110** | Low | Planned | |
| 940153 | Elk Creek | SR1508 | Watauga | 11 | N | N | 27 | 32 | 0.1 | 1.1 | 1.3 | **111** | Low | | |
| 690005 | Chapel Creek | SR 1103 | Pasquotank | 1 | SD | FO | 18 | 26 | 0.3 | 1.0 | 1.3 | **112** | Low | | Y |
| 670334 | Dry Creek | Perry Creek Dr | Orange | 7 | SD | N | 10 | 14 | 1.1 | 0.1 | 1.2 | **113** | Low | | |
| 240103 | Core Creek | SR1001 | Craven | 2 | N | N | 38 | 99 | 0.6 | 0.6 | 1.2 | **114** | Low | | |
| 090065 | Batarora Branch | NC87 | Brunswick | 3 | SD | FO | 41 | 44 | 0.7 | 0.3 | 1.1 | **115** | Low | | |
| 430046 | Jonathan Creek | SR1364 | Haywood | 14 | SD | FO | 19 | 24 | 0.1 | 1.0 | 1.1 | **116** | Low | | Y |
| 000036 | Tom'S Creek | SR1613 | Alamance | 7 | N | N | 35 | 41 | 0.2 | 0.8 | 1.0 | **117** | Low | | |
| 580267 | Catawba River | SR1103 | McDowell | 13 | SD | FO | 32 | 37 | 0.6 | 0.4 | 1.0 | **118** | Low | Planned | |
| 100200 | North Fork Ivy Creek | NC197 | Buncombe | 13 | N | N | 26 | 99 | 0.2 | 0.8 | 0.9 | **119** | Low | | |
| 800153 | Big Horse Creek | SR2102 | Rutherford | 13 | SD | FO | 16 | 21 | 0.2 | 0.7 | 0.9 | **120** | Low | | |
| 220123 | Ut To Sandy Run Creek | SR1162 | Cleveland | 12 | N | FO | 23 | 26 | 0.5 | 0.4 | 0.9 | **121** | Low | Planned | |
| 630155 | Trib Of Pig Basket Cr. | SR1417 | Nash | 4 | SD | N | 19 | 28 | 0.5 | 0.3 | 0.8 | **122** | Low | | |
| 100043 | Avery Creek | NC191 | Buncombe | 13 | N | FO | 23 | 29 | 0.5 | 0.3 | 0.8 | **123** | Low | | |

| Bridge | Feature Crossing | Route | County | Div. | Struc. Def. | Func. Obs. | Posted SV Weight | Posted TTS Weight | Weighted Trav | Weighted Det* | Comp Score | Score Rank | Priority Class from Model | Repl. Status | Manual Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 330275 | Nc67 | Robinhood Rd | Forsyth | 9 | SD | FO | 35 | 40 | 0.6 | 0.2 | 0.8 | **124** | Low | | |
| 490032 | Savannah Creek | NC116 | Jackson | 14 | SD | FO | 26 | 31 | 0.4 | 0.3 | 0.8 | **125** | Low | | |
| 560248 | Big Laurel Creek | SR1457 | Madison | 13 | SD | FO | 10 | 14 | 0.7 | -0.1 | 0.7 | **126** | Low | | |
| 720021 | North Flat River | SR1715 | Person | 5 | N | FO | 31 | 36 | 0.2 | 0.5 | 0.7 | **127** | Low | | |
| 890090 | Maple Springs Branch | SR1947 | Union | 10 | N | N | 38 | 99 | 0.2 | 0.4 | 0.7 | **128** | Low | | |
| 360015 | Buckland Mill Branch | SR 1304 | Gates | 1 | N | N | 21 | 31 | 0.1 | 0.5 | 0.6 | **129** | Low | | Y |
| 990016 | Elk Fork Creek | NC197 | Yancey | 13 | N | FO | 10 | 17 | 0.1 | 0.5 | 0.6 | **130** | Low | Planned | |
| 770446 | Gum Branch Canal | NC41 | Robeson | 6 | SD | FO | 26 | 40 | 0.5 | 0.1 | 0.6 | **131** | Low | Repl./Active | |
| 130029 | Yadkin River | NC268 | Caldwell | 11 | N | FO | 34 | 39 | 0.3 | 0.3 | 0.6 | **132** | Low | | |
| 440011 | River Overflow | SR1314 | Henderson | 14 | N | FO | 19 | 23 | 0.1 | 0.5 | 0.6 | **133** | Low | | |
| 760068 | Rocky Fork Creek | SR1487 | Richmond | 8 | N | N | 15 | 21 | 0.2 | 0.4 | 0.6 | **134** | Low | Repl./Active | |
| 980010 | South Deep Creek | SR1710 | Yadkin | 11 | SD | FO | 20 | 26 | 0.1 | 0.4 | 0.5 | **135** | Low | | |
| 240052 | Grape Creek | SR1001 | Craven | 2 | N | N | 25 | 33 | 0.4 | 0.1 | 0.5 | **136** | Low | | |
| 630077 | Fishing Creek | SR1506 | Nash | 4 | N | FO | 23 | 28 | 0.2 | 0.2 | 0.4 | **137** | Low | | |
| 800155 | Big Horse Creek | SR2105 | Rutherford | 13 | SD | FO | 17 | 22 | 0.4 | -0.3 | 0.4 | **138** | Low | | |
| 220218 | Brushy Creek | SR1363 | Cleveland | 12 | N | N | 38 | 41 | 0.2 | 0.2 | 0.4 | **139** | Low | | |
| 890058 | Crooked Creek | NC218 | Union | 10 | N | FO | 38 | 42 | 0.2 | 0.2 | 0.4 | **140** | Low | | |
| 550085 | Cowee Creek | NC28 | Macon | 14 | SD | FO | 41 | 99 | 0.3 | 0.1 | 0.4 | **141** | Low | | |
| 030231 | Cabin Branch | SR1637 | Anson | 10 | N | FO | 13 | 17 | 0.3 | -0.2 | 0.3 | **142** | Low | | |
| 360014 | Buckland Mill Branch | SR 1302 | Gates | 1 | N | N | 21 | 30 | 0.0 | 0.3 | 0.3 | **143** | Low | | Y |
| 690031 | Little River | SR 1140 | Pasquotank | 1 | N | FO | 6 | 0 | 0.1 | 0.3 | 0.3 | **144** | Low | | Y |
| 220009 | Seaboard Coast Line Rr | US74 BUS | Cleveland | 12 | SD | FO | 13 | 17 | 0.2 | 0.1 | 0.3 | **145** | Low | Planned | |
| 850062 | Stewarts Creek | SR1350 | Surry | 11 | SD | FO | 24 | 28 | 0.2 | 0.1 | 0.3 | **146** | Low | | |
| 440192 | Mud Creek | SR1126 | Henderson | 14 | N | FO | 21 | 30 | 0.3 | -0.2 | 0.3 | **147** | Low | Planned | |
| 500145 | Swift Creek | SR1555 | Johnston | 4 | N | FO | 19 | 25 | 0.2 | 0.0 | 0.2 | **148** | Low | | |
| 800239 | Catheys Creek | SR1325 | Rutherford | 13 | SD | FO | 13 | 18 | 0.2 | -0.1 | 0.2 | **149** | Low | | |
| 030234 | Cabbage Branch | SR1637 | Anson | 10 | N | FO | 10 | 18 | 0.2 | -0.1 | 0.2 | **150** | Low | | |
| 440071 | Shepherd Creek | SR1127 | Henderson | 14 | SD | FO | 19 | 28 | 0.1 | 0.1 | 0.2 | **151** | Low | | |
| 970067 | Contentnea Creek | SR1163 | Wilson | 4 | N | FO | 33 | 38 | 0.1 | 0.0 | 0.2 | **152** | Low | | |
| 280082 | Lick Creek | NC47 | Davidson | 9 | SD | N | 22 | 28 | 0.1 | 0.1 | 0.1 | **153** | Low | Repl./Active | |
| 760075 | Bell'S Creek | SR1452 | Richmond | 8 | N | N | 15 | 22 | 0.1 | -0.1 | 0.1 | **154** | Low | Repl./Active | |
| 480212 | Patterson Creek | SR1892 | Iredell | 12 | SD | FO | 26 | 26 | 0.1 | 0.0 | 0.1 | **155** | Low | Planned | |
| 030235 | Palmetto Branch | SR1637 | Anson | 10 | N | N | 12 | 20 | 0.1 | -0.1 | 0.1 | **156** | Low | | |
| 080010 | Reservoir | NC211B | Bladen | 6 | N | N | 38 | 99 | 0.1 | 0.0 | 0.1 | **157** | Low | | |
| 740029 | S.Br.Little White Oak Crk | NC9 | Polk | 14 | SD | FO | 30 | 30 | 0.0 | 0.0 | 0.1 | **158** | Low | | |

*None Found and negative Weighted Detour values are excluded (treated as zero) for calculation of Composite Scores. None Found detour values result from the absence of alternative routes in the Network Dataset. Negative detour values can result due to the interaction of the Network Dataset route preference settings and the speed limit of the roadways. When businesses are forced to detour around bridges, the preference for primary routes can become compromised by forcing businesses to take complex routes on local streets that while faster in theory could be slower and more difficult in practice.

*Table A2. Priority Levels from Stakeholder Feedback (Replacements planned, active or complete excluded)*

| Bridge | Feature Crossing | Route | County | Div. | Struc. Def. | Func. Obs. | Posted SV Weight | Posted TTS Weight | Priority from Comment |
|---|---|---|---|---|---|---|---|---|---|
| 870207 | Lamb Creek | SR1592 | Transylvania | 14 | N | FO | 24 | 32 | High |
| 480473 | Southern R.R. | SR2398 | Iredell | 14 | N | FO | 31 | 36 | High |
| 870222 | Morgan Mill Creek | SR1388 | Transylvania | 5 | N | FO | 38 | 38 | High |
| 440237 | Southern Railroad | SR1545 | Henderson | 1 | N | N | 38 | 44 | High |
| 550193 | Cullasaja River | SR1677 | Macon | 4 | N | FO | 39 | 42 | High |
| 380002 | Ledge Creek | NC56 | Granville | 14 | N | N | 30 | 30 | High |
| 870102 | Kings Creek | Railroad Ave | Transylvania | 1 | N | N | 32 | 37 | High |
| 690026 | Canal | SR 1144 | Pasquotank | 12 | SD | FO | 15 | 21 | High |
| 820025 | Shoe Heel Creek | SR1369 | Scotland | 9 | SD | N | 35 | 38 | High |
| 350007 | Ut To S Fork Catawba Rivr | SR2014 | Gaston | 1 | N | FO | 25 | 38 | High |
| 170086 | Mclin Creek | SR1739 | Catawba | 12 | SD | FO | 10 | 15 | High |
| 950039 | Little River Overflow | NC581 | Wayne | 5 | N | FO | 39 | 99 | High |
| 490317 | Scott Creek | SR1432 | Jackson | 1 | SD | N | 7 | 0 | High |
| 630090 | Henry Branch | SR1919 | Nash | 11 | SD | FO | 32 | 36 | High |
| 500105 | I95 | SR1007 | Johnston | 7 | SD | FO | 35 | 40 | High |
| 750230 | I73, Us220 | SR1952 | Randolph | 1 | SD | FO | 18 | 26 | High |
| 350116 | Beaverdam Creek | SR1627 | Gaston | 2 | N | N | 38 | 99 | High |
| 170158 | N. Fork Mountain Creek | SR1817 | Catawba | 14 | SD | FO | 19 | 24 | High |
| 350092 | Ut To Mill Creek | NC274 | Gaston | 4 | SD | N | 19 | 28 | High |
| 410003 | Little Fishing Creek | SR1343 | Halifax | 14 | SD | FO | 26 | 31 | High |
| 740087 | Broad River | SR1004 | Polk | 5 | N | FO | 31 | 36 | High |
| 360022 | Middle Swamp | SR 1312 | Gates | 1 | N | N | 21 | 31 | High |
| 220040 | Potts Creek | SR 1001 | Cleveland | 14 | N | FO | 19 | 23 | High |
| 840176 | Lick Creek | SR1926 | Stokes | 11 | SD | FO | 20 | 26 | High |
| 140014 | Dismal Swamp Canal | US17B | Camden | 14 | SD | FO | 41 | 99 | High |
| 480338 | Kinder Creek | SR 2139 | Iredell | 1 | N | N | 21 | 30 | High |
| 310044 | Nc55 | Pettigrew St | Durham | 1 | N | FO | 6 | 0 | High |
| 870139 | Taxaway Creek | SR1139 | Transylvania | 11 | SD | FO | 24 | 28 | High |
| 710029 | Perquimans River | SR 1200 | Perquimans | 4 | N | FO | 19 | 25 | High |
| 220039 | Knob Creek | NC10 | Cleveland | 14 | SD | FO | 19 | 28 | High |
| 020021 | Little River | NC18 | Alleghany | 4 | N | FO | 33 | 38 | High |
| 670086 | University Lake | SR1005 | Orange | 14 | SD | FO | 30 | 30 | High |
| 220070 | Beasons Creek | SR2238 | Cleveland | 12 | N | FO | 22 | 31 | Medium |
| 480510 | Dishman Creek | SR1599 | Iredell | 12 | N | FO | 32 | 37 | Medium |
| 690005 | Chapel Creek | SR 1103 | Pasquotank | 12 | N | N | 34 | 38 | Medium |
| 670334 | Dry Creek | Perry Creek Dr | Orange | 12 | N | N | 26 | 31 | Medium |
| 240103 | Core Creek | SR1001 | Craven | 12 | N | FO | 12 | 15 | Medium |
| 430046 | Jonathan Creek | SR1364 | Haywood | 12 | N | FO | 38 | 41 | Medium |

| Bridge | Feature Crossing | Route | County | Div. | Struc. Def. | Func. Obs. | Posted SV Weight | Posted TTS Weight | Priority from Comment |
|---|---|---|---|---|---|---|---|---|---|
| 630155 | Trib Of Pig Basket Cr. | SR1417 | Nash | 14 | N | N | 20 | 28 | Low |
| 490032 | Savannah Creek | NC116 | Jackson | 14 | N | N | 34 | 40 | Low |
| 720021 | North Flat River | SR1715 | Person | 14 | SD | FO | 10 | 14 | Low |
| 360015 | Buckland Mill Branch | SR 1304 | Gates | 8 | N | N | 38 | 99 | Low |
| 440011 | River Overflow | SR1314 | Henderson | 4 | N | FO | 39 | 99 | Low |
| 980010 | South Deep Creek | SR1710 | Yadkin | 14 | N | N | 25 | 37 | Low |
| 240052 | Grape Creek | SR1001 | Craven | 4 | N | N | 20 | 29 | Low |
| 630077 | Fishing Creek | SR1506 | Nash | 8 | N | FO | 39 | 42 | Low |
| 220218 | Brushy Creek | SR1363 | Cleveland | 12 | SD | FO | 6 | 0 | Low |
| 550085 | Cowee Creek | NC28 | Macon | 12 | N | FO | 25 | 38 | Low |
| 360014 | Buckland Mill Branch | SR 1302 | Gates | 4 | N | N | 35 | 44 | Low |
| 690031 | Little River | SR 1140 | Pasquotank | 14 | SD | FO | 14 | 18 | Low |
| 850062 | Stewarts Creek | SR1350 | Surry | 12 | SD | FO | 22 | 28 | Low |
| 500145 | Swift Creek | SR1555 | Johnston | 7 | SD | N | 10 | 14 | Low |
| 440071 | Shepherd Creek | SR1127 | Henderson | 2 | N | N | 25 | 33 | Low |
| 970067 | Contentnea Creek | SR1163 | Wilson | 4 | N | FO | 23 | 28 | Low |
| 740029 | S.Br.Little White Oak Crk | NC9 | Polk | 12 | N | N | 38 | 41 | Low |

# Appendix B – Technical Documentation of GIS Process

## I. <u>Building the Network Dataset</u>

The Network Dataset used in the Travel Model is built from a statewide road network dataset maintained by NCDOT. The original data must be processed to ensure it contains all the required values and fields for building the Network Dataset with logical constraints. Initial processing steps include calculating the Time Cost for each network segment, assigning a Hierarchy value to each network segment, and dividing the network into the Connectivity and Intersection Classes.

Original Road Network Data Source: Connect NCDOT GIS Data Layers

- Road Characteristics Arcs File Geodatabase Format
- Road Characteristics Field Descriptions (pdf)

### 1. Calculation of Time Cost for each Network Segment

The Network Dataset models routes using the time required to traverse each network segment (referred to here as Time Cost) as the default Impedance attribute. All network segments must have a valid Time Cost value. Time Costs are calculated using speed limit values, which may be missing for some segments. The steps below detail the process of estimating speed limits for segments with missing speed limit values.

a. Use the available columns in the Road Characteristics Arcs data and speed limit guidelines from the U.S Department of Transportation of Federal Highway Administration (Figure B1). See the Road Characteristics Field Descriptions to identify fields containing Land Use, Road Division, and Lane information. Assign a speed limit of 30 mph for any remaining segments that cannot be assigned speed limits based on these attributes.

| | | Land Use | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Rural | | | | Urban | | | |
| | | *Undivided* | | *Divided* | | *Undivided* | | *Divided* | |
| **Classification** | | **1 lane per direction** | **2+ lanes per direction** | **1 lane per direction** | **2+ lanes per direction** | **1 lane per direction** | **2+ lanes per direction** | **1 lane per direction** | **2+ lanes per direction** |
| Arterial | Major | 55 mph (90 km/h) | 60 mph (100 km/h) | 60 mph (100 km/h) | 70 mph (110 km/h) | 50 mph (80 km/h) | | 55 mph (90 km/h) | |
| Arterial | Minor | 50 mph (80 km/h) | 55 mph (90 km/h) | 55 mph (90 km/h) | 60 mph (100 km/h) | 45 mph (70 km/h) | | 50 mph (80 km/h) | |
| Collector | Major | 45 mph | 50 mph | 50 mph | 55 mph | 45 mph | | 50 mph | |

Lane = through lane

Divided = a median that separates travel lanes of traffic in opposing directions, which may be flush with, raised above, or depressed below adjacent travel lanes

*Figure B1. Speed Limit Guidelines per FHWA.*

b. Add a Time Cost field to the road network data to store Time Cost values.

c. Use speed limits and segment lengths (calculate geometry and convert to miles if necessary) to calculate a new field that stores time (in minutes) to traverse each segment at the segment speed limit. Divide segment length by the speed limit in miles per hour and convert the result to minutes. Store the final value in a field for Time Cost.

**2. Calculation of Hierarchy Value of each Network Segment**

The Network Dataset will optimize routing using a Hierarchy attribute, which dictates that travel be maintained to the maximum extent possible on primary roads.

a. Add a Hierarchy field to the road network data to store Hierarchy values.
b. Select primary roads using queries and calculate the new Hierarchy field. Assign a Hierarchy value of 1 (Primary Roads) to all limited-access roads (except the Blue Ridge Parkway), all I-, US-, and NC- highways, and all ramps, using the SQL statement below:

```
(AccessCont = 'Full' AND RouteName NOT LIKE 'FED-%') OR (RouteName LIKE 'I-%' OR
RouteName LIKE 'US-%' OR RouteName LIKE 'NC-%' OR RouteName LIKE 'RMP-%')
```

c. Assign a Hierarchy value of 2 to all other roads.
d. For more information on Hierarchy attributes in Network Datasets see: https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/network-analysis-with-hierarchy.htm

**3. Preparation of Connectivity Classes and Intersection Classes**

The original road data must be broken into three feature classes (referred to here as Connectivity Classes) corresponding to Local Streets, Limited Access Highways, and Ramps to ensure that limited access features are only accessed at ramps and highway endpoints. This process uses queries to select the appropriate features from the original road data and export them to new feature classes. The point intersections of Connectivity Classes (referred to here as Intersection Classes) must also be calculated to define access points between Connectivity Classes.

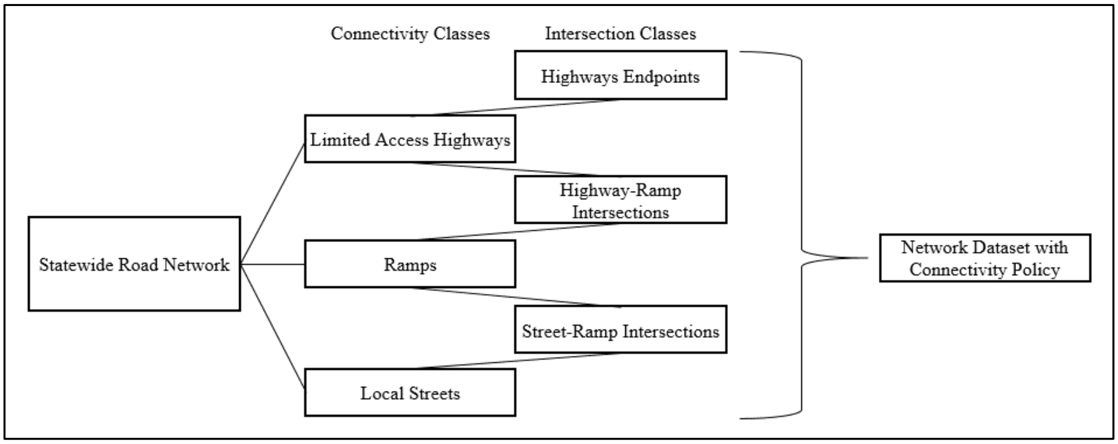


*Figure B2. Connectivity Classes and Intersection Classes.*

a. Use queries with the following SQL statements to select the appropriate features for each connectivity class and export the selected features to new feature classes:
   - Limited Access Highways (fully access-constrained, or route is interstate highway):

```
AccessCont = ‘Full’ OR RouteName LIKE ‘%I-’%
```

   - Ramps:

```
RouteName LIKE '%RMP%’
```

   - Full Access Roads: All Remaining

b. Intersection Classes must be derived using the following methods:

- Intersection Class of Limited Access Highways and Ramps: Use Intersect Tool with output type of Points to create new feature class.
- Intersection Class of Ramps and Full Access Roads: Use Intersect Tool with output type of Points to create new feature class.
- Intersection Class of Local Streets and Limited Access Highways: Use Feature Vertices to Points Tool with Limited Access Highway Connectivity Class and specification of Dangles to create new feature class.

c. NOTE: In some cases, it may be desirable to merge the separated Connectivity Classes back into a single network feature class that contains information about the Connectivity Class to which each feature belongs. To create such a recombined network:

- Create a new field in each Connectivity Class to store the network segment ID. Make sure the new fields have the same name in each Connectivity Class.
- Calculate the network segment ID in each Connectivity Class as the concatenation of the feature class name and the feature ObjectID (Ex: Network_LimAcc_Hwy999)
- Use the Merge tool to merge each Connectivity Class (segments only) into a single recombined feature class.

**4. Building the Network Dataset**

The Network Dataset must be built within a geodatabase containing the Connectivity and Intersection Classes. Use the following settings to create the Network Dataset.

a. General:

- Version 10.1

b. Sources:

All Connectivity and Intersection Classes (aliases shown below) and automatically-added system junctions.

- Limited Access Highways (Network_LimAcc_Hwy)
- Local Streets (Network_LocalStreets)
- Ramps (Network_Ramps)
- Highway Endpoints (Dangles)
- Highway-Ramp Intersections (Intersect_H_R_Point)
- Local Streets-Ramp Intersections (Intersect_S_R_Point)

Sources:

| Name | Element Type | Type |
|---|---|---|
| Network_LimAcc_Hwy | Edge | Edge Feature |
| Network_LocalStreets | Edge | Edge Feature |
| Network_Ramps | Edge | Edge Feature |
| Dangles | Junction | Junction Feature |
| Intersect_H_R_Point | Junction | Junction Feature |
| Intersect_S_R_Point | Junction | Junction Feature |
| Network_ND_Junctions | Junction | System Junction |

*Figure B3. Network Dataset Sources.*

c. Connectivity:
Use three connectivity columns to assign the Connectivity and Intersection Classes to connectivity groups as shown in Figure B4. Note that the Connectivity Policy must be set to "Any Vertex" for Connectivity Classes and "Honor" for Intersection Classes.

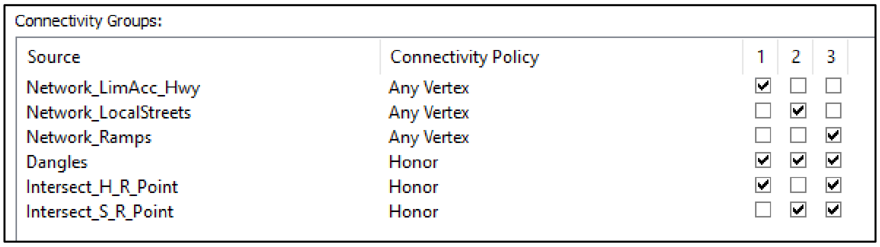


*Figure B4. Connectivity Group Assignments.*

d. Elevation:
- None

e. Attributes:
The Network Dataset will employ attributes for Hierarchy ("Hierarchy"), Time Cost ("TimeCost"), and primary route preference ("PreferPrimary") as shown in Figure B5. All attributes will be used by default. Steps to set up each attribute are described below.

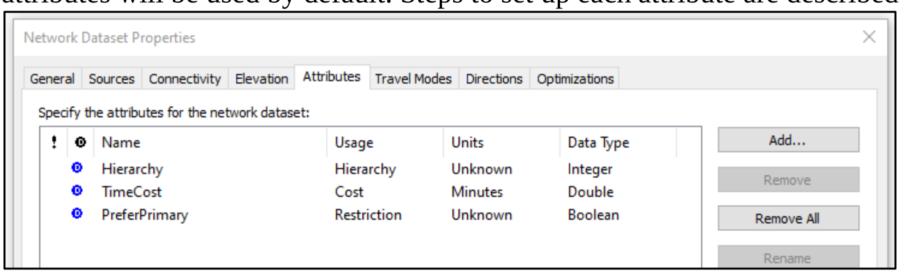


*Figure B5. Attributes of the Network Dataset.*

- Hierarchy
  - Usage: Hierarchy

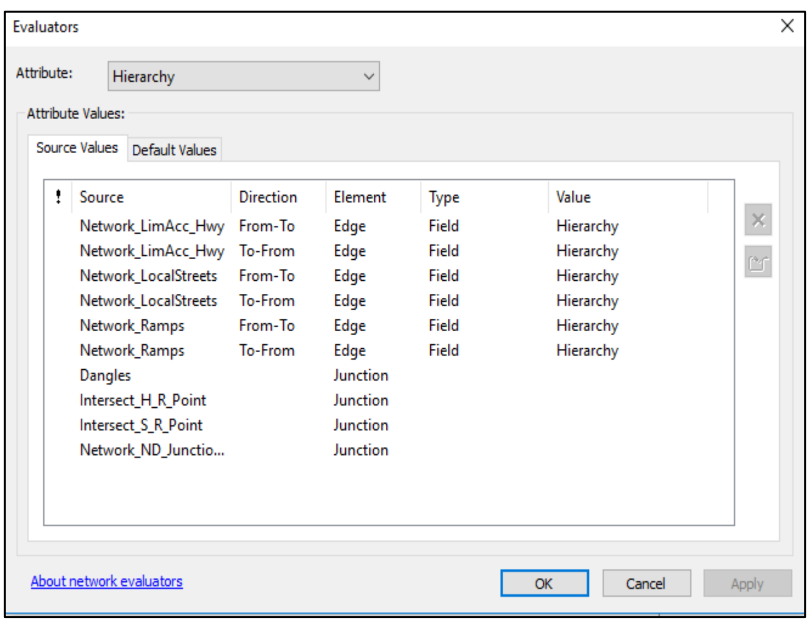


*Figure B6. Hierarchy Attribute Settings.*

- Evaluators: Field > Hierarchy

Ranges for the Hierarchy attribute (set from Attributes tab) must be set to reflect the values defined in Part 2 above:

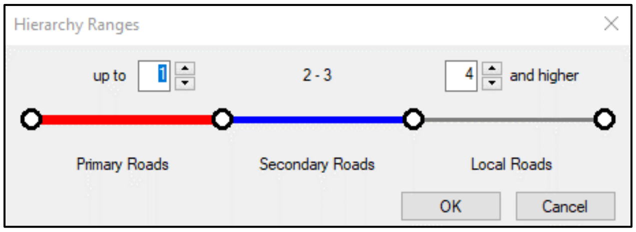


*Figure B7. Hierarchy Ranges.*

- TimeCost
    - Evaluators: Field: TimeCost (follow the same process as for Hierarchy setting)
    - Usage Type: Cost
- PreferPrimary
    - Usage Type: Restriction
    - Restriction Usage: Prefer (Medium)
    - Evaluators: Field: Expression
    - A Python Script Code is used to assign a value of True to segments with a Hierarchy value of 1 for each Connectivity Class source. Segments with a Hierarchy value greater than 1 are given a value of False. Use the Field Evaluators dialogue box shown below to define values for all Connectivity Classes and Intersection Classes.

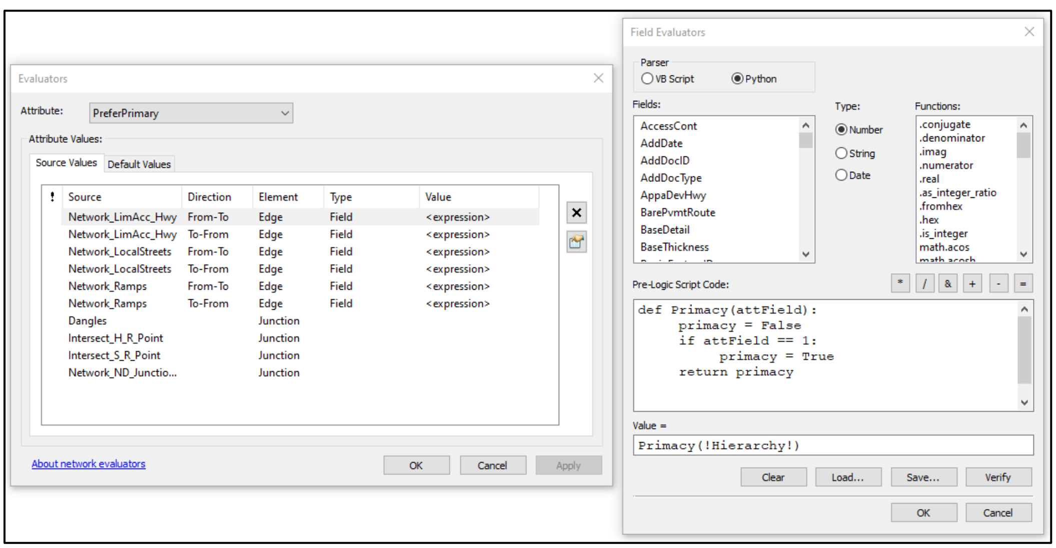


*Figure B8. Field evaluator settings used to define values for PreferPrimary restriction.*

f. Travel Modes:
    - None

g. Directions:
    - None

h. Build Service Area:
    - No

## II. Preparing the Model Inputs

### 1. Businesses

A point feature class of Businesses is used as the origin of routes in the Travel Model (see Section III). The Businesses feature class may be composed of business information from a single source or many sources. At a minimum, businesses used in the analysis must have a known geographic location, a unique identifier (referred to as Business ID), and an index of trucking intensity calculated on a uniform scale. The steps below detail the process for preparing a Businesses feature class from the businesses and associated data included in ESRI's Business Analyst dataset.

Original Business Data Source: ArcGIS Business Analyst

- All businesses in North Carolina

a. Calculate Trucking Intensity for Each Business
   - The Impact Analysis for Planning (IMPLAN) economic input-output platform is required for estimating trucking intensity by industry. The Use and Make tables of the Social Accounting Matrices (SAMs) within IMPLAN provide estimates for how each of IMPLAN's 546 industrial sectors rely on Sector 417, Truck Transportation, as a factor of production. This metric is used for "trucking intensity" in the analysis. ArcGIS Business Analyst (BA) Business Data includes North American Industry Classification System (NAICS) codes and employment estimates for all businesses in the dataset. The IMPLAN crosswalk is used to bridge the 546 IMPLAN sectors to NAICS designations, so that trucking intensity estimates from IMPLAN can be joined to businesses in the BA dataset. Finally, the industry sector TI is multiplied by the employment at each business to yield the trucking intensity of each business (referred to here as TI), which must be stored as a numeric value in a new field appended to the BA business dataset.
   - Businesses with TI values greater than or equal to 1.0 are included in the analysis. These businesses are selected by a query and exported to a new Businesses feature class.

b. Store the Coordinates of Each Feature
   - Create new fields, as necessary, to store projected Shape X and Shape Y coordinate information (independently) in the Businesses feature class. These coordinates are used in the travel model to determine the distance from bridges to businesses that generate traversals.

c. Augmenting the Business Feature Class with Additional Sources
   - Other sources of business locations can be merged with the Businesses feature class, provided they contain the fields described in Table 1. Note that TI must be calculated with a consistent method for all business sources.

### 2. Weight-Restricted Bridges

A point feature class of Weight Restricted Bridges is used to determine bridge crossings and store bridge-based metrics calculated in the Travel Model (see Section III). The set of bridges analyzed is filtered from a dataset of structures maintained by NCDOT.

Original Structure Locations Data Source: Connect NCDOT GIS Data Layers

- Structure Locations Statewide

a. Filtering for Weight Restrictions
   - Any structure with a single-vehicle weight restriction is included in the analysis. The original structure data is filtered with the following SQL expression and exported to a new Weight-Restricted Bridges feature class:

```
"POSTED_SV" < 99
```

b. Snapping Bridges to the Road Network

- Structures included in the analysis must be checked for correct alignment with the underlying road network features in the network dataset and snapped to the correct position on the network. Bridge features that occur at the intersection of two roadways should be snapped to road features in such a way that only routes utilizing the bridge will be recorded as a traversal when spatially-joined with bridge features (Figure B9). This process typically only needs to be completed once, as the correctly snapped feature data can be reused in subsequent analyses. However, new features should be assessed for correct snapping when they are added.

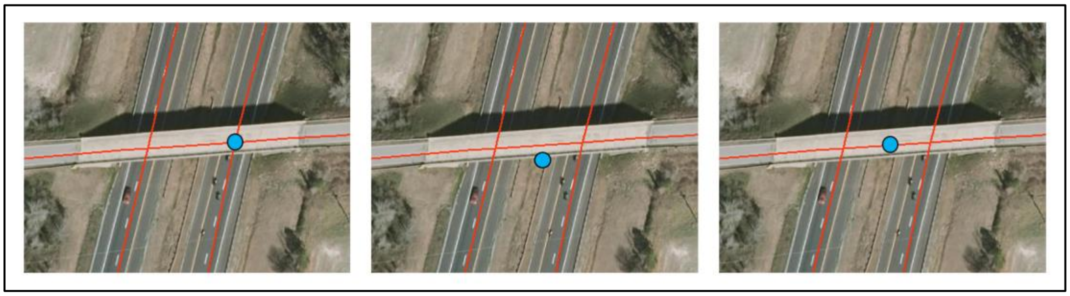

*Figure B9. Left: Incorrect Snapping results in traversals from under-passing routes. Center: Lack of snapping results in no traversals. Right: Correct snapping results in traversals only from the route that includes use of the bridge.*

c. Store the Coordinates of Each Feature

- Create new fields, as necessary, to store projected Shape X and Shape Y coordinate information (independently) in the feature class. These coordinates are used in the travel model to determine the distance from bridges to businesses that cross them.

**3. Border Points**

A point feature class of Border Points is used as the destination of routes in the Travel Model (see Section III). Border points are point feature classes with features located at the intersection of major trucking routes (I-, US-, and some state highways) and the state border, including coasts. Store one feature class of points for each border direction in a Border Points Feature Dataset (

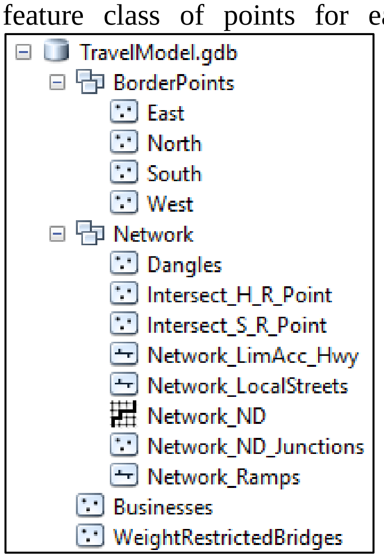


Figure *B10*). It is not necessary to store any additional attribute information with border points, but it may be desirable to store the route name for each border point. The default Border Points used in the Travel Model are shown in Table B1.

| North | | South | | East | West |
|---|---|---|---|---|---|
| US-21 | NC-86 | US-17 | I-95 | I-40 | US-64/74 |
| I-74/77 | US-501 | US-1 | US-701 | US-158 | US-441 |
| US-52 | I-85 | US-601 | US-52 | US-64 | I-40 |
| NC-8 | I-95 | US-21 | US-521 | US-70 | I-26 |
| US-220 | US-258 | I-85 | NC-200 | | US-19E |
| NC-14 | US-17 | I-26 | US-321 | | US-421 |
| US-29 | NC-168 | US-25 | US-221 | | NC-226 |
| | | US-441 | US-178 | | |
| | | US-129 | | | |

*Table B1. Default Border Point Locations.*

## III. Running the Travel Model (Python Modules)

Running the Travel model, including the Traversals and Detours modules, requires, at a minimum, the following fully-processed inputs within a single File Geodatabase (see Appendix B, Section I and Section II):

| Input | Required Attributes | Appendix B Section |
|---|---|---|
| Network Feature Dataset with Network Dataset | TimeCost, Hierarchy | Section I |
| Business Feature Class | BusinessID, TI, X_Coord, Y_Coord | Section II |
| Weight-Restricted Bridges Feature Class | BridgeNumber, X_Coord, Y_Coord | Section II |
| Border Points Feature Dataset with Border Points Feature Classes for all Borders | | Section II |

*Table B2. Required Travel Model Inputs*

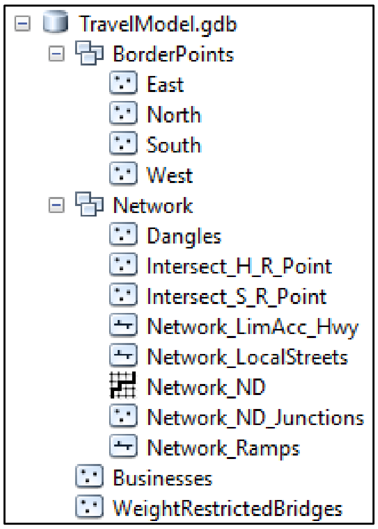


*Figure B10. GDB Contents for Travel Model*

The Travel Model is run in two separate Python Modules (Traversals and Detours) using the *arcpy* package to maximize efficiency. ***Running the Travel Model outside of these modules is not recommended***. The steps below describe the functionality of the Python Modules as a GIS workflow.

**1. Traversals**

The following steps are run once for each feature class in the Border Points feature dataset (4 times in the default analysis described here):

a. A Closest Facility Layer is created using the Network Dataset created in Section I. The Layer Properties for Network Locations are defined such that feature snapping is only permitted to the Shape of the Local Streets features. This ensures routes do not originate on Ramps or Limited-Access Highways. The Network Dataset uses the Hierarchy and PreferPrimary attributes by default and TimeCost as the default Impedance attribute.
b. The first Border Points feature class is loaded as "Facilities".
c. The Businesses feature class is loaded as "Incidents".
d. The Copy Traversed Source Feature tool is used to solve the Closest Facility Layer and generate a table of traversed edges.
e. The resulting Routes feature class is spatially-joined (one-to-many) to the Weight-Restricted Bridges feature class based on intersecting features and a tolerance of 5 feet, creating a Route-Bridge feature class.

f. A new feature class (referred to here as the "Bridge Table") is created to store unique business-bridge combinations with the following fields:
   - BusinessID
   - BridgeNumber
   - BaseTime (total TimeCost of the route)
   - Bridge X_Coord
   - Bridge Y_Coord
g. Routes with non-null bridge crossings are copied from the spatially-joined Route-Bridge feature class to the Bridge Table, including all of the attributes described above for each record.
h. Business coordinates and Trucking Intensity (TI) attributes are table-joined from the Businesses feature class to the Bridge Table using the unique business identifier.
i. The XY-to-Line tool generates a new feature class from the Bridge Table containing Euclidean distance calculations for all bridge-business pairs in the Bridge Table.
j. The distance between each bridge-business pair is table-joined back to the Bridge Table and converted to miles if necessary.
k. TI is divided by the number of directions (the number of Border Points feature classes in the Border Points dataset) and stored as the directional TI.
l. A new field is added to the Bridge Table to calculate the unique distance-weighted trucking intensity value for each record by dividing the directional TI by the distance from Business to Bridges.

$$TI_{DW} = TI_{DIR} / Dist$$

Where:

$TI_{DW}$ = Distance-weighted TI
$TI_{DIR}$ = Directional TI
Dist = Business to Bridge distance (miles)

m. The Frequency tool is used to generate a frequency table that collapses the Bridge Table by BridgeNumber and sums distance-weighted TI for each bridge.
n. The distance-weighted TI from the frequency table is table-joined back to the Weight-Restricted Bridges feature class and store the Weighted Traversal value in a new field.

The process described in Steps a-n is repeated with the next set of Border Points. The Weighted Traversal values for each direction are then summed for each bridge, producing the total Weighted Traversal value for each bridge.

## 2. Detours

The following steps are run once for each feature class in the Border Points feature dataset (4 times in the default analysis described here):

a. The Bridge Table generated in the Traversal Model is copied. This new table will be referred to as the "Detour Table".
b. A field for storing Barrier Time is added to the Detour Table.
c. The Closest Facility Tool is run once for each record in the Detour Table to determine the Detour Time for each business-bridge pair. For each record, a feature layer is created from the Businesses feature class using the BusinessID in the Detour Table record, and another feature

layer is created from the Weight-Restricted Bridges feature class using the BridgeNumber stored in the same Detour Table record.

d. A Closest Facility Layer is created using the Network Dataset created in Section I. The Layer Properties for Network Locations are defined such that snapping is only permitted to the Shape of the Local Streets features. This ensures routes do not originate on Ramps or Limited-Access Highways. The Network Dataset uses the Hierarchy and PreferPrimary attributes by default and TimeCost as the default Impedance attribute.
e. The set of Border Points corresponding to the first Detour Table is loaded as "Facilities".
f. The first Business feature layer is loaded as "Incidents".
g. The first Weight-Restricted Bridge feature layer is loaded as a "Point Barrier". This ensures the feature cannot be crossed by a route.
h. The Closest Facility Layer is solved.
i. The length (total TimeCost) of the resulting Route feature is copied to the Detour Table and stored as BarrierTime for the first record.
j. A new field is created to store the difference (referred to as the Detour Time) between the BarrierTime and the BaseTime.
k. The unique distance-weighted TI value for each business-bridge pair is used to calculate the weighted Detour Time with the following formula:

$$DT_{DW} = TI_{DW} \times DT$$

Where:

$DT_{DW}$ = Distance-weighted Detour Time
$TI_{DW}$ = Distance-weighted TI
DT = Detour Time (minutes)

l. After all records in the table have been run, the Frequency tool is used to generate a frequency table that collapses the Detour Table by BridgeNumber and sums weighted Detour Times by bridge.
m. The Weighted Detour Time from the frequency table is table-joined back to the Weight-Restricted Bridges feature class and stored as the Weighted Detour value in a new field.

The process described in Steps a-m is repeated with the next set of Border Points. The Weighted Detour value for each direction is summed for each bridge, producing the total Weighted Detour value for each bridge.

**3. Calculation of Composite Score**

a. A new field is added to the Weight-Restricted Bridges feature class to store the Composite Score.
b. The Composite Score for each bridge is calculated as the sum of the Weighted Traversal value and Weighted Detour value.