NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

North Dakota Truck Harmonization Study

DRAFT REPORT to the North Dakota DOT and THS Steering Committee

ACKNOWLEDGEMENTS

Steering Committee Members: (need names)

- ND Department of Commerce
- ND Highway Patrol
- North Dakota DOT
- ND Grain Growers Association
- ND Motor Carriers Association
- North Dakota Port Services
- North Dakota Petroleum Council
- ND Corn Growers Association
- ND League of Cities
- ND Township Officers Association
- ND Association of Counties

Other Contributors Included:

- ND Associated General Contractors
- Johnsen Trailer Sales
- ND Wheat Commission
- ND Soybean Growers Association
- ND Grain Dealers Association
- North Dakota Port Services
- United Pulse Trading – AGT Foods
- American Crystal Sugar/Transystems
- Basin Electric Cooperative
- Recipients of Long Combination Vehicle Permits

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Executive Summary and Key Findings

This study was initiated by the North Dakota Legislature in HB 1012 (NDDOT's budget bill). HB 1012 directs the North Dakota Department of Transportation (NDDOT) to collaborate with the Upper Great Plains Transportation Institute (UGPTI) to study the impacts and potential implications in North Dakota of harmonizing truck size and weight regulations with states in the Western States Transportation Alliance regarding standard commercial truck envelope limits of 129,000 lbs. gross vehicle combination weight, or 110 feet in overall length, or 100-ft. Cargo carrying length of a truck-tractor semitrailer and full trailer.

The primary objectives of the study are to

1. Conduct a comprehensive analysis of currently legal truck configurations in North Dakota,
2. Analyze the effects of potential changes to current configurations and/or legal weight limits, including the use of double trailer combinations and tridem axle and spread axle tractor-semi trailer combinations.

A comprehensive analysis determined the benefits and impacts for each existing and potential new (or modified) truck configuration studied. The analysis categories include the following:

1. Legislative, regulatory, and enforcement issues
2. Truck operating costs, energy efficiency, and any resulting air quality changes
3. Safety, crash, and fatality risks
4. Traffic operations impacts resulting from a change of legal truck sizes and weights
5. Potential impacts to transportation infrastructure including pavement, bridge, roadway connectivity, and roadway geometry
6. Potential changes to shipping origins, destinations, and mode choice (rail vs. truck)
7. Regional economic models.

These analysis categories served as the starting point for a comprehensive economic impact analysis, which considered the effects on statewide economic productivity and major industry groups. A public outreach effort coordinated with major industry group representatives and stakeholders throughout the state. Several major industry groups were also represented on the executive steering committee.

Several scenarios were analyzed involving the Rocky Mountain Double (RMD) operating at 105,500 lbs. and the 129,000-lb. double trailer configuration; these scenarios included (1) movements on the National Truck Network in North Dakota, (2) movements in select corridors, and (3) movements over the entire highway system, including County Major Collector (CMC) routes.

Key findings were as follows:

- Truck harmonization would reduce shipper costs for shipments that can take advantage of increased loading, for both intrastate and interstate long-combination vehicles. Note that interstate shipments would primarily benefit origins or destinations west and south of North Dakota because truck size and weight would still be limited by Minnesota regulations. Truck harmonization economic benefits for trucking within North Dakota are estimated to range from $140 million to $285 million per year.

- The increased size and weight of trucks would reduce the number of trucks on the roadways. The number of semi- and long-combination trucks carrying divisible loads would be reduced by 31% to 36%. This reduction in travel would reduce diesel fuel tax generation at the state level from $2.9 to $5.1 million. The reduction in federal fuel tax is estimated to range from $3.1 million to $5.3 million per year. The move to larger trucks would increase overall equivalent single axle load (ESAL) miles by about 2%. The increased ESALs yield a pavement impact in the range of $2.8 to $3.6 million annually. Some might consider this a negligible amount.
- Bridge analysis due to increased truck weights yielded as much as $2.26 billion in statewide bridge replacement needs with approximately $716 million occurring on the state system. While bridges in North Dakota are exposed to trucks of this size from time to time by permit, it was assumed that the inventory rating should be used to assess the situation where these trucks are part of the normal traffic flow and a bridge could experience more than one of these loads simultaneously. Note that NDDOT was able to perform a detailed analysis of all state system bridges using AASHTO-VIRTIS software.
- Local road connectivity issues include inadequate roadway intersection geometry to accommodate longer trucks that require larger turning radii, and increased traffic delay in urban areas and signalized intersections. A county and township road intersection geometric needs analysis yielded from $130 million to $306 million of impacts. Urban signalized corridors could be impacted as signal timing is adjusted to accommodate the starting of heavier trucks.
- Agency and association impacts were identified for updating software, websites, printed materials, and staff for motor vehicle registration, permitting, and enforcement. The impacts are estimated to cost from $102,000 to $165,000 for software changes. If the long combination vehicle permit was eliminated, it would reduce revenue by about $6,200 per year. Staffing impacts were difficult to predict.
- The crash analysis and seasonal trip generation analysis were inconclusive due to a lack of data. Literature and other studies generally include speculation that fewer trucks with heavier loads will increase safety while others point out that heavier trucks take longer to stop and longer trucks need more passing distance. Longer combination vehicles, however, generally have more braking axles to apply when stopping. Studies regarding longer, heavier trucks have been mixed in showing the increased or decreased stopping distances.
- Stakeholder outreach indicated commercial shippers would upgrade their fleets to take advantage of increases in allowable truck size and weights. Agricultural producers may be slower to upgrade their fleets for various reasons such as economics, shorter trip lengths, commercial driver’s license requirements for multi-trailer combination vehicles, and/or local road limitations.
- Changing from North Dakota's existing exterior bridge formula to the interior/exterior bridge formula would reduce the allowable legal loads on a triple axle by 6,000 lbs. and would also increase law enforcement time required to verify a vehicle's legal weight. However, use of the

interior/exterior bridge formula would reduce confusion and improve efficiency of interstate trucking. Harmonization with the laws of surrounding states will increase the legal weight for a quad axle configuration in North Dakota. Currently the legal weight on a quad axle configuration in ND is less than what South Dakota and Montana allow.

Literature Review – Analysis of Similar Federal, Regional and State Studies

Several past FHWA, USDOT, and state-specific studies were reviewed to identify potential practices to apply to this study. The three most comparable studies were

- Idaho 129,000 Pound Pilot Project - 2013
- FHWA Comprehensive Truck Size and Weight Study – 2015
    - Applicable Sections:
        - Pavement Analysis
        - Structure Analysis
        - Modal Shift
        - Compliance Comparative Analysis
- USDOT Western Uniformity Scenario Analysis – 2004

Idaho 129,000-Pound Pilot Project

<u>Purpose</u>

Idaho Transportation Department (ITD) prepared this report under the direction of the 2003 Idaho legislature. The legislature through HB 395 required a 10-year study of truck impacts on the state system (non-interstate). The study allowed trucks to operate at 129,000 lbs. through a special permit on 35 designated routes. ITD was directed to report on changes to pavement and bridge performance and safety as a result of the pilot permitted traffic.

<u>Approach</u>

To determine the effects of increased loads on pavements, ITD allowed trucking companies to operate under a 129,000-lb. permit under the condition that they reported each trip. The allowance resulted in 127 participating with 1,359 trucks. ITD measured pavement rutting, cracking, and International Roughness Index (IRI) on the routes and compared the data to routes without the permitted trucks. Bridges were rated as per National Bridge Inventory (NBI), and bridges on the pilot study routes were compared to the non-pilot routes. Crash data were compared as well.

<u>Methods and Data</u>

As mentioned above, the methods used were empirical and did not involve any modeling. No projections of future traffic were used. Past records of heavier load base trips were used. The test routes that experienced traffic over the pilot period were measured at the end with respect to ride, rutting, faulting, and fatigue and compared with routes that didn't experience the loads.

Important Findings

The study showed that the pavement and bridges of the routes that had experienced the heavier loads did not show any difference in pavement or bridge performance.

Possible Ideas to Adopt in a UGPTI Study

Due to the extended pilot study period versus the short NDDOT study period, there is very little to be adopted into the NDDOT study. The measures depended on actual pavement and bridge deterioration over a multi-year period. No modeling was involved. The Idaho study does not seem to be relevant to the NDDOT study other than to show it as a case study.

The study does provide an example of how regulatory change could occur gradually by creating a pilot period where only a few designated routes are allowed higher GVW and require users to register their loads so over a period of time, state and participating county road authorities could identify changes in infrastructure in comparison with control routes.

Limitations of Idaho Study

No limitations seem to be relevant to our study.

Sequel to the Idaho Study – Idaho Implementation of the 129,000-pound Network

As a follow-up to discussions with the steering committee, research and outreach was advanced with ITD to assess how they are advancing the 129,000-lb. concept across the state as a result of congressional action. In December 2015, the Omnibus appropriations bill provided the following section with respect to the Idaho interstate system:

- VEHICLES IN IDAHO—A vehicle limited or prohibited under this section from operating on a segment
- of the Interstate system in the State of Idaho may operate on such a segment if such vehicle–
- ‘‘(1) has a gross vehicle weight of 129,000 lbs. or less
- ‘‘(2) other than gross vehicle weight, complies with the single axle, tandem axle, and bridge formula limits set forth in subsection (a)"

  Same axle weights and federal bridge formula as currently allowed by federal law

Idaho has implemented a public and technical review based program for adding routes to the 129,000-lb. network. Not all Idaho state routes are posted at 129,000 lbs. Prior to July 1, 2013, trucks configured to increase gross vehicle weights from 105,500 lbs. to 129,000 lbs. were permitted on a select number of state highways in southern Idaho via a pilot project. Legislation approved in 2013 made those 35 specified routes permanent and provided authority to the responsible highway jurisdiction to allow gross vehicle weights up to 129,000 lbs. on additional specified routes. An Idaho Transportation Board subcommittee on 129,000-pound truck routes was established in 2013 to address legislation related to gross vehicle weights up to 129,000 lbs. The subcommittee's charge was to develop the process to allow 129,000-lb. gross vehicle weights on additional state routes and then to review requests for these additional routes and make a recommendation to the full Idaho Transportation Board.

Additional routes are allowed to be proposed by the public and these are reviewed for safety, geometrics, pavement, and bridges. Public input is requested and a public hearing is held regarding the proposals.

In follow-up discussions with Idaho Motor Carrier Services, it was found that all routes that have been approved for 129,000-lb. trucks continue to require permits. The permits are not trip or route specific. Customers can obtain an annual Up to 129K permit from the Idaho Overlegal Permit office, Port of Entry weigh stations, and also via the web at trucking.idaho.gov. The annual permit is specific to the company and power unit. The annual permit allows for movement on all current designated routes and is valid for any future routes as they are approved. Permits are also required on the interstate system regardless of the language in the 2015 appropriations bill.

The FHWA Comprehensive Truck Size and Weight Study

The FHWA Comprehensive Truck Size and Weight Study (CTSW) covered infrastructure, safety, enforcement, and modal shifts. A review of the methodologies sections for pavements, bridges, modal shift, and compliance comparative analysis are as follows:

Pavements

Purpose

USDOT prepared this report to define the life-cycle costs to the pavement infrastructure on the Federal Highway System (Interstate and National Highway) across the nation if higher axle and GVWs were implemented. The analysis attempted to forecast life-cycle costs for four types of pavement and in four climatic zones within the country using the American Association of Highway and Transportation Officials (AASHTO) Mechanistic-Empirical Pavement Design Guide (MEPDG).

Approach

To determine the effects of increased loads on pavements, USDOT has created eight test vehicle classifications. Two of the classifications are considered control loads of GVW 80,000 lbs. and differing wheel and trailer configurations, while the other six progressively raise the GVW to 129,000 lbs. and total axles to nine.

The data used in the pavement analyses of this study came from several FHWA sources, namely the Highway Performance Monitoring System (HPMS), vehicle classification and weight data reported by the States to FHWA, the Long-Term Pavement Performance (LTPP) database, and MEPDG calibration data from four state departments of transportation. The models used for the analysis are those that are in Version 2.0 of the AASHTO *Pavement ME Design®* software.

After compiling the input data required for each of the sections, the base case traffic volumes were analyzed for each geographic location and pavement type and a set of analyses for each of the six modal shift scenarios were ran in order to estimate the change in initial service interval.

Truck weight scenarios were a bit unique. In five- and six-axle scenarios it appears that tandems and tridems were allowed to exceed 34,000 lbs. and 42,000 lbs., respectively. In North Dakota it is common to see a Rocky Mountain Double (RMD), a five-axle semi-truck pulling a single-axle-based trailer; but no such vehicle was shown in the USDOT study.

MEPDG was used to forecast improvements based on predicted IRI, rutting and fatigue cracking for asphalt and IRI, faulting and transverse cracking for rigid pavements. MEPDG was stated as not being good at modeling asphalt cement (AC) pavements over rigid (concrete) pavements or AC over AC. By forecasting the improvements, a life-cycle cost could be assigned to the various scenarios.

The study points out that using Equivalent Single Axle Loads (ESALs) as a method of comparison was considered but not advanced; the study stated: Since using ESALs as a basis for differentiating among trucks for national policy considerations is neither technically defensible nor politically feasible, the second and third types of approach have more potential for use in the CTSW.

Methods and Data

The FHWA CTSW study used four different rigid and flexible pavement sections to cover the four climatic regions. The study modeled high, medium, and low volume loads for each section. The study then forecast base loading and scenario loading based improvements for seven loading scenarios. The life-cycle costs were then calculated for two discount rates (1.9% and 7.0%).

The analysis, as mentioned earlier, was based on MEPDG projections of future improvements. Various input parameters came from LTPP studies. The study did not use ESALs as previously mentioned. Axle loading assumptions were made and applied to the AASHTO MEPDG. Various sources were used to make the loading assumptions, including HPMS, classification data, and weigh in motion data.

Important Findings

The most important findings were that the truck configurations varied with respect to increasing or reducing life cycle costs. Trucks with single axles generally have increased pavement life-cycle costs due to their increased pavement damage per ton-mile.

The decision to not use ESALs as a basis of analysis is probably not advisable for the North Dakota study. ESAL-based concepts are regularly used by UGPTI and NDDOT in reporting to the legislature. In addition, NDDOT has not adopted the use of MEPDG in its asphalt pavement analysis, which would make it difficult for them to review an MEPDG-based analysis. It recommended that commodities be assessed for individual trucks and that a study scenario be based for each truck type to be studied for the commodity to be hauled and a ton-ESAL-mile factor be developed. If possible, this should be applied to pavement life increase or decrease analysis.

Possible Ideas to Adopt in a UGPTI Study

- Limiting analysis to a limited number of truck configurations
- Considering if we do life-cycle analysis for each truck type
- Select a limited number of pavement configurations to study/model
    - 3 or 4 AC over aggregate base – AC (e.g., 3 in., 5 in., and 8 in.)
    - 1 rigid
    - One composite – AC over concrete

Limitations of USDOT Study

- Applying MEPDG – can't analyze composite pavements
- No routing of key commodities
- Limitation to Interstate System (IS) and National Highway System (NHS)
- Truck configurations not matching types selected for NDDOT
- Using overloaded tandems and tridems is not suggested for NDDOT study – NDDOT wants consideration of inner and outer bridge and legal axle loads.

Bridges

Purpose

USDOT prepared this report to define the economic costs to the bridge infrastructure on the Federal Highway System (IS and NHS) across the nation if 129,900 lb. load limits are implemented. The analysis attempted to include long-term and immediate infrastructure upgrade costs to the system.

Approach

To determine the effects of increased loads on U.S. bridges, USDOT has created eight test vehicle classifications. Two of the classifications are considered control loads of GVW 80,000 lbs. and differing wheel and trailer configurations, while the other six progressively raise the GVW to 129,000 lbs. and total axles to nine. These eight configurations were then analyzed across 490 different representative bridges sorted over 11 broad categories based on structure material and type. The 490 bridges were taken as representative sample of the 88,945 NBI bridges on the Federal Highway System, both IS and NHS.

These selected bridges were analyzed using the *AASHTO LRFD Bridge Design Specifications* to create a Rating Factor (RF). After analysis, if the RF of a particular bridge is below 1.0, the bridge is considered deficient and will need load posting, structural strengthening, or rebuild. The percentage of these deficient bridges was then calculated for each type, span length, and age to show the impact of the weight limit change.

To determine costs related to the bridges requiring rehabilitation or replacement, a standard unit price of $235 per square ft. (SF) was derived to include all construction, design, and inspection costs. The bridge data were sorted into span length categories of 20-ft. increments from 0- to 200-ft. lengths. Each span category was assigned a rehabilitation value based on the upper limit of length (e.g., 0-20 ft. category was assumed to be a 20-ft. bridge), a set width depending on the function of the bridge (IS or NHS), and multiplied by the unit price cost. There was no differentiation in cost or decision made regarding load posting, bridge strengthening, or replacement.

To determine the aggregate cost of all the bridges in the system, the deficiency percentage of each span length was expanded to the entire system. This calculated number of deficient bridges was then multiplied by the set cost to rehabilitate them in order to get the aggregated cost to the system to upgrade.

One additional system cost comparison was calculated and denoted as Δcost. The Δcost was calculated for each variable truck classification comparing it to the control configuration. Δcost was simply calculated by subtracting the cost for rehabilitating the system for the control vehicle (removing postings on existing bridges, etc.) from the cost to upgrade the system for the higher truck weight classification. Aggregate Δcost was the final amount reported in the executive summary.

<u>Methods and Data</u>

The 490 test bridges were selected based on 11 broad categories from 14 states based on structural material and structure description/type. The bridges were actual bridges within the NBI and were considered to be representative bridges for the category they were placed in. The categories were compared to the NBI and were broken out in similar ratios for the representative sample. The sample bridges were analyzed and the results were broken down to the categories, span length, and age to exhibit the increase in load restrictions due to increased truck loading. Increased truck traffic was not accounted for in analysis, as a single truck at the given weight limit was enough to warrant the rehabilitation.

Bridge structural analysis was completed using the current structural analysis specification (*AASHTO LRFD Bridge Design Specifications*) within the AASHTO Bridge Rating (ABR) software suite when applicable. Load ratings were broken down using the Load and Resistance Factor Rating (LRFR) and Load Factor Rating (LFR) analysis. LRFR was chosen due to its simplicity since a single load rating for the bridge, regardless of axle count and weight, is produced. LFR analysis was completed only when LRFR standards did not exist for the type of bridge (steel through truss and girder floor beam categories). A single strength limit denoted as the Rating Factor (RF) was given for each bridge based on the calculated load capacity (LRFR and LFR) and the loading configuration. Any bridge was considered deficient when the RF was below 1.0 for the tested truck configuration. Fatigue was accounted for during the initial analysis, but no financial cost was assigned for this portion of the analysis due its complex analysis. Deck wear and damage was also touched on, but no financial cost was assigned either.

The data were reported multiple times using different charts and tables. The test bridge data were broken down in several different charts to illustrate its differing ages, spans lengths, and structural types. It was also broken down several times to show how it was representative of the existing federal bridge system. Additional tables show the aggregate costs of the updates to the system required and costs per span length range.

Important Findings

The most important finding was the total cost and aggregate cost (Δcost) for the system and the varied costs for each truck configuration. These reflected costs were an attempt at the worst case scenario for the entire system to reflect the cost to upgrade without any economic decision making, rather than a full rehabilitation/replacement for the bridge no matter how close to passing the particular bridge was. The range was also quite large, from $400 million for the five-axle, 88,000 lb. load condition to $5.4 billion for the nine-axle, 129,000 lb. load condition. All of these costs are presented as a one-time cost to bring the bridge system up to the load capacity. No long-term costs to the system were presented due to complex fatigue calculations, complex deck wear calculations, lack of Average Annual Daily Traffic (AADT) forecasts, and lack of future vehicle configuration mixture forecast. All these four variables were deemed too complex and too unknown to be quantified within this report.

There is a paragraph at the end of the report discussing impacts to local bridges within the report. The USDOT team did not sample any local bridges, but with the assumption that most local bridges are short simple spans (20-40 ft.), broad conclusions regarding moment and shear increases are noted. At this span length, three of the six load cases showed an increase in stresses, two cases showed a decrease, and one case was about equal in stresses.

To determine the aggregate cost of all the bridges in the system, the deficiency percentage of each span length was expanded to the federal highway (IS and NHS) system. This calculated number of deficient bridges was then multiplied by the set cost to rehabilitate them in order to get the aggregated cost to the system to upgrade. This cost comparison was denoted as Δcost. The Δcost was calculated for each variable truck classification comparing it to the control configuration. Δcost was simply calculated by subtracting the cost for rehabilitating the system for the control vehicle (removing postings on existing bridges, etc.) from the cost to upgrade the system for the higher truck weight classification. Aggregate Δcost was the final amount reported in the executive summary.

Possible Ideas to adopt in a UGPTI Study

- Use of sampling of bridges and creating broad categories to create a statistical sample
- Sampling using the NBI
- Breakdown of bridges based on length across entire system
- Deriving cost from percentage of sample bridges that fail
- Breakup of state highway and county system and accounting for both system-wide and individual classes of bridges in analysis
- Use of several test vehicles and standard 80k loads as control vehicle
- Use of Δcost to illustrate additional costs to infrastructure from existing system repairs required
- Use of base cost year for structural costs (similar to previous needs studies)
- Use of N.D. posting laws to determine the mode of action for bridges (not used in USDOT study, but addressed)

Limitations of USDOT Study

- Only initial system upgrade cost addressed
- No future traffic forecasted for system
- Only six load cases analyzed, any other possible truck configurations may result in increased or decreased costs
- ESALs, Weigh In Motion (WIM), Vehicle Miles Traveled (VMT) and Passenger Car Equivalents (PCE) not used in analysis
- Each loading scenario was independently investigated for costs
- Only representative bridges (490) analyzed
- Used high-cost proprietary software for analysis
- Bridge classification based on length of upper-end replacement cost given for each bridge in each length class aggregated across all bridge lengths giving a very high system cost
- No economic decisions weighed (rehab vs. rebuild), $235/SF standard cost
- Standardized deck width taken based on road classification
- No regional cost data created, just a single national cost
- No fatigue, deck wear, or chloride deterioration economic analysis

The Modal Shift Comparative Analysis Technical Report

Overview

The Modal Shift Comparative Analysis Technical Report presents the analysis of six truck size and weight policy options. The resulting impacts of these scenarios include the following:

- The total number of trips and miles of travel required to haul a given quantity of freight
- The transportation mode chosen to haul different types of freight between different origins and destinations
- The truck configurations and weights [and resulting ESALS] used to haul different types of commodities
- The axle loadings to which pavements and bridges are subjected
- Potential highway safety risks
- Costs of enforcing federal size and weight limits
- Energy requirements to haul the nation’s freight
- Emissions harmful to the environment and public health
- Traffic operations on different parts of the highway system
- Total transportation and logistics costs to move freight by surface transportation modes
- The productivity of different industries
- The competitiveness of different segments of the surface transportation industry

Each of the above impacts results from shifting of freight movements from smaller to larger trucks or from rail to truck transportation. These impacts range from agency costs resulting from ESAL changes, congestion impacts from VMT changes to industry-specific cost impacts, and modal competition. The six scenarios analyzed include three single trailer configurations (plus an 80,000 control), and three multi-trailer configurations (plus an 80,000 control). As these configurations are described elsewhere and are consistent through the entire study process, they are not presented here.

Methods

The primary tool used to estimate modal shifts was the Intermodal Transportation and Inventory Model (ITIC). The assumption that any potential shift would be the result of reduced total logistics costs for the commodity being shipped. As mentioned above, this shift could be between truck types or between modes, depending on the comparable total logistics cost.

To provide input to the ITIC model, multiple data sources were utilized to describe commodity flows. These data include the Freight Analysis Framework and Carload Waybill Sample. These sources provided information as to the county-to-county freight flows by commodity. County-to county flows were then routed over highway networks to provide mileage estimates from origin-destination pairs and highway jurisdiction. In addition, attributes of the selected commodities were obtained to determine equipment type, carrying cost, vehicle configuration, and likelihood of mode change.

The resulting updated freight flow data were used as input to the ITIC model. The base scenario estimated existing total logistics costs for commodity movements identified by origin-destination. The build scenario estimated the total logistics costs under the new regulatory environment. By selecting the least-cost option, modal shifts were estimated. The shifts in traffic were used to update VMT by highway class and truck configuration, and the results were used to estimate transportation savings costs to shippers and agency costs as a result of VMT changes.

Additional discussion

The appendices of the document provided a comprehensive overview of methods previously utilized to estimate modal shift, including advantages and disadvantages of each. Of particular interest is the description of data requirements for each method. One of the main limitations of previous studies is the lack of publicly available data sources. Many of the presented studies indicated that secondary benefits due to industry-wide transportation costs reductions are not estimated, and the cost savings are estimated for the short run.

Application to North Dakota’s Study

The methods used in the FHWA study are readily applicable to the current North Dakota study with the exception of the confidential waybill sample availability. However, North Dakota has unique data sources that were not available for the FHWA study, which will allow researchers to provide an accurate description of grain movements within the state. Due to the limited geographic scope of the study, true modal shift is likely to be limited as many of the primary terminal destinations are long-haul movements, which favor rail transportation. Intramodal truck mode shifts will likely be the primary impact of regulatory changes within the state.

Summary of the Compliance Comparative Analysis Technical Report[1]

Purpose

The purpose of the compliance comparative analysis "is to assess the cost and effectiveness of enforcing truck size and weight limits for trucks currently operating at or below current truck weight limits as compared with a set of alternative truck configurations."

Methodology

The analysis of costs and effectiveness undertaken in this study takes a performance-based approach. This approach considers enforcement program performance (or effectiveness) in terms of inputs, outputs, outcomes, and pertinent relationships between these measures.

Enforcement program inputs reflect the resources (i.e., personnel, facilities, technologies) available to carry out the TSW enforcement task.

Outputs reflect the way enforcement resources are used, the scale or scope of activities performed, and the efficiency of converting allocated resources into a product (e.g., quantity of weighings, weight citations).

Outcomes reflect the degree of success of the TSW enforcement program in achieving its goal, which from an operational and programmatic perspective is to achieve compliance with TSW regulations. The outcome measures used in this study are the proportion of axle or truck observations that fall within the federal weight compliance limits compared to the severity of overweight observations.

Type of Measure	**Performance Measures**
Input	• Enforcement program cost • Number of weigh scales by type • Number of WIM sites used for screening truck weights
Output	• Number of weighings • Citations • Number load shifting or offloading vehicles • Number of oversize/overweight permits issued • Weighing cost-efficiency • Citation rate • Citation rate as a function of enforcement intensity
Outcome	• Proportion of weight-compliant observations • Severity of overweight observations

State-Level Analysis

[1] Available at: http://ops.fhwa.dot.gov/freight/sw/map21tswstudy/technical_rpts/index.htm

At a broad level, readily available state-specific data provide the foundation for comparing costs and effectiveness between states that currently allow trucks above federal weight limits and those that do not. As the state-level data used in these comparisons do not allow disaggregation by vehicle configuration, these comparisons can be understood as a surrogate way of revealing potential vehicle-specific differences at the state level. The report notes that, "Because of budget constraints, a subset of 29 states (referred to as comparison states) are used for this analysis." Later in the report, it is indicated that "13 of the 29 comparison states are designated as at-limit and 16 as above-limit (allow vehicles in excess of federal limits)."

The comparative analysis focuses on costs reported for 2011 only. To help account for differences in the relative size of the Truck Size and Weight (TSW) enforcement task in different states, all costs are normalized using 2011 estimates of truck VMT in that state. The truck VMT estimates include all single-unit trucks, single-semitrailer trucks, and multiple-trailer trucks. To reduce the impact of outlying data points, the comparison uses ranges and median values to compare costs and resources available for TSW enforcement in at-limit and above-limit states.

The comparison of at-limit and above-limit states does not reveal any difference in enforcement program effectiveness when measured in terms of citation rate (citations per weighing) and enforcement intensity (weighings per million truck VMT). Rather, effectiveness as measured by this relationship appears more sensitive to the enforcement method (i.e., fixed or portable weighings) used in the state.

Vehicle-Specific Analysis

A more detailed comparative analysis of enforcement program costs and effectiveness involves vehicle-specific comparisons (where possible). These comparisons focus on enforcement cost and effectiveness differences between the control vehicles and the six alternative truck configurations introduced into the traffic stream for the six 2014 CTSW study scenarios. Thus, the results of the vehicle-specific comparisons directly support the scenario analysis, which estimates system-wide cost and effectiveness impacts that could result from the operation of the alternative truck configurations relative to the 2011 base case.

As no publicly available systematic data source exists to support such analysis, information about the time required to weigh various truck configurations was gathered from seven commercial motor vehicle state enforcement officials.

For each of these truck configurations, weighing times were provided for the four main types of weigh scales: fixed static scales (including scales that weigh axle groupings and weigh bridges that weigh the entire vehicle at once), portable scales, semi-portable scales, and WIM scales (including the use of a WIM at a virtual weigh scale).

Overall, considering only the portion of VMT associated with the control and alternative configurations and accounting for the VMT changes predicted in each of the four scenarios relevant for this analysis, the results reveal limited impacts on the estimated proportion of total weight-compliant VMT expected under the scenario traffic conditions when compared to the base case traffic conditions.

Primary Data Sources

The measures of input included in the analysis of national-level trends are program cost (disaggregated into costs for personnel and facilities) and the number and type of weigh scales used to enforce truck weights, including WIM sites used for screening truck weights. State Enforcement Plans (SEPs), which are submitted annually by States to the FHWA, provide the primary source data for the analysis of enforcement costs and resources.

The output measures are sourced from the Annual Certifications of Truck Size and Weight Enforcement database. While these outputs on their own provide some indication of program effectiveness, additional outputs and inputs can improve the overall understanding of program effectiveness.

WIM data gathered at selected sites provide the basis for comparing the truck weight compliance impacts that may result from introducing the alternative truck configurations into the traffic stream.

The base analysis year for the study is 2011. To capture annual trends in enforcement program costs, the analysis examines data reflecting program resources and activities from 2008 through 2012, inclusive, thereby using the most current, reliable data available.

Issues or problems encountered during the analysis (e.g., data limitations)

While the work focuses on TSW enforcement costs, much of the available cost data reflect the allocation of resources for both TSW and commercial vehicle safety enforcement. The costs reported by states reflect resources (e.g., personnel, facilities) directed at TSW enforcement and truck safety enforcement. No attempt has been made to disaggregate costs allocated to these separate programs.

The costs reported in the SEPs reflect those costs deemed by the state to be directed at enforcement activities in that state each year. For the most part, specific states show consistent cost trends over time; however, costs for certain states exhibit anomalies when major capital expenditures (e.g., new enforcement facilities) are undertaken in a particular year.

The SEPs do not contain any systematically reported information about TSW enforcement costs for specific vehicle configurations, routes, networks, industries, commodities, or permitted versus non-permitted trucks.

It appears that certain states may be reporting the actual number of portable scales in operation while others may be reporting the number of locations at which portable scales are used or even the number of weighings conducted with portable scales.

This work analyzes resources directed at enforcing truck size and weight. However, to support the purpose of this work, certain aspects of the analysis focus solely on truck weight.

The Annual Certifications of Truck Size and Weight Enforcement database contains data reported by states for each of the output measures and is the primary data source used to analyze enforcement program outputs. Data from 2008 to 2012 are included in the analysis. The following limitations apply to the data:

• The federal regulations that require states to certify the enforcement of federal truck size and weight laws do not explicitly define the vehicles that fall within the scope of TSW enforcement activities. It is understood, however, that the types of vehicles included in the scope of TSW enforcement activities generally coincide with the definition of a commercial motor vehicle. According to the 23 CFR Part 658, a commercial motor vehicle is "a motor vehicle designed or regularly used to carry freight, merchandise, or more than ten passengers, whether loaded or empty, including buses, but not including vehicles used for vanpools, or recreational vehicles operating under their own power." While this definition includes passenger-carrying vehicles, these represent a negligible proportion of vehicles subject to weighings in most states. In fact, passenger-carrying vehicles are generally not required to stop at weigh stations simply because they have passengers on board and there is concern with delaying the passengers. In addition, some states may include recreational vehicles and various types of light duty trucks within the scope of their weight enforcement activities. For these reasons, there may be inconsistencies in the data submitted by the states.

• The federal regulations that require states to certify the enforcement of federal truck size and weight laws do not provide a clear distinction between violations and citations. As defined earlier, it is impossible to have a citation without a violation. However, a vehicle found to be in violation may result in a citation, multiple citations (corresponding to multiple violations), or no citations. The regulations themselves also appear to use the terms "violation" and "citation" interchangeably. For these reasons, there may be inconsistencies in the data submitted by the states.

• The federal regulations that require states to certify the enforcement of federal truck size and weight laws do not specify whether the reported number of weighings by WIMs should include only those WIMs used within a state's TSW enforcement program, or also WIMs used within a state's traffic monitoring program. It is generally understood that most states only report weighings by WIMs used specifically for TSW enforcement purposes.

• None of the data contained in the Annual Certifications of Truck Size and Weight Enforcement database can be disaggregated by truck configuration. This precludes the analysis of weighings and citations for the specific control vehicles and alternative truck configurations of interest in the 2014 CTSW study. The citations recorded in the database cannot be attributed to a specific enforcement method (i.e., fixed, portable), industry, commodity, or time period (other than calendar year). In addition, the actual axle or gross vehicle loads that triggered the issuance of a citation, shifting of the load, or off-loading are not recorded.

Important results or conclusions

Key findings concerning enforcement costs are as follows:

• From a national-level programmatic perspective, states spent a total of approximately $635 million (in 2011 U.S. dollars) on their TSW enforcement programs in 2011. Personnel costs represented about 85% of total costs, while facilities expenditures (including investments in technologies) accounted for the remaining costs. Technologies play an important role in TSW enforcement and are increasingly deployed by state enforcement agencies.

• Based on the state-level comparisons, there is no indication of a change in enforcement costs that can be attributed to whether or not a state allows trucks to operate above federal limits. Rather, differences in how states deliver enforcement programs (e.g., methods of enforcement used, technologies, intensity of enforcement) may have greater influential on total costs.

• The vehicle-specific comparative analysis indicates that, because the alternative truck configurations have more axles or axle groups than the control vehicles (except the Scenario 4 configuration with two 33-ft. trailers), they will require more time to weigh using certain standard weighing equipment and thus result in higher personnel costs.

• When estimating cost impacts on a system-wide basis in the scenario analyses, personnel costs decrease because the reduction in VMT predicted by the scenarios necessitates fewer weighings overall (assuming the rate of weighing vehicles relative to VMT is held constant) and this outweighs the increased costs associated with weighing the alternative truck configurations. Viewed another way, the rate at which weighings occur (per VMT) or the time spent conducting a weighing could be increased under the scenario conditions for the same level of expenditures on enforcement personnel.

Key findings concerning enforcement effectiveness are as follows:

• Considering national-level trends, both the weighing cost-efficiency (personnel costs per non-WIM weighing) and citation rate (citations per non-WIM weighing) decreased from 2008 to 2012. The relationship between citation rate and enforcement intensity revealed that the citation rate decreases as enforcement intensity increases (i.e., more weighings per million truck VMT), but reaches a point of diminishing return. Moreover, those states that conduct a higher proportion of portable and semi-portable weighings generally have a lower overall enforcement intensity and a higher citation rate. Measuring enforcement effectiveness in terms of a citation rate is complex because both relatively low and relatively high citation rates could be interpreted as a reflection of an effective enforcement program.

• Based on the state-level comparisons, as with the cost results, there is no indication of a change in enforcement effectiveness (as measured by the relationship between citation rate and enforcement intensity) that can be attributed to whether or not a state allows trucks to operate above federal limits.

• For the vehicle-specific comparison of enforcement effectiveness, an analysis of data from selected WIM sites indicates that, except for six-axle tractor semitrailers operating off interstates, the alternative truck configurations exhibit a higher proportion of compliant GVW observations than the control vehicles—hence our use of the 71,700-lb. average GVW for those calculations involving the control double configuration. However, for all the comparisons, the intensity of overweight observations is higher for the alternative truck configurations than the control vehicles.

• System-wide, in each of the scenarios analyzed, the impact on the proportion of total weight-compliant VMT for the control vehicle and alternative truck configuration is limited relative to the base case.

Relevance to the ND Truck Size and Weight Study

In order to conduct a similar analysis, we need to determine the availability of the State Enforcement Plans and/or access to the Annual Certifications of Truck Size and Weight Enforcement database.

Safety

Purpose

The USDOT sought to assess safety based on crash outcomes and vehicle performance for alternative large truck configurations during actual operations on U.S. roadways based on state, fleet, and corridor study units.

Approach

Eight truck configuration scenarios were defined to determine the effects of increased size and weight on crash incidence and crash likelihood. Crash event and traffic exposure data were collected from individual states in which larger truck types are permitted to operate. This field data were used to develop comparative crash incidence rates for alternative configurations and traffic environments. In addition, the actual data were used to develop models to predict relatively likelihood for crashes among the various truck/traffic environment strata. A separate exercise was conducted to assess truck stability and control in computer simulations of the alternative truck configurations.

Methods and Data

Comparative analysis, regression modeling, and vehicle simulation methods were used in the study. Comparative assessment, based on actual crash and traffic data, was designed to assess the crash frequency and severity for truck configurations considering traffic environment. Regression models were also developed based on the crash and traffic exposure data, to predict relative crash likelihood for the configurations while again controlling for the traffic situation. Simulations were also developed to estimate relative impacts of the configurations on crash-related truck stability and control performance of the six alternative configurations relative to the two control cases.

Viable datasets were collected from 12 states that allowed operation of heavy trucks. The study was further limited to states where the actual operations closely matched control and alternative truck scenario configurations. For instance, only data from Idaho, Michigan, and Washington interstates and the Kansas Turnpike were used in the comparative analysis for crash involvement for five-axle and six-axle semitrailers. The data were parsed to include only Idaho and Kansas Turnpike interstate cases for crash incidence with the twin and triple configurations. Data are weak with regard to a robust, representative sample considering that crash events were very limited in geography and number, especially for the six-axle or more and multi-trailer scenarios. Detailed tables on crash counts show only 43 crashes in Idaho with twin trailers and 34 on the Kansas Turnpike during the three- and five-year study periods, respectively. The figures for triple-trailer crashes are even smaller at 15 and 10 for Idaho and Kansas, respectively. In addition, crash severity is often more heavily considered than an overall crash rate in assessing traffic safety. Crash counts by severity level show that neither Idaho nor Kansas data include a fatal crash event for twin trailers; one fatal crash for triple trailers is reported in Idaho.

The truck configuration including load status, and traffic count including vehicle configuration detail, are required to accurately develop representative estimates of crash incidence among the various truck configuration and road class location combinations. Unfortunately, findings were indeterminate with regard to crash incidence for the larger trucks due to insufficient data in the truck configuration, traffic exposure, and crash reporting. Lack of any individual truck weight detail, very limited vehicle configuration, and geographically limited traffic exposure available from states was prohibitive in compiling a robust crash event dataset that could be used to make inferences about U.S. fleet safety related to truck size and weight properties.

<u>Important Findings</u>

Neither substantiated crash involvement rates nor crash prediction metrics could be assigned in the scenarios due to gaps in the crash and traffic exposure datasets.

<u>Limitations</u>

The USDOT large truck scenario most similar to the proposed North Dakota configuration does not operate in the United States, so it was not considered in the crash safety analysis.

Serious data gaps, with regard to truck characteristics and traffic datasets, prohibited rigorous crash incidence, and crash prediction analysis essential in projecting safety implications.

- Lack of truck weight data in crash databases
- Restrictions in annual daily traffic and weigh-in-motion data collection limited analysis to the interstate system
- Lack of sufficient truck configuration detail in state crash databases
- Few states with sufficient data so findings not generalizable on a national basis

<u>Transferable to the North Dakota Study</u>

Needed database enhancements identified for future large truck crash/roadway scenario risk assessment include

Crash and Inspection Data

- Truck Configuration: detail such as axles, spacing, etc.
- Vehicle Weight: load status/GVW/GVWR
- Cargo body type

Traffic Data

- Reliable WIM collection
- Expanded WIM collection, as relevant

Assure road groups represented as relevant and data linkages between state and federal data.

Western Uniformity Scenario Analysis

A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association
April 2004 USDOT

The western United States has for many years had longer combination vehicles (LCV) operating under various and different, state truck size, and weight limits. These differing state regulations have played an important role in the efficiencies of the trucking industry and for shippers in the region. In an effort to determine the effects of increasing truck size and weight limitations and making them uniform across the region, the Western Governors' Association (WGA) requested an additional analysis to the United States Department of Transportation's (USDOT) Comprehensive Truck Size and Weight Study[2]. The WGA requested the "Western Uniformity Scenario," an analysis to assess the impacts of lifting the LCV size and weight freeze initiated in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The WGA asked for this analysis to measure the impacts of truck size and weights limited only by the federal axle load limits, the federal bridge formula, and a maximum GVW limit of 129,000 lbs. Figure 1 illustrates the states included in the analysis.

[2] Western Uniformity Scenario Analysis, A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, The United States Department of Transportation, April, 2004

Figure 1. The Western Uniformity Scenario States

Source: Western Uniformity Scenario Analysis, a Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, April 2004

Most states in the scenario currently do not allow the truck size and weight limitations analyzed in the study but several states indicated that, even if permitted to do so, they would not increase truck size and weight to the scenario's limits.

Several major conventional and LCV combinations were used in the study. The major conventional truck combinations included the five-axle tractor semi-trailer and the twin 28.5-ft. double or STAA double. Major LCV combinations in the scenario included 1) seven-axle double or Rocky Mountain Double (RMD), 2) eight-axle B-train double, 3) 10-axle resource hauling double, 4) nine-axle Turnpike Double (TPD) and 5) triple trailer combination. The scenario states already allow some LCVs but not all the scenario LCVs analyzed in this study. The scenario analysis itself focused on estimating the impacts of removing the LCV freeze on three LCVs, 1) Rocky Mountain Doubles, 2) Turnpike Doubles, and 3) Triple-Trailer Combinations (Triples). Two scenario cases were developed for different trailer lengths resulting in "High Cube" and "Low Cube" cases. Figure 2 illustrates the LCVs' vehicle combinations used in the scenario analysis.

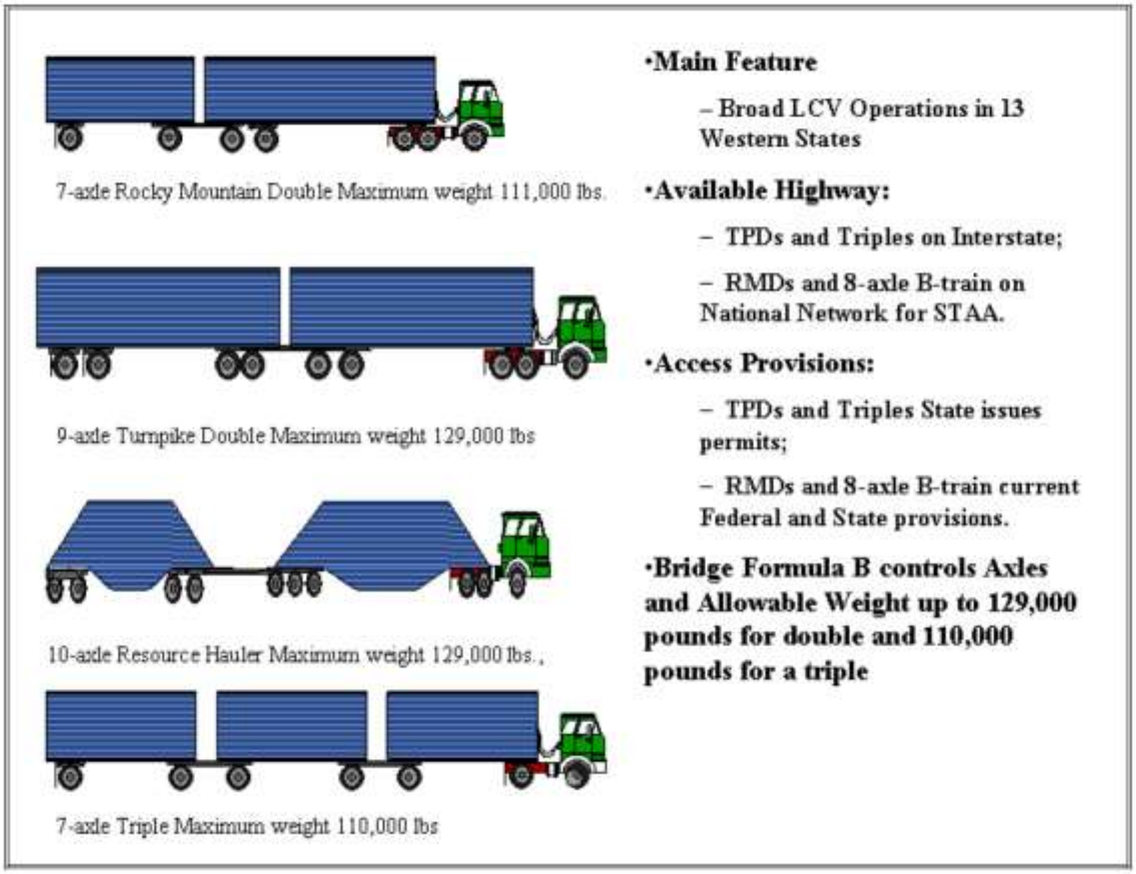


Figure 2. The Western Uniformity Scenario LCV Combinations

Source: Western Uniformity Scenario Analysis, a Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, April 2004

Several highway networks were considered in analysis and the report notes that the scenario states have a higher percentage of rural highways than the U.S. as a whole. The highway networks utilized in the study include the National Network (NN) for large trucks designated pursuant to the STAA of 1982, the current networks on which LCVs now operate, and highway networks assumed to be available for each type of LCV. The scenario highway networks used the NN system for the RMD and the Interstate Highway System for the TPDs and triples. Extensive highway routing maps were created meeting each state's truck size and weight regulations.

The study used the year 2000 for the base case. The scenario analysis year was 2010 and employed traffic forecasts developed utilizing economic forecasts by Global Insights and the year 2000 traffic characteristics. Traffic characteristics included vehicle class, operating weight, commodity, origin and destination, and highway functional class. Scenario impacts were estimated for:

- Freight diversion
- Shipper costs

- Pavement costs
- Bridge costs
- Roadway geometry
- Safety
- Traffic operations
- Environmental quality
- Energy consumption
- Rail industry competitiveness

Estimated Scenario Impacts

Freight Distribution and Shipper Costs

The study noted the current situation for shippers in the western region with the disparity among each state's truck size and weight limitations. "Often shippers must study each State's regulations and then design a vehicle to match the State with the most restrictive truck size and weight rules to avoid costly re-configuration at the borders."[3]

The changes analyzed by the scenario mean cost structure changes for shippers. The analyses specifically involved changes in mode choice and truck configuration with impacts to shippers as well as pavements, safety, fuel consumption, and air and noise pollution.

Freight distribution was allocated using the base case year 2000 VMT as developed for study vehicles and the scenario year 2010 VMT as forecast by Global Insight commodity-specific demand-based forecasting. Truck analysis included short-haul, long-haul and triples scenarios. Freight traffic was assigned to the truck configuration with the lowest cost as determined by the load size and market rates.

The study's shipper cost analysis noted that changes in truck size and weight affect shipper transportation and inventory costs. The scenario case only calculated the changes in shipper's transportation costs using the changes in VMT between the base and scenario case.

Rail traffic is diverted to trucks in the scenario case when the truck variable cost is lower than the rail variable cost. Moreover, in the scenario, rail shippers benefit when railroads reduce their rates to keep traffic that is costed at above the truck variable cost but below the railroad's revenue. The 2000 STB waybill is used for rail variable costs and revenue.

Two alternative maximum lengths are used in the scenario for the longest double trailers. The low-cube alternative restricts the longest double to 95-ft. combined trailer length while the scenario's high-cube alternative allows 101-ft. combined trailer length.

All VMT is lower for the 2010 scenario than in the base case year 2000 for all highway classifications as larger loads result in fewer VMT. In the low-cube case there is a 9.5% decline in the number of VMT as

[3] Ibid., page II-10

compared with the base case. The percentage of the VMT in LCVs increased in the scenario, mostly due to the shift from tractor-semitrailer configurations to LCVs.

In the high cube case, which uses the longer turnpike double, VMT is reduced by 25.5%. Again, significant increases are seen in the number of VMT shifting to LCVs. For example, specialized freight (bulk, tank, flatbed) in the base case have 12.7% movement in LCVs while in the high-cube case of the scenario, 96.1% of this freight group move in LCVs. All commodity and traffic-flow combinations showed substantial shifts to LCVs in the scenario case with the high-cube case showing the greatest changes.

Small impacts on rail traffic were estimated for both the high and low cube case, in contrast to the national truck size and weight study. Only 0.22% of the rail carload miles and 0.07% of rail intermodal miles divert to truck.

Shippers experience lower transportation costs by switching to LCVs in the scenario analysis. The savings to shippers is summarized in Table 1. As shown in Table 1, shippers changing to LCVs in the scenario case save $1,190 million in the low-cube case and $2,036 million in the high-cube case. Shippers switching from rail to truck save $2.3 million in the low-cube case and $3.2 million in the high-cube case. Rail shippers who continue to ship on rail experience reduced rail rates to remain competitive with increased LCV traffic. These shippers save $26 million in the low-cube case and $48 million in the high-cube case. Total savings in the low-cube case is $1,218.3 million and $2,087.2 in the high-cube case.

	Western Uniformity Scenario	
	Low-Cube Case	High-Cube Case
Truck-to-Truck		
Dollars (millions)	$1,190	$2,036
Percent Change	2.3%	3.9%
Rail-to-Truck		
Dollars (millions)	$2.3	$3.2
Percent Change	0.01%	0.01%
Rail Discount		
Dollars (millions)	$26	$48
Percent Change	0.06%	0.11%

Table 1. The Western Uniformity Scenario Shipper Cost Savings

Source: Western Uniformity Scenario Analysis, a Regional Truck Size and Weight Scenario Requested by the Western Governors' Association, April 2004

Pavement Impacts

The National Pavement Cost Model was used to estimate the scenario pavement impacts. The different axle-truck configurations and the weight of the traffic are the important components of the model and produce the pavement improvement needs for the truck configuration being analyzed. Changes among the axle and weight configurations provide the analytical comparisons for the scenario and estimate the pavement impacts of the scenario as compared to the base case.

Small pavement impacts were observed. The low-cube analysis showed a slight decrease of 0.4% in pavement costs over the 20-year period of pavement cost analysis. The high-cube case showed a 4.2% decrease in pavement costs over the 20 years.

This study reports that this small impact is not surprising since the proposed scenario does not change the axle weight limits, which is the major factor in pavement damage assessments.

Bridges

The western scenario states require bridges to meet the Federal Bridge Formula B (BFB) standard. Moreover, of the 90,000 bridges in the 13 states, about 25% percent are on the National Truck Network for large trucks on which the scenario trucks operated. The incremental costs for improving or replacing bridges that become overstressed in the "Inventory Rating" scenario case are the costs associated with the increased bridge load stress as compared with the base case.

For estimating bridge costs or investment needs, the study assumed that bridges overstressed by 15% to 20% when compared to the base case would require replacement or strengthening. Under this assumption, the scenario estimates for bridge costs are between $2.329 and $4.125 billion.

Roadway Geometry

This section of the study analyzed roadway ramps, interchanges and intersections. The introduction of longer LCVs would require improvements to roadway ramps and interchanges and intersections, particularly for safety reasons. Longer LCVs need additional roadway lane space for turning, thereby increasing safety concerns. The additional turning space is needed to counter off-tracking, which occurs when a vehicle's rear wheels do not follow and track its front wheels.

Roadway geometric data existed for two states in the scenario, Kansas and Washington. An analysis of these data, expanded to the entire research region, showed costs of $420 million in the low-cube case and $775 million in the high-cube case.

Safety

The study focused on two research aspects of truck safety: vehicle safety performance and crash data. The truck configurations studied included van, tank, and hopper trailer-body types.

Vehicle safety performance analysis used three measures of a truck's crash risk. These were

- Static rollover threshold
- Rearward amplification
- Load transfer ratio.

The static rollover threshold analysis showed that all the configurations tested had a good to excellent rating for static threshold ratings with the van body types rating the lowest.

The rearward amplification examination studied the effects on the trailer of rapid tractor movements or steering. The tractor-semitrailer connections examined included the A-train, B-train, and C-train. The A-train is the most commonly used connection but is the most susceptible to excessive trailer movement. The poorest rated configurations, noted the report, were the Triple A-Train Van and the Rocky Mountain Double Hopper loaded at 105,500 lbs. The triple-trailer combination has a significant 39% improvement in rearward amplification when a C-train connection is used.

The load transfer ratio is a measure of the proximity to rollover as the load is being transferred to one side of the vehicle to the other. A high load transfer ratio (approaching 1) means that a rollover is likely. The study quotes a Canadian performance standard that recommends a load transfer ratio should not exceed 0.6 for moving, loaded vehicles.[4] B-train and C-train configurations were the most stable of the base and scenario vehicles with the triple A-train, van having a load transfer Ratio of 1, indicating the vehicle would have rolled over during the test maneuver.

The study's crash database analysis included the review of prior studies to determine if a causal relationship between truck size and weight and crash rates has been found or established. Seven recent statistical studies of multi-trailer combination vehicle safety were examined. The studies, taken as a whole, had a wide range of estimated crash rates because of the different data, methodologies, and time frames. The report noted that these differences highlight the difficulties in analyzing a small sample of vehicles and getting reliable and accurate VMT and crash data for each vehicle type.

An update to the crash database was reported in the study. This part of the report analyzed 1995-1999 fatal involvement and travel data but was still limited by the difficulties encountered in the previous studies, including the fact that past safety data may not predict future safety, and LCVs cannot be isolated from STAA doubles in the data. In the scenario region, single trailer combinations fatal crash rate was 2.88 per 100 million VMT and 3.13 per 100 million VMT for multi-trailer combinations.

The study concludes that it is not possible to accurately predict the changes in crash rates due to the scenario. It points out, however, the public concern with additional LCV traffic and the importance of addressing public safety issues despite the lack of substantial data and/or crash rate analysis.

[4] Recommended Regulatory Principles for Interprovincial Heavy Vehicle Weights and Dimensions, Vehicle Weights and Dimensions Study Implementation Planning Subcommittee, final release September, 1987

Traffic Operations

The study notes that large trucks negatively impact traffic in several ways. Large trucks reduce the quality of traffic flow impacting the fluid movement of the surrounding traffic. Moreover, large trucks have an impact on crash severity due to the increased weight of the truck in the collision. In general, traffic operations will degrade with increased truck traffic.

The study continues by noting the effect of a large truck's slower acceleration and/or speed maintenance as a factor in large truck's impacts on traffic. As reported in the paper, the CTSW Volume III showed that crash involvement might be 15-16 times more likely with a speed difference of 20 miles an hour compared with no speed difference. Because of this, crash risks increase significantly with increasing speed differences between vehicles. Large trucks, with reduced capacity to accelerate or maintain speed compared to other vehicles, contribute to the increased crash risk. As well, large trucks contribute to longer passage times at intersections and longer passing times for other vehicles.

The scenario impacts on traffic operations generally predict a small decrease in traffic delay and congestion costs with some degradation to passing, lane changing, low-speed off-tracking, and intersection traffic operations. Longer combination vehicles reduce total truck VMT, which results in the decreases in traffic delay and congestion costs while the longer vehicles degrade the other traffic operations factors.

Energy and Environment

The impacts of truck size and weight limitation changes for trucks and LCVs include energy consumption, air quality, global warming, and noise emissions. In order to present valid comparisons among the various truck configurations, the scenario assumes that each truck configuration operates at the same speed under the same conditions. Moreover, the report also notes that fuel usage does not increase on a one-to-one relationship with vehicle weight and the longer configuration at the same weight does not increase fuel consumption.

The scenario impacts show that energy consumption in both the low-cube and the high-cube case decreased from the base case. The low-cube energy consumption decreased 3.2% while the high-cube case decreased 12.1%. Emissions were assumed to decrease equivalently to the decrease in energy consumption. Noise costs were reduced 1.4% for the low-cube case and 9.7% for the high-cube case. Air pollution costs were not estimated because the Environmental Protection Agency's models do not incorporate the different vehicle classes in the scenario.

Rail

The study analyzed the impacts on railroads of the increase in LCVs as envisioned by the scenario. LCVs may reduce transportation costs to shippers currently utilizing railroads for those commodities that may be hauled by both modes by providing a more competitive environment between the two modes.

Two models were used in the analysis, the DOT's Intermodal Transportation and Inventory Cost (ITIC) Model, and an Integrated Financial Model. The ITIC model assumes that railroads reduce their rates to compete with increased truck productivity; the financial model uses changes in income statements to measure the effect of any changes in a railroad's financial condition.

The study estimates small losses to the major railroads in the region and theorizes that a larger loss was prevented by the transloading requirements and costs of LCVs at the regional boundaries in the scenario. However, the study notes that any business would attempt to make adjustments to maintain the base case financial conditions whether through changes to rates, services, and/or investments.

Conclusions

This study considered the impacts of a group of western states increasing their truck size and weight limitations. The study estimated shippers would experience substantial benefits from increased LCVs, and additional benefits would be seen in reduced fuel consumption, emissions, and noise-related costs. Long-term highway infrastructure costs and improvements, while not necessary immediately, are estimated to total between $300 million and $2 billion.

Safety issues were addressed by the study but the data necessary for an informed analysis do not exist. The study recommends that before any substantial increase is allowed for LCVs that the western states initiate methods for monitoring LCV safety issues. The study also notes that safety issues include minimum standards for LCV stability and control as well as adequate maintenance programs.

The study concludes that the DOT sees no federal compelling interest to change truck size and weight limits unless there is strong support to do so from state officials. The report suggests that strong state support to change truck size and weight limits is not currently apparent.

The 2004 USDOT Western Uniformity Scenario Analysis (WUSA) offered the most procedures and situations that fit this study because North Dakota was included in the WUSA. The findings were as follows:

- Substantial productivity gains could be realized if assumed LCV operations actually occurred.
- Infrastructure impacts would be relatively lower than estimated in the FHWA Comprehensive Study because many western states already operate LCVs.
- Rail impacts were also low compared to the comprehensive study.
- Bridge impacts were significant and stated that inventory ratings should be considered even though a past TRB study used operating ratings. The overall bridge costs for the 13 states for the interstate and the NHS for bridges experiencing 10% to 15% in excess of the inventory rating equaled a range of bridge needs of $2.33 billion to $4.1 billion for the interstate and National Truck Networks of the 13 states. The study stated that states could be expected to determine the priority and timing of needed bridge improvements based on the volumes of traffic and the degree to which the bridge was being overstressed. In some cases, states might not allow larger, heavier trucks to use all segments of the network immediately, but would open segments only when the infrastructure was adequate to accommodate the new vehicles.
- Pavement impacts would be modest.

- Geometric impacts would be as high as $1.6 billion across the 13 states (interstate and National Truck Network).

Existing State and Federal Regulations and Laws

Truck shipments from North Dakota to adjacent states are challenged with different state laws and regulations. The federal government also plays a part in vehicle size and weight limits in the states. The following information provides vehicle weight and length laws in North Dakota, South Dakota, Minnesota, Montana, Manitoba, and Saskatchewan, and explains how existing federal regulations affect vehicle weight and length limits.

North Dakota

Weight Limits - The legal Gross Vehicle Weight (GVW) on North Dakota state highways is 105,500 lbs. unless otherwise posted. The legal GVW on local roads is 80,000 lbs. unless otherwise designated, but not to exceed 105,500 lbs. A single axle, which can also be a steering axle, is legal up to 20,000 lbs. A tandem axle, two axles with a linear measurement of more than 40 in. but less than 8 ft. from axle center to axle center, is legal up to 34,000 lbs. A group of three or more axles shall not exceed 48,000 lbs. No axle in a group of two or more axles shall exceed 19,000 lbs. No tire shall exceed 550 lbs. per inch of tire width or the weight rating of a tire. State law requires vehicles and vehicle combinations hauling divisible loads to comply with the exterior bridge length of the federal bridge formula when traveling on the state and local roadway systems. Exterior bridge length is the linear measurement from the center of the steering axle to the center of the rearmost trailer axle. (NDCC 39-12-05.3)

Vehicles traveling on North Dakota's interstate system must comply with both the interior and exterior bridge length of the federal bridge formula. Interior bridge length is linear measurement from the first axle to the last axle center in a group of axles. It is also the linear measurement from the center of the first axle in a group of axles to the center of the last axle in another group of axles. A vehicle combination may have multiple interior bridge lengths. The legal weight on the steering axle is determined by the axle rating or weight rating on a tire, not to exceed 20,000 lbs. The legal weight on a tandem axle is 34,000 lbs. The legal weight on a group of three or more axles is determined by the interior bridge length. No axles in a group of two or more axles shall exceed 17,000 lbs. No tire shall exceed 550 lbs. per inch of tire width with the exception of the steering axle. No tire shall exceed the manufacturer's weight rating. The legal GVW on the interstate system is 80,000 lbs. A vehicle with sufficient axles and bridge lengths can exceed 80,000 lbs., but not to exceed 105,500 lbs. A permit must be purchased when over 80,000 lbs. GVW on the interstate system.

Length Limits - The legal overall length of a combination of two or more vehicles traveling on North Dakota's highway system is 75 ft. The highway system includes local roads. Authorized vehicle combinations, as shown in North Dakota Administrative Code 37-06, may exceed 75 ft., but shall not exceed 95 ft. in overall length when traveling on designated state highways. On the national network or designated state highways, the overall length shall not exceed 110 ft. However, when the vehicle combination is a truck-tractor semitrailer and full trailer, and travel is on the national network, the combination trailer length shall not exceed 100 ft., and there is no overall length limit. Vehicle combinations authorized to exceed 75 ft. in overall length may travel a distance of 10 miles on state highways off the designated highway system. (NDCC 39-12-04 subsections 3 and 4, NDAC 37-06)

Bridges on County Roads – FHWA regulations require bridges to be posted when unable to safely carry legal loads of 72,000 lbs. (36 tons) GVW. N.D. county officials are required to post a bridge when it cannot safely carry 72,000 lbs. GVW (36 ton). Government entities are allowed to post a bridge at a lower weight to protect roadways and bridges.

Exceptions – Interstate Permit: The legal GVW on the interstate system is 80,000 lbs. A vehicle with sufficient axles and bridge lengths can exceed 80,000 lbs., but not to exceed 105,500 lbs. A permit must be purchased when over 80,000 lbs. GVW. The single trip permit fee is $25 and the annual permit fee is $300. The interstate system is regulated by federal law. (Title 23 – Appendix C, NDCC 39-12-02, 39-12-05).

Ten Percent Weight Exemption Permits: From July 15 through November 30, vehicles hauling harvested product from the field to the first point of storage, or hauling sugar beets, potatoes, and solid waste from any location can carry 10% more weight over legal weight limits. From December 1 through March 7, vehicles hauling any product from any location can carry 10% more weight over legal weight limits. The GVW cannot exceed 105,500 lbs. A carrier must obtain a permit that is vehicle specific. The fee is $50 per 30-day period or $250 for the period of July 15 through March 7. Travel is not allowed on the interstate system, local roads, or on state highways with reduced axle weight limits year around. Travel is not allowed on specific bridge structures. (NDCC 39-12-05.3, subsections 4 and 5, 39-12-02.

Equipment Approval Permit: A single unit truck with a group of three or four axles is allowed to carry a maximum GVW of 64,000 lbs. provided the vehicle meets specific requirements. The carrier must obtain a $15 annual equipment approval certificate. The gross weight on the group of three or four axles is legal up to 51,000 lbs. Travel is not allowed on the interstate system and on specific bridge structures. The federal bridge formula is not used. (NDCC 39-12-05.3 subsection 3, NDAC 38-06-03). In 2015, industry purchased 586 equipment approval permits and in 2014, industry purchased 659 permits.

Longer Combination Vehicle (LCV) Permit: From December 1 through March 7, a vehicle combination with sufficient number of axles as per exterior bridge length (interior bridge length check not required) may carry a GVW up to 131,000 lbs. All axle weights must be legal, and travel is not allowed on the interstate system, local roads, or on state highways with reduced weight postings. The carrier has the option to purchase a $100 30-day permit or a $35 single trip permit ($15 for routing fee.) The permit is truck specific. (NDCC 39-12-02, 39-12-05.3) In 2015, industry purchased 59 30-day LCV permits and 17 single-trip LCV permits. In 2014 there were 35 30-day LCV permits purchased and 39 single-trip LCV permits. As of February 9, 2016, there were 17 30-day LCV permits purchased.

Bridge Length Permit: The bridge length permit exempts a single unit truck with a group of four or more axles in the rear from the gross weight limitations as set by state law (39-12-05.3, subsection 1) when traveling on the state system. The bridge length permit allows for a group of four or more axles with sufficient interior bridge length to exceed 48,000 lbs. The interior and exterior bridge lengths of a vehicle are used when determining legal weights. The GVW may not exceed 80,000 lbs. The fee for an annual permit is $150. The fee for a single-trip permit is $30 plus a $15 routing fee ($45). (NDCC 39-12-05.3 subsection 7, 39-12-05, 39-12-02)

South Dakota

Weight Limits - South Dakota does not have a maximum legal GVW limit on most state and local roads. Roads with reduced weight limits are posted. On the interstate system, the legal GVW is 80,000 lbs. The interstate system is regulated by federal law.

A vehicle with sufficient number of axles and bridge lengths, and legal axle weights can obtain an interstate permit to exceed 80,000 lbs. There is no maximum GVW limit, unless the vehicle combination is considered to be an LCV. When considered an LCV and travel is on the national network, which includes the interstate system, the GVW cannot exceed 129,000 lbs. An LCV permit must be purchased and can be used in lieu of the interstate permit when travel is on the interstate. The interstate system is regulated by federal law.

The legal weight on the steering axle is determined by the weight rating of a tire when travel is on the interstate system, and on other roads the steering axle shall not exceed 600 lbs. per inch of tire width. The legal weight may not exceed 20,000 lbs. A single axle is legal up to 20,000 lbs. and a tandem axle is legal up to 34,000 lbs. On a group of three or more axles, the legal weight is determined by the federal bridge formula. On all axles but the steering axle, no tire shall exceed 500 lbs. per inch of tire width. Vehicles and vehicle combinations hauling divisible loads on South Dakota's roads must comply with both interior and exterior bridge length of the federal bridge formula.

Length Limits - On the South Dakota road system the legal cargo carrying length of "doubles combination trailers" is 81 ft. 6 in. The legal length of a single trailer in this combination is 45 ft. There is no overall length limit when the combination length of the two trailers does not exceed 81 ft. 6 in. and a neither trailer in that combination exceeds 45 ft. Travel is allowed on all highways.

When the cargo-carrying length of the doubles combination trailers exceed 81 ft. 6 in. or a single trailer in that combination exceeds 45 ft., it is considered an LCV, and the overall length shall not exceed 110 ft. LCVs must be permitted and are authorized to travel only on the national network, which includes the interstate system. Length limits for two-vehicle combinations vary. The overall length of a straight truck and trailer in combination is 80 ft. The legal length of a semitrailer operating in a truck-tractor semitrailer combination is 53 ft., and there is no overall length limit. Travel is allowed on all highways.

Exceptions – Interstate Permit: Vehicles that exceed the legal GVW of 80,000 lbs. when traveling on the interstate system are subject to an interstate permit. All axle weights must be legal, and the vehicle must have sufficient number of axles and bridge lengths. The fee for a single trip permit is $25; for an annual permit the fee is $60.

Longer Combination Vehicle Permit: An LCV permit is required when the cargo-carrying length of doubles combination trailers exceeds 81 ft. 6 in. or a single trailer in that combination exceeds 45 ft. The overall length may not exceed 110 ft. A straight truck and trailer combination that exceeds 80 ft. can obtain a permit not to exceed an overall length of 85 ft. The GVW may not exceed 129,000 lbs. and all axle weights must be legal. Travel is allowed only on the national network. The national network consists of the interstate system and segments of divided state highways. The fee for a book of 10 single-trip permits is $100 ($10 for each single trip permit). An LCV permit can be used in lieu of an interstate permit when travel is on the interstate system.

Ten Percent Weight Exemptions: Vehicles hauling harvested product from the field to the first point of storage qualify to carry an additional 10% more weight. The distance traveled cannot exceed 50 miles. Vehicles hauling product from farm storage to the market are granted a 5% tolerance above legal weight limits. The distance traveled cannot exceed 50 miles. There is no permit and no additional fee assessed for these weight exemptions.

Bridges on County Roads - County officials are not required to post their bridges showing axle or GVW limits. It is, however, highly recommended that a bridge be posted if the bridge has a low weight rating.

Minnesota

Weight Limits - The legal GVW on Minnesota roads is 80,000 lbs. Minnesota's legal axle weights and lbs. per inch of tire width are the same as South Dakota. The legal weight on the steering axle is determined by the weight rating of a tire when travel is on the interstate system, and on other roads the steering axle shall not exceed 600 lbs. per inch of tire width. The legal weight may not exceed 20,000 lbs. A single axle is legal up to 20,000 lbs. and a tandem axle is legal up to 34,000 lbs. On a group of three or more axles, the legal weight is determined by the federal bridge formula. On all axles but the steering axle, no tire shall exceed 500 lbs. per inch of tire width. Vehicles and vehicle combinations hauling divisible loads on Minnesota roads must comply with both interior and exterior bridge length of the federal bridge formula.

Length Limits - The legal overall length for a two- or three-vehicle combination is 75 ft. on all Minnesota roads. There is no permit issued or any exceptions authorizing vehicle combinations to exceed this length limit.

Exceptions - Ag Products Permit: A carrier hauling raw ag product (product that has not been processed), with a six-axle vehicle combination or seven-axle vehicle combination can purchase an ag products permit that authorizes GVWs up to 90,000 and 97,000 lbs., respectively. All axle weights must be legal and must meet the federal bridge formula. Travel is allowed on state and U.S. highways. Travel is not valid on the interstate system. The fee for the permit is $300 for 90,000 lbs. and $500 for 97,000 lbs. During the winter months, the ag products permit is valid for up to 99,000 lbs. GVW provided the vehicle combination has legal axle weights and sufficient bridge distances. The carrier must increase the vehicle registration for a higher GVW.

Ten Percent Weight Exemption Permit: Carriers with this permit can haul 10% more weight above legal weight limits, not to exceed 88,000 lbs. GVW. Travel is allowed on the interstate system. The $60 permit is vehicle specific, and the carrier must also increase the vehicle's registered weight. The permit is valid during the winter period only.

Montana

Weight - The legal GVW on state and local roads in Montana is 131,060 lbs. unless otherwise posted. The legal GVW on the interstate system is 80,000 lbs. Vehicles with sufficient axles and bridge lengths can legally have a GVW of 131,060 lbs. when traveling on the interstate system. Unlike most states, Montana does not issue a permit. Vehicles registered for more than 80,000 lbs. GVW are assessed accordingly in motor vehicle registration fees collected.

When travel is on the interstate system, the legal weight on the steering axle is determined by the axle rating or tire rating, not to exceed 20,000 lbs. When travel is on all other Montana roads, the steering axle shall not exceed 600 lbs. per inch of tire width. The legal weight shall not exceed 20,000 lbs.

A single axle is legal up to 20,000 lbs. and a tandem axle is legal up to 34,000 lbs. On a group of three or more axles, legal weight is determined by the federal bridge formula. No wide base tire shall exceed 500 lbs. per inch of tire width. A tire is considered wide base when the tire sidewall width is 14 in. and greater. If the tire width is less than 14 in., the lbs. per inch of tire width are not considered.

A vehicle or vehicle combination hauling a divisible load traveling on Montana's roads must comply with both interior and exterior bridge length of the federal bridge formula.

Length – On Montana's road system, the legal length of a two-vehicle combination is 75 ft. The legal length of a semitrailer in a two-vehicle combination is 53 ft. The legal length of a single trailer in a combination of two trailers is 28 ft. 6 in. The legal combination length of two trailers is 61 ft. The legal length limits for vehicle combinations in Montana vary.

Exceptions - Doubles Permit: When the combination length of two trailers exceeds 61 ft. or a single trailer in the combination exceeds 28 ft. 6 in., there is no overall length limit, but a permit is required. With this permit, the combination length of two trailers may exceed 81 ft. provided the overall length does not exceed 95 ft. Travel is allowed on all Montana roads. The permit is $75 for a calendar year or $20 for single-trip movement. When the overall length of this vehicle combination exceeds 95 ft., travel is allowed only on the interstate system and the overall length may not exceed 100 ft. The carrier must purchase an annual doubles interstate permit. The fee is $125 per calendar year.

Triple Trailer Combination Permit: Triple trailer combinations are allowed to travel only on the interstate system in Montana. The overall length may not exceed 110 ft. The fee for annual permit is $200; a single trip permit is $20.

Tolerance Permit: A tolerance permit may be issued by the state department when a vehicle is found to be in violation of legal axle weights or GVW limits by no more than 10%. The permit allows the carrier to travel to the first facility where the load can be adjusted or to its destination. The tolerance permit is not a method to haul overweight but a process to allow for a mistake. The fee for the single-trip permit is $10.

Exemption: Farm vehicles transporting agricultural products from a harvesting combine or other harvesting machinery may exceed legal weight limits by 20% for each axle but not to exceed 670 lbs. per inch of tire width. Travel must be within 100 miles of the harvested field. Travel is not allowed on the interstate system. There is no permit and no additional fee is assessed for this weight exemption.

Interstate System: The legal GVW on the interstate system is 80,000 lbs. Montana does not issue a permit. Vehicles hauling divisible loads with a GVW over 80,000 lbs. are assessed accordingly in motor vehicle registration fees collected. Vehicles with sufficient axles and bridge lengths can legally have a GVW of 131,060 lbs. when traveling on the interstate system. All axle weights must be legal.

Manitoba

Weight - On highways designated as Road Transportation Association of Canada (RTAC) routes, authorized vehicle combinations are legal up to 137,787 lbs. GVW. On some RTAC routes, the legal GVW is 139,992 lbs. On highways designated as A1 routes, RTAC vehicles are legal up to 124,559 lbs. GVW. Non-RTAC vehicles traveling on RTAC and A1 designated routes are legal up to 119,048 lbs. GVW. On routes identified as B1 highways, RTAC vehicles and non-RTAC vehicles are legal up to 105,005 lbs.

TransCanada Highway 1 is similar to the interstate system in the United States. In Canada however, TransCanada Highway 1 is regulated by each province as opposed to their federal government. In Manitoba, TransCanada 1 is designated as an RTAC highway allowing a legal GVW up to 139,992 lbs. (63,500 KG's).

RTAC compliant vehicles conform to the national standards designated by the RTAC. These vehicles meet the required wheelbase measurements, kingpin setback, interaxle spacing and axle spread criteria. Tire width and number of tires per axle are also factors used to determine the legal weight. On vehicles that do not meet the RTAC standards the legal weight is reduced and a permit may be required.

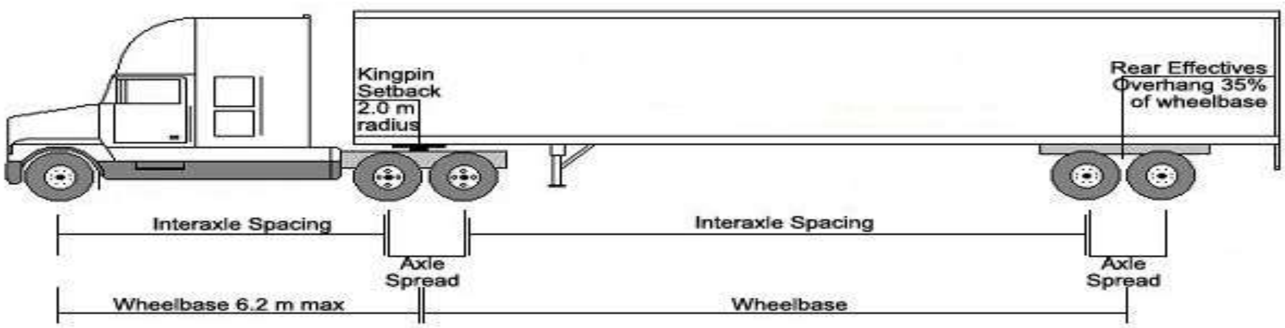


Figure 3. Definitions of Truck Measurements

On an RTAC route, a steering axle is legal up to 13,227 lbs. A single axle with dual tires is legal up to 20,061 lbs. A tandem axle is legal up to 37,478 lbs. and a triple axle is legal up to 52,910 lbs. On highways designated as B1, a single axle with dual tires is legal up to 16,975 lbs., a tandem axle is legal up to 30,423 lbs., and a triple axle is legal up to 41,887 lbs.

Length – On Manitoba's road system, a non-RTAC vehicle combination is legal up to 75 ft. 4 in. An RTAC vehicle combination is legal up to 90 ft. 3 in. when traveling on any road in Manitoba.

Saskatchewan

Weight – On primary roads in Saskatchewan, the legal GVW is 137,787 lbs. Some primary highways have been designated as 63,500 kg and the legal GVW is 139,992 lbs. On secondary roads, the maximum legal GVW is 121,253 lbs.

TransCanada Highway 1 is similar to the interstate system in the United States. TransCanada Highway 1 is regulated by each province as opposed to their federal government. In Saskatchewan, highways 1 and 16, which are mostly four-lane, are designated as primary 63,500 kg and the legal GVW is 139,992 lbs.

The wheelbase measurements, interaxle spacing, axle spread, axle configuration, kingpin setback, tire width, and number of tires per axles are factors used to determine legal axle and GVW of a vehicle combination. Vehicles that conform to the standards set by law are given more weight than those that do not meet those standards.

On a primary road, the steering axle is legal up to 13,227 lbs. A single axle is legal up to 20,061 lbs. A tandem axle can be legal up to 37,478 lbs., and a triple axle is legal up to 52,910 lbs. On a secondary road, the steering axle is legal up to 13,227 lbs., a single axle is legal up to 18,077 lbs., a tandem axle is legal up to 31,966 lbs., and a triple axle is legal up to 44,092 lbs.

Length – In Saskatchewan, the legal overall length of vehicle combination(s) on all roads is up to 85 ft. 3 in.

Exceptions – Permits: Vehicles that do not conform to standards set by law may qualify for a permit. The weights authorized will be less than what is allowed on a vehicle that does conform to standards stipulated in law. A vehicle that does not meet standards set by law loses 280.4 lbs. for every inch (500 kg for every .1 meter).

Winter: During the winter months, vehicles are allowed winter weights on single and tandem axles. A single axle can weigh up to 22,046 lbs. and a tandem axle can weigh up to 39,682. There is no additional weight allowed on a triple axle. A vehicle cannot exceed the GVW limit of 137,787 lbs. on primary roads and 121,253 lbs. on secondary roads.

Existing Federal Regulations Regarding Grandfathered Situations

In 1956, the federal government began to regulate the size of trucks traveling on interstate highways. In 1974, Congress adopted the AASHTO Formula B for the interstate system. This law increased the weights on single and tandem axles to 20,000 lbs. and 34,000 lbs., respectively. It also established the legal GVW of 80,000 lbs. In 1975, the N.D. Legislature adopted the AASHTO Formula B as the new weight law. Since most North Dakota state highways were already at a GVW to 82,000 lbs. in 1973, the highway commissioner authorized the issuance of interstate permits so vehicles could carry the same GVW on the interstate system as the state system. In 1979, North Dakota increased the legal GVW on designated state highways to 105,500 lbs. This GVW of 105,500 lbs. was eventually allowed on most state highways.

Surface Transportation Assistance Act of 1982 (STAA of 1982) – The Act of 1982 established the national network highway system and stipulated that states must give vehicles and vehicle combinations reasonable access from the national network highway system to terminals, facilities for food, fuel, repairs, and rest. North Dakota currently allows multiple vehicle combinations that exceed the legal length limit of 75 ft. access of 10 miles on a state highway off the designated national network. This act also froze the length of the semitrailer when used in combination with a truck-tractor. North Dakota cannot set its maximum trailer length to less than 53 ft. for a truck-tractor semitrailer combination. In addition, the

STAA stipulated that no state shall impose an overall length limit on a truck-tractor semitrailer or truck-tractor semitrailer and trailer combination (A-train). These are considered STAA vehicle combinations.

Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991: ISTEA froze the length limits of longer combination vehicles (LCVs) traveling on the national network. In North Dakota, the legal overall length of an LCV is 110 ft. when traveling on the national network, except if it considered an STAA vehicle combination. Because the Act of 1982 does not allow a state to set the overall length limit of an A-train, it established that the cargo carrying length of semitrailer and the trailer cannot exceed 100 ft. when used with a truck-tractor.

ISTEA froze the GVW limits of vehicles traveling on the interstate system in every state. If states were allowing vehicles to exceed 80,000 lbs. GVW when traveling on the interstate system, they were allowed to continue that practice. The federal government allowed jurisdictions to continue with the GVW limit they had in place provided the limit was actually and lawfully in effect on June 1, 1991. North Dakota was issuing permits authorizing vehicles with legal axle weights and sufficient bridge lengths to carry a GVW up to 105,500 lbs. North Dakota had increased the legal GVW to 105,500 lbs. in 1979.

Summary: ISTEA froze the length limits of authorized vehicle combinations (NDAC 37-06) traveling on the national network. ISTEA also froze the maximum GVW limit on North Dakota's interstate system to a maximum of 105,500 lbs. With harmonization, vehicle combinations over 105,500 lbs. could not travel on the interstate system. Multiple vehicle combinations traveling on the national network would be restricted to an overall length of 110 ft. with the exception of the A-train, also known as a double bottom. The cargo carrying length of a double bottom combination cannot exceed 100 ft. These length limits are frozen due to ISTEA and STAA. A double bottom vehicle combination consists of a truck-tractor, semitrailer, and full trailer. State highways that are part of the national network are four-lane and two-lane roadways. [National network state highways: 4-Lane = US-83 (Bismarck to Minot), US-2. 2-Lane: US-52, US-281, US-85, US-81, US-83, 83-Bypass, US-12; segments of ND-13, ND-46, ND-22, ND-32, ND-30, ND-66, ND 1804]

The length limitations map below shows North Dakota roads considered part of the National Network. The map also identifies the legal length limits of multiple vehicle combinations traveling on all North Dakota state/interstate highways. A list of vehicle combinations can be found in NDAC 37-06.

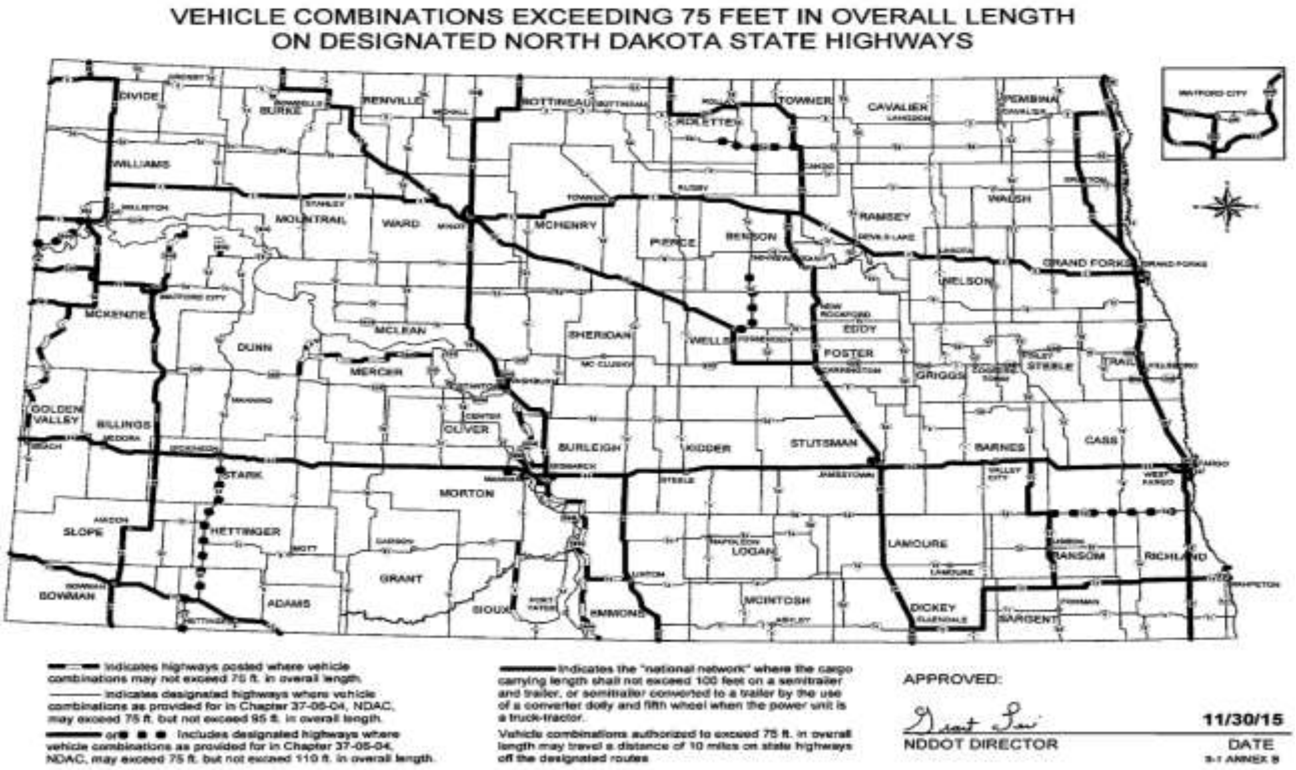


Figure 4: Vehicles Combinations Exceeding 75' Overall Length on Designated ND Highways
Source: NDDOT

Summary

Harmonizing North Dakota weight laws with adjacent states would require trucks traveling on North Dakota state and local roads system to comply with both interior and exterior bridge laws.

Harmonizing weight laws with adjacent states could mean increasing the legal GVW limit for vehicles traveling on North Dakota state highways.

Harmonizing N.D. weight laws could partially eliminate the differences of weight laws currently encountered by industry when traveling on N.D. state highways versus the interstate system. Currently, trucks traveling into North Dakota on state and local roads comply with different weight laws than trucks traveling on highways in adjacent states and on North Dakota's interstate system.

On the North Dakota interstate highways and in adjacent states, a vehicle must comply with both the interior and exterior bridge lengths of the federal bridge formula. When that same vehicle travels on N.D. state and local highways it is required to comply only with exterior bridge length. Because only exterior bridge length of the federal bridge formula is used when travel is on the state and local roads system, a group of three or more axles is legal up to 48,000 lbs. When that same vehicle is traveling on the N.D.

interstate system and in adjacent states, the legal weight on a group of three or more axles is determined by the interior bridge length of the federal bridge formula. A group of three axles is typically legal up to 43,500 lbs., and group of four axles is legal up to 51,500 lbs. A six-axle truck-tractor semitrailer combination traveling in adjacent states and the N.D. interstate system is typically carrying a GVW of 89,500 lbs. That same six-axle vehicle combination traveling on N.D. state highways and local roads system can carry a GVW up to 94,000 lbs. provided it has sufficient exterior bridge length. However, with insufficient exterior bridge length, the legal GVW for this vehicle combination will be less than 94,000 lbs.; thus, it will be less impacted with harmonization.

The legal GVW limit in North Dakota and adjacent jurisdictions varies as follows: North Dakota – 105,500 lbs., Montana – 131,060 lbs., South Dakota – 129,000 lbs. for longer combination vehicles, otherwise no maximum GVW limit, Minnesota - 80,000 lbs., Manitoba – 137,787 lbs., and Saskatchewan – 137,787 lbs.

In 1991, the federal government passed a transportation bill called ISTEA. ISTEA froze the GVW limits on the interstate systems. ISTEA also froze the length limits of authorized vehicle combinations traveling on the national network. The length limit for highways that are not part of the national network is determined by the state. The length limit of vehicle combinations vary from one jurisdiction to the next. A similarity seen between North Dakota, Montana, and Minnesota is an overall length limit of 75 ft. Another similarity between North Dakota and Montana is the overall length limit of 95 ft.; however, Montana requires a permit when the combination length of two trailers exceed 81 ft. A similarity seen between South Dakota and North Dakota is the overall length limit of 110 ft. for a longer combination vehicle traveling on the national network. South Dakota requires the carrier to purchase a permit when the combination trailer length exceeds 81 ft. 6 in. North Dakota does not require a permit.

Minnesota and North Dakota have the highest number of highways considered part of the national network. In Montana, the interstate system is the only highway considered part of the national network; in South Dakota, the national network is made up of segments of divided highways and the interstate system.

In North Dakota and Minnesota, motor carriers can purchase permits that authorize higher GVW limits, and/or higher axle weight limits. In North Dakota there are 10% winter and harvest weight exemption permits available. The permits authorize 10% more weight on a vehicle's axles and/or GVW. The GVW cannot exceed 105,500 lbs. An LCV permit, which is available during the winter months, authorizes up to 131,000 lbs. GVW. Vehicles must meet only the exterior bridge length requirement and have legal axle weights. Travel is not allowed on the interstate system or local roads.

In Minnesota, vehicles hauling raw ag or forest products can obtain permit authorizing a GVW up to 97,000 lbs. During the winter, the permit authorizes up to 99,000 lbs. GVW. Carriers hauling other products during the winter can permit up to 88,000 lbs. and travel on the interstate system.

South Dakota does not require vehicles hauling harvested product to obtain a permit when carrying ten percent more weight from the field to the first point of storage. They do however restrict the distance traveled to 50 miles. Montana does not issue permits authorizing vehicles hauling divisible loads to exceed legal weight limits set by state law.

Manitoba and Saskatchewan legal vehicle weights are derived from different factors than what is used in North Dakota. On state highways in North Dakota exterior bridge length, axle spacing, number of tires per axle, and tire width are used to determine legal weight for a vehicle. In the provinces, the inter-axle spacing, wheelbase measurements, kingpin setback, axle spread, number of tires per axle, and tire width are used to determine legal vehicle weight. A couple of similarities between North Dakota and the provinces are the use of tire width, number of tires per axle, and the law that no tire shall exceed 550 lbs. per inch of tire width or the tire manufacturer's weight rating are used when determining legal weights on a vehicle.

Harmonizing weight laws with adjacent jurisdictions will benefit some carriers and impact others. Table 2 on the following page summarizes the legal truck sizes allowed in North Dakota and surrounding states and provinces.

	Width (inches)	Length (feet)	Height	Lb./Inch of Tire Width	GVW Interstate Highways	Maximum GVW Other Highways	Single Axle (lbs.)	Tandem Axle[5] (lbs.)	Group of 3 or More Axles (lbs.)
ND	102"	75'[1]	14'	550[2]	80,000[3] Interior/Exterior Bridge	105,500[4] Exterior Bridge	20,000	34,000	48,000[6]
SD	102"	110'[7]	14'	600/500[8]	80,000[9] Interior/Exterior Bridge	No GVW Interior/Exterior Bridge	20,000	34,000	Determined by Bridge Formula
MN	102"	75'	13'6"	600/500[10]	80,000 Interior/Exterior Bridge	80,000 Interior/Exterior Bridge	20,000	34,000	Determined by Bridge Formula
MT	102"	75'[11]	14'	600/500[12]	80,000[13] Interior/Exterior Bridge	131,060 Interior/Exterior Bridge	20,000	34,000	Determined by Bridge Formula
Man.	102"	75'4" [14]	13'6"	550 [15]	139,992 [16] Interaxle Spacing, Axle spread, Wheelbase	137,787 [17] Interaxle spacing, Axle spread, Wheelbase	16,975 to 20,061 [18]	30,423 to 37,478 [19]	41,887 to 52,910 [20]
Sask.	102"	85'2"	13'6"	550 [21]	139,992 [22] Interaxle spacing, Axle spread, Wheelbase	137,787 [23] Interaxle spacing, Axle spread, Wheelbase	18,077 to 20,061 [24]	31,966 to 37,478 [25]	44,092 to 52,910 [26]

Table 2: Summary of Legal Truck Sizes in N.D. and Surrounding Areas

[1] The legal overall length of a combination of two or more vehicles traveling on North Dakota's highway system is 75 ft. Authorized vehicle combinations, as shown in North Dakota Administrative Code 37-06, may exceed 75 ft., but shall not exceed 95 ft. in overall length when traveling on designated state highways. On the national network or on designated state highways, the overall length shall not exceed 110 ft. When the vehicle combination is a truck-tractor semitrailer and full trailer and travel is on the national network, the combination trailer length shall not exceed 100 ft., and there is no overall length limit. Vehicle combinations authorized to exceed 75 ft. in overall length may travel a distance of 10 miles on state highways off the designated highway system (NDCC 39-12-04 subsections 3 and 4, NDAC 37-06)

[2] No tire shall exceed 550 lbs. per inch of tire width, with the exception of the steering axle. On the interstate system, the legal weight on the steering axle is determined by axle rating or tire weight rating not to exceed 20,000 lbs. On all axles, no tire shall not exceed the manufacturer's weight rating.

[3] A vehicle with sufficient number of axles and bridge lengths can exceed 80,000 lbs. but not to exceed 105,500 lbs. A permit must be purchased when over 80,000 lbs. GVW.

[4] The legal GVW on local roads is 80,000 lbs. unless otherwise designated, but not to exceed 105,000 lbs. A single axle, which can also be a steering axle, is legal up to 20,000 lbs.

[5] A tandem axle, two axles with linear measurement of more than 40 in. but less than 8 ft. from axle center to axle center, is legal up to 34,000 lbs.

[6] A group of three or more axles shall not exceed 48,000 lbs. on the state system. No axle in a group of two or more axles shall exceed 19,000 lbs. Legal weight on the interstate is determined by the bridge formula.

[7] On South Dakota road system the legal length of doubles combination trailers is 81 ft. 6 in. The legal length of a single trailer in this combination is 45 ft. There is no overall length limit when the combination length of two trailers does not exceed 81 ft. 6 in. or a single trailer in the combination does not exceed 45 ft. When the length of the doubles combination trailers exceed 81 ft. 6 in. or a single trailer in that combination exceeds 45 ft., it is considered a long combination vehicle, and the overall length may not exceed 110 ft.. LCV's must be permitted and are authorized to travel only on the national network which includes the interstate system.

[8] The legal weight on the steering axle is determined by the axle rating when travel is on the interstate system, and on other roads the steering axle shall not exceed 600 lbs. per inch of tire width. On all axles but the steering axle, no tire shall exceed 500 lbs. per inch of tire width. On all axles, no tire shall exceed the manufacturer's weight rating.

[9] On the interstate system, the legal GVW is 80,000 lbs. A vehicle with sufficient number of axles and bridge lengths, and legal axle weights can obtain an interstate permit to exceed 80,000 lbs. There is no GVW limit, unless the vehicle combination is considered to be a longer combination vehicle (LCV). When considered a LCV, travel is allowed only on the national network which includes the interstate system. The GVW cannot exceed 129,000 lbs. An LCV permit must be purchased and can be used in lieu of the interstate permit when travel is on the interstate. The interstate system is regulated by federal law.

[10] The legal weight on the steering axle is determined by the axle rating when travel is on the interstate system, and on other roads the steering axle shall not exceed 600 per inch of tire width. On all axles but the steering axle, no tire shall exceed 500 lbs. per inch of tire width.

[11] On Montana's road system the legal length of a two-vehicle combination is 75 ft. The legal length of a single trailer in a combination of two trailers is 28 ft. 6 in. The legal combination length of two trailers is 61 ft. The legal length limits for vehicle combinations in Montana vary. When the combination length of two trailers exceed 61 ft. or a single trailer in that combination exceeds 28 ft. 6 in., there is no overall length limit but a permit is required.

[12] When travel is on the interstate system, the legal weight on the steering axle is determined by the axle rating or tire rating, not to exceed 20,000 lbs. When travel is on all other Montana roads no tire on a steering axle tire shall exceed 600 lbs. per inch of tire width. The legal weight shall not exceed 20,000 lbs. On a group of three or more axles, legal weight is determined by the federal bridge formula. No wide base tire shall exceed 500 lbs. per inch of tire width. A tire is considered wide base when the tire width is 14 in. or greater. If the tire width is less than 14 in., the lbs. per inch of tire width are not considered.

[13] The legal GVW on the interstate system is 80,000 lbs. Montana does not issue a permit. Vehicles hauling divisible loads with a GVW over 80,000 lbs. are assessed accordingly in motor vehicle registration fees collected. Vehicles with sufficient axles and bridge lengths can legally have a GVW of 131,060 lbs. when traveling on the interstate system. All axle weights must be legal.

[14] The overall legal length of a non-RTAC (Road Transportation Association of Canada) vehicle combination is 75 ft. 4 in. An RTAC vehicle combination is legal up to 90 ft. 3 in. when traveling on any road in Manitoba.

[15] The maximum weight per tire shall not exceed the tire manufacturer's weight rating or the width of the tire stamped on the sidewall multiplied by 10 kg/mm. This equates to 550 lbs. per inch of tire width.

[16] The legal GVW on the TransCanada highway is 139,992 lbs. Qualifying RTAC vehicle combinations such as the Super B train can carry a GVW up to 139,992 lbs. Most vehicles will not exceed 137,787 lbs.

[17] On B1 routes, the legal GVW shall not exceed 105,005 lbs. On designated A1 routes a vehicle can have a legal GVW up to 124,559 lbs. On all RTAC routes the legal GVW is 137,787 and on designated RTAC routes the legal GVW is 139,992 lbs.

[18] The legal weight on a single axle is from 16,975 to 20,061 lbs., dependent on the route of travel. When a vehicle does not meet standards the weight may be less.

[19] The legal weight on a tandem axle is from 30,423 to 37,478 lbs., dependent on the route of travel. When a vehicle does not meet standards, the weight may be less.

[20] The legal weight on a triple axle is from 41,887 to 52,910 lbs., dependent on the route of travel. When a vehicle does not meet standards, the weight may be less.

[21] The maximum weight per tire shall not exceed the tire manufacturer's weight rating or the width of the tire stamped on the sidewall multiplied by 10 kg/mm. This equates to 550 lbs. per inch of tire width.

[22] The legal GVW on the TransCanada highway is 139,992 lbs. Qualifying RTAC vehicle combinations such as the Super B train can carry a GVW up to 139,992 lbs. Most vehicles will not exceed 137,787 lbs.

[23] On primary routes the legal GVW is 137,787 lbs. On primary routes designated as 63,500 KG's, a vehicle can carry a GVW up to 139,992 lbs. On secondary routes the legal GVW shall not exceed 121,253 lbs.

[24] The legal weight on a single axle ranges from 18,077 to 20,061 lbs. dependent on the route of travel. When a vehicle does not meet standards the weight may be less.

[25] The legal weight on a tandem axle ranges from 31,966 to 37,478 lbs., dependent on the route of travel. When a vehicle does not meet standards, the weight may be less.

[26] The legal weight on a triple axle ranges from 44,092 to 52,910 lbs., dependent on the route of travel. When a vehicle does not meet standards, the weight may be less.

Major Truck Classifications – Harmonization: Impacts and Benefits

Harmonizing N.D. vehicle weight limits with adjacent states will require North Dakota to change current weight laws that are applicable only to N.D. state highways and local roads. The vehicle weight laws in North Dakota for the state and local roads system slightly vary with the weight laws for vehicles traveling on the interstate system. N.D. weight laws for vehicles traveling on the interstate system are similar to vehicle weight laws in adjacent states, but with some variances.

On the North Dakota state system and local road systems, exterior bridge length of the federal weight formula and the total number of axles are two of the five factors considered with determining legal GVW. Exterior bridge length is the measurement in feet from the center of the steering axle to the center of the rear most axle on a vehicle or vehicle combination. When determining legal weight on a group of three or more axles or on a combination of axle groups, the interior bridge length of the federal bridge weight formula is not used. Current state law allows a group of three or more axles a gross axle weight up to 48,000 lbs. The only requirement relating to bridge length is for each axle to have a minimum measurement of over 40 in. from axle center to axle center. When the measurement is 8 ft. or more from consecutive axle to consecutive axle, it is considered the start of a new axle group.

Figure 5: Illustration of Exterior Bridge Distance

On the interstate system, interior and exterior bridge lengths and number of axles are considered. Interior bridge length is as follows:

1. The measurement in feet from the center of the first axle to the center of the last axle in a group of axles.
2. The measurement in feet from the center of the first axle of an axle group to the center of the last axle in another axle group.
3. A vehicle or vehicle combination can have more than one interior bridge length.
4. The same rules apply relating to more than 40 in. from axle center or 8 ft. and greater.

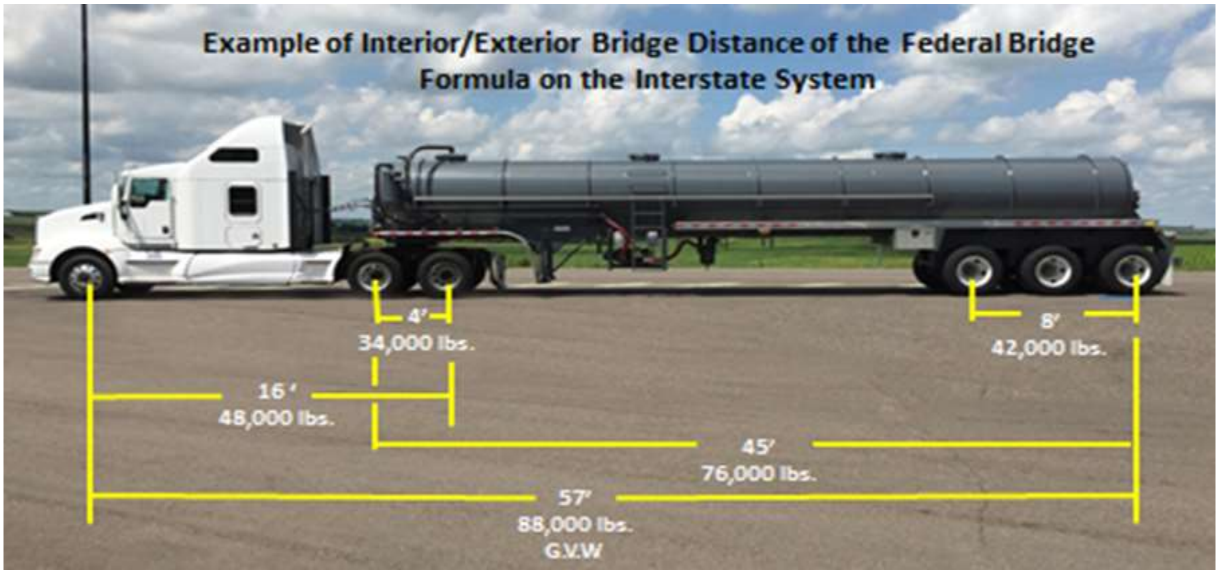


Figure 6: Illustration of Interior/Exterior Bridge Distance

A significant number of North Dakota motor carriers use state highways and local roads exclusively because of the higher weight allowed on the triple axle and other axle configurations that are not impacted by the interior bridge length of the federal bridge weight formula. These motor carriers include, but are not limited to, the agricultural industry, sugar beet industry, companies hauling aggregate and road materials, and the oil industry. With harmonization, vehicles with triple axles or with axles not meeting interior bridge length measurements may be impacted. However, these same vehicles with a triple axle may already have a reduced legal GVW (less than 94,000 lbs.) because the vehicle does not have sufficient exterior bridge length to allow all axles to haul maximum legal gross axle weights.

Typically, vehicles that have an axle configuration with four or more axles in a group, have a total of seven or more axles, or have more than two vehicles in the vehicle combination will benefit. Some vehicles and vehicle combinations will not benefit and some would not be impacted by harmonization.

The following information shows a comparison of current law to harmonization relating to GVW allowed and weight allowed on axle groups. The number in parentheses following each vehicle type correlates with the illustration shown in Appendix A. Appendix A shows current legal axle and gross weights based on axle configuration, weights with harmonization, and how interior bridge length may reduce weight allowed on vehicles.

A. Vehicles impacted by harmonization typically will have a triple axle(s) or have an axle configuration that does not meet the interior bridge length requirement.

    1. Currently, a straight truck with a steering axle and triple drive axle (#1) traveling on state highways or local roads can legally have a GVW ranging from 56,500 to 60,100 lbs. The number of axles and axle configuration allow for the higher GVW; however the exterior bridge length of this vehicle typically reduces the legal GVW to less than 60,100 lbs. The triple axle is legal up to 48,000 lbs. Carriers will purchase an approved equipment permit in order to carry a higher GVW.
        a. With an approved equipment permit, this vehicle can carry a GVW up to 64,000 lbs. and the triple axle is legal up to 51,000 lbs.

        i. In 2015 the NDHP issued 586 permits, and in 2014 there were 659 permits purchased.
   b. With harmonization the legal GVW of this vehicle would range around 54,000 lbs. to 55,600. The legal weight on the triple axle would be reduced from 48,000 to between 42,000 to 43,500 lbs.

2. Currently on the state system a six-axle vehicle combination (#2) – a truck-tractor with a steering axle and tandem drive axle towing a triple axle semitrailer will have GVW ranging from 86,000 lbs. up to 94,000 lbs.
   a. In North Dakota, the length of a semitrailer ranges from 40 ft. to 53 ft. The shorter semitrailer length will result in a shorter exterior bridge length and lower legal GVW.
        i. The shorter semitrailer is usually used for the short haul such as from the field to farm or town.
        ii. The agriculture industry is currently using 40-ft. and 43-ft. tandem axle semitrailers. The trend is a move to 48-ft. and 50-ft. triple axle semitrailers. The longer triple axle semitrailer is more economical and feasible for the long distance haul.
        iii. Vehicles hauling oil, water, and gravel typically use triple and quad axle semitrailers.
        i. Another trend seen in the agriculture and other commercial industry is the 53-ft. semitrailer with a quad axle or a triple axle plus a single axle. Typically the four axle semitrailer is a special order from a commercial carrier hauling product and traveling on the interstate systems.
   b. This six-axle configuration is more prevalently seen on North Dakota's state highway system.
   c. With harmonization, this axle configuration will typically carry a GVW ranging from 86,000 to 89,500 lbs.
        i. Harmonization will reduce the gross weight of the triple axle from 48,000 lbs. to range between 42,000 to 43,500 lbs.
        ii. The weight on the triple axle will be determined by the interior bridge distance.

3. Currently on the state system, a seven-axle vehicle combination (#3) – a truck-tractor with a steering axle and triple drive axle towing a triple axle semitrailer typically is at a GVW ranging from 92,500 to 105,500 lbs. when traveling on the state system.
   a. The length of a semitrailer typically ranges from 40 ft. to 53 ft. The shorter semitrailer results in a shorter exterior bridge length. As a result of a shorter exterior bridge length, the legal GVW is reduced.
   b. This axle configuration is more prevalently seen on western North Dakota's state highway system.
   c. With harmonization, the GVW of this axle configuration will typically range from 92,500 to 99,500 lbs.
        i. With harmonization, the gross weight on each triple axle will be determined by interior bridge formula.
        ii. Typically the interior bridge length ranges from 8 to 10 ft. The gross weight with an interior bridge length of 8 to 10 ft. ranges from 42,000 to 43,500 lbs.

4. Currently on the state system, a six-axle vehicle combination (#4) – a truck-tractor with a steering axle and tandem drive axle towing a semitrailer with a tandem axle and single axle configuration is legal up to a GVW ranging from 94,000 to 100,000 lbs.
    a. The gross weight on the semitrailer is legal up to 54,000 lbs.
    b. The distance of 8 ft. from the center of axle 5 to axle 6 defines this as two axle groups, as dictated by current state law.
    c. The length of a semitrailer and exterior bridge length of the axle configuration are factors in determining legal GVW. Typically the exterior bridge length will limit the GVW to 94,000 lbs.
    d. With harmonization, the interior bridge length would be used in determining legal weight on axles 4 through 6. The gross weight on axles 4 through 6 would typically be about 45,000 lbs.
        i. The GVW of this axle configuration would typically range around 91,000 lbs.

B. The following vehicles, vehicle combinations/axle configurations, will benefit with harmonization. Typically these vehicles will have an axle group consisting of four or more axles and/or have a total of seven or more axles, and/or have more than two vehicles in the vehicle combination. As mentioned earlier, harmonization vehicle combinations that exceed 105,500 lbs. GVW cannot travel on the interstate system as a result of the ISTEA freeze. In addition, ISTEA also froze the length limits of authorized vehicle combinations (NDAC 37-06) traveling on highways identified as part of the national network.

5. Currently on the state system, a five-axle straight truck (#5) – a straight truck with a quad axle group is legal at a GVW up to 60,100 lbs.
    a. The legal weight on the quad axle group cannot exceed 48,000 lbs.
    b. Carriers running with a quad axle straight truck will generally purchase an approved equipment permit, so when they are traveling on the interstate system, they are able to carry the same weight as authorized by permit on the state system.
        i. The permit authorizes up to 64,000 lbs. GVW, and the triple axle group is legal up to 51,000 lbs.
        ii. In 2015 there were 586 permits purchased, and in 2014 there 659 permits purchased. The cost of the permit is $15 per vehicle per calendar year.
        iii. The lift axle is put down when the vehicle traverses from the state system onto the interstate system in order to comply with weight laws for the interstate.
    b. With harmonization, the legal weight on the quad axle group would be determined by the interior bridge length. With an interior bridge length of 14 ft., (measurement from the center of axle #2 to axle #5) the legal weight on a quad axle would be up to 51,500 lbs., and the GVW would be legal up to 63,100 lbs.
    c. With harmonization, the permit may not be necessary.
    d. These trucks are typically used by motor carriers working locally and next to the interstate system.

6. Currently on the state system, a two-vehicle combination with the following eight-axle configuration (#6) – A straight truck with a steering axle and triple drive axle towing a full semitrailer with two sets of tandem axles is typically carrying a GVW of 105,500 lbs.
    a. With harmonization, the GVW based on the axle configuration could range from 122,000 to 123,600 lbs. The interior bridge lengths may reduce the GVW to less than 122,000 lbs.

i. The total number of axles and interior bridge lengths between axles enable the axle configuration under this vehicle combination to carry the higher GVW even though the legal weight on the triple drive axle would be reduced from 48,000 to 43,500 lbs.

b. The overall length of this vehicle combination cannot exceed 103 ft. The legal length of a single unit is 50 ft. and of a trailer is 53 ft.

c. Movement would be allowed on the national network and on state highways designated for 110 ft.

7. Currently on the state system, a two-vehicle combination with the following eight-axle configuration (#7) – A truck/tractor with a steering axle and triple drive axle towing a five-axle semitrailer (a single axle, triple axle, and a single axle) is typically at GVW of 105,500 lbs.

    i. Current law allows the semitrailer to carry a gross weight up to 88,000 lbs. The probability of the five-axle semitrailer hauling 88,000 lbs. gross weight is minimal. The axle spacing from the first axle to the second axle is 8 ft. and greater. The distance from the center of the back triple axle to the very last axle under the trailer is 8 ft. and greater. This semitrailer/axle configuration is not prevalent in North Dakota but has been seen.

    b. With harmonization, the GVW would typically be around 112,000 lbs.

        i. The 53-ft. trailer length limit and interior bridge will limit the GVW from reaching 120,100 lbs. GVW.

        ii. Based on the interior bridge length and number of axles, the five-axle trailer will weigh around 64,500 lbs.

8. Currently on the state system, a seven-axle vehicle combination (#8) - a truck-tractor with a steering axle and tandem drive axle towing a tandem axle semitrailer and a two-axle full (pup) trailer (A-train or double bottom) is typically at a GVW of 105,500 lbs.

    a. With harmonization, the GVW for the axle configuration under this vehicle combination could typically be around 120,000 lbs.

    b. ISTEA froze the cargo-carrying length of the trailer combination to 100 ft. when travel is on the national network.

    c. On the designated state highways, the overall length shall not exceed 95 ft. or 75 ft. This will reduce the GVW legal for this vehicle combination.

    d. On the interstate system, the GVW cannot exceed 105,500 lbs. ISTEA froze the GVW to 105,500 lbs. A permit would continue to be required when the GVW is over 80,000 lbs.

    e. The A-train or Rocky Mountain double bottom is one of the most prevalent multiple vehicle combinations in the western states.

9. Currently the eight-axle vehicle combination (#9) – A truck-tractor with a steering axle and tandem drive axle towing a triple axle semitrailer, and tandem axle semitrailer (Super B-train) is carrying the GVW of 105,500 lbs.

    a. With harmonization, the GVW for the axle configuration under this vehicle combination will typically range around 123,600 lbs.

    b. ISTEA froze the overall length of this vehicle combination 110 ft. when travel is on the national network.

    c. On the designated state highways, the overall length shall not exceed 95 ft. This will reduce the GVW legal for this vehicle combination/axle configuration.

d. ISTEA froze the GVW to 105,500 lbs. when travel is on the interstate system. The freeze also requires the carrier to purchase a permit when the GVW is over 80,000 lbs. The Super B-train is a vehicle combination typically seen coming into North Dakota from Canada.

10. & 11. Currently the following ten-axle vehicle combinations (#10 & #11) are carrying a GVW of 105,500 lbs.
   a. A truck tractor with a steering axle and tandem drive axle towing a triple axle semitrailer and a full trailer with two sets of tandem axles.
   b. A truck-tractor with a steering axle and triple drive axle towing a tandem axle semitrailer and a full trailer with two sets of tandem axles;
      a. With harmonization, the GVW for the axle configuration under this vehicle combination allows for a GVW up to 129,000 lbs.
      b. ISTEA froze the cargo carrying length to 100 ft., when traveling on the national network
         i. With a 100-ft. cargo carrying length limit and this axle configuration, the interior bridge length requirement will easily be met.
      c. ISTEA froze the GVW legal on the interstate system.
         i. The GVW cannot exceed 105,500 lbs.
      d. The carrier must purchase a permit when the GVW exceeds the legal limit of 80,000 lbs. This vehicle combination is prevalent in North Dakota but the axle configuration is not. This vehicle combination has more axles than necessary to haul the legal GVW of 105,500 lbs.

C. The following vehicle combinations are not impacted, minimally impacted, or will minimally benefit with harmonization.

12. Currently, the five-axle vehicle combination (#12) – a truck-tractor with a tandem drive axle towing a tandem axle semitrailer and commonly known as the 18-wheeler is carrying a GVW of 80,000 lbs. on all highways in North Dakota.
   e. With harmonization, the GVW stays at 80,000 lbs.
   f. There is no benefit or impact with harmonization.
   g. This is the most prevalent vehicle combination/axle configuration in the United States and very prevalent in North Dakota.

13. Currently on the state system a five-axle vehicle combination (#13) – a truck-tractor with a steering axle and tandem drive axle towing a spread axle semitrailer will typically carry a GVW of 86,000 lbs.
   a. With harmonization, the GVW of this axle configuration will typically be around 84,000 to 86,000 lbs. There is no benefit and very little impact.
   b. The minimal impact will be because the current rule requires only 8 ft. between the two axles on the trailer to haul 20,000 lbs. per axle. With harmonization, a distance of 10 ft. would be required between the two axles on the trailer (axle center to axle center) to carry 20,000 lbs. per axle.

14. Currently on the state system, an eight-axle vehicle combination (#14) – a truck-tractor with a steering axle and triple drive axle towing a four-axle trailer is typically at a GVW of 105,500 lbs.

a. With current law, this vehicle has more axles than needed to carry the legal GVW of 105,500 lbs.
    i. The fourth axle on the trailer typically used when traversing from the state system to the interstate system.
b. With harmonization, the GVW for the axle configuration under this vehicle combination could range from 104,500 to 106,500 lbs. There is little benefit or impact.
c. This vehicle combination has sufficient number of axles to benefit with harmonization. The interior bridge length of 14 ft. allows axles 5 – 8 a gross weight up to 51,500 even though the interior bridge length of 10 ft. reduces the gross weight on the triple axle group.

15. Currently on the state system, a two-vehicle combination with the following eight-axle configuration (#15) – A truck-tractor with a steering axle and triple drive axle towing a four-axle semitrailer (triple axle and single axle) is typically weighing 105,500 lbs.
    a. Under current law, the axle configuration under the semitrailer, a triple axle and single axle is legal up to 48,000 lbs. and 20,000 lbs. respectively, provided there is an 8-ft. distance from axle 7 to 8.
        i. Typically the trailer would not carry 68,000 lbs., but would carry more than 48,000 lbs.
    b. With harmonization, the interior bridge length of 18 ft. from axle 5-8 will allow the trailer to weigh up to 54,000 lbs., and the 10 ft. from axle 2-4 will reduce the weight on the drive axle from 48,000 to 43,500 lbs.
    c. With harmonization, the GVW will increase to around 106,500 lbs. Even though the axle configuration will allow up to 116,000 lbs., the 53 ft. trailer length and interior bridge lengths will limit the GVW to range around 106,500 lbs.

Summary:

UGPTI staff partnered with NDDOT and North Dakota Highway Patrol (NDHP) staff to identify existing North Dakota laws to compare them with federal laws as well as laws in Minnesota, Montana, South Dakota, and the Canadian provinces.

In general, North Dakota allows 105,500 lbs. of gross vehicle weight (GVW) on the non-interstate system and 105,500 lbs. on the interstate system by permit. North Dakota and federal regulations require checking for the interior and exterior bridge formula on the interstate but just the exterior bridge formula on the state system. On local roads, the GVW is generally 80,000 lbs. unless otherwise designated. Allowable tire pressure is 550 lbs. per inch tire width. North Dakota also allows up to 48,000 lbs. on a triple axle on the non-interstate system. On the interstate system and in all other states, the weight on a triple axle typically cannot exceed 42,000 to 43,500 lbs. North Dakota has a fairly extensive state system designated as the National Truck Network which allows a 110-ft. overall length.

The federal government requires interior and exterior bridge formula checks on the interstate system. The weight limit on the interstate is 80,000 lbs. in North Dakota and up to 105,500 lbs. with a permit. Triple axles typically cannot exceed 42,000 to 43,500 lbs. The Federal December 2015 Omnibus Appropriation recently allowed Idaho to change its interstate GVW to 129,000 lbs. These types of changes are unusual as federal weights have, in general, been frozen since 1991.

Montana allows 131,060 lbs. on all state and local highways unless posted for less. The interstate system is designated as 80,000 lbs. with up to 131,060 lbs. through the vehicle registration process. Triple axles are restricted by interior bridge length and typically cannot exceed 42,000 to 43,500 lbs. anywhere. Triple trailers are allowed only on the interstate. The legal overall maximum length on all highways is 75 ft. On the state system, trucks cannot exceed 95 ft. in overall length without a permit. The National Truck Network in Montana consists of only the interstate system.

South Dakota allows longer combination vehicles with a GVW of up to 129,000 lbs. on the national network. Other vehicle combinations do not have a maximum GVW when traveling on state or local roads. GVW on the interstate is designated as 80,000 lbs. with up to 129,000 lbs. by permit. Triple axles typically may not exceed weights of 42,000 to 43,500 lbs. anywhere. Triple trailers are allowed only on the interstate. The National Truck Network consists of just the interstate system and segments of divided state highway where 110-ft. overall length is permitted. Travel is allowed on all highways when the cargo carrying length of two trailers does not exceed 81.5 ft. on roads below the National Truck Network.

Minnesota allows a GVW of 80,000 lbs. on all roads unless otherwise posted. They require the interior and exterior bridge formula check. The interstate allows a GVW of 80,000 lbs. with up to 88,000 lbs. by permit. Triple trailers are not allowed in Minnesota.

The Roads and Transportation Association of Canada (RTAC) regulates principal highways in Saskatchewan and Manitoba. Basic RTAC limits are higher for tandem axle weights, tridem axle weights, and GVWs compared to the United States on both interstate and non-interstate highways. Manitoba and Saskatchewan allow 137,788 lbs. on the assigned system. Some designated routes in Manitoba and Saskatchewan allow up to 139,992 lbs. Canada does not use the U.S. version of the federal bridge formula.

Truck Configurations Important to the Study

Because there are so many variations of trucks used throughout North Dakota, the UGPTI team identified a short list of the primary trucks that would be impacted if full harmonization with other states was pursued. This concept came from a similar FHWA study of truck size and weight. These configurations were presented to the THS steering committee on January 21, 2016, and were approved for inclusion in the study. The impacted trucks are primarily those that use triple axles which could lose up to 6,000 lbs. of capacity if full harmonization was enacted. The number of vehicles fully impacted is unknown and may be minimal. The N.D. Legislature could exempt this situation for N.D. roads if desired, but this situation needed to be identified. Trucks identified fit the following configurations shown in Table 3:

#/Axles	**Single Unit Vehicle Axles**
4	Steering, triple
5	Steering, quad

#/Axles	**2 Vehicle Combinations Axles**
6	Single, tandem, triple
7	Steering, triple, triple
5	Steering, tandem, single, single
8	Steering, triple, tandem, tandem
8	Steering, triple, quad

Table 3: Truck Configurations Included For Study

The UGPTI team also recommended a short list of trucks for analysis of bridge, pavement, and commodity flow impacts and benefits; shown in Table 4. These are generally long combination vehicles that currently carry about 105,500 lbs. in North Dakota but in some cases would be able to carry up to 129,000 lbs. This category was used to evaluate changes in pavement deterioration due to fewer trucks carrying a fixed amount of commodities.   Truck examples are also shown in Appendix A.

# Axles	2 Vehicle Combinations Axles
5	Single, tandem, tandem
7	Steering, triple, triple
5	Steering, tandem, single, single
9	Steering, triple, single, triple, single

	3 Vehicle Combinations Axles
7	Rocky Mountain Double: Steering, tandem, tandem, single, single
8	Super B Train: Steering, tandem, triple, tandem
11	Steering, tandem, triple, tandem, triple
10	Steering, triple, tandem, tandem, tandem

Table 4: Trucks for analysis of bridge, pavement, and commodity flow impacts and benefits.

Implications, Benefits and Impacts of Applying Federal and State Bridge Formulas

The weight laws for North Dakota's state highways and local roads are slightly different from the weight laws for vehicles traveling on North Dakota's interstate system and in adjacent states. A major difference is the use of the federal bridge formula. On the state and local roads system, the exterior bridge length of the federal bridge formula is used; and on the interstate system and in adjacent states the interior/exterior bridge lengths of the formula are used. This difference is confusing for motor carriers and others. The differences in regulations are difficult to interpret and inefficient for the trucking industry, shippers, and enforcement.

Harmonization of intra- and interstate truck weight laws would promote the efficient movement of freight and is in the best interest of businesses within the region. Harmonization would reduce confusion, promote regulatory compliance and most importantly improve commerce. Uniformity in regulations would enhance the seamless movement of freight.

Higher GVWs may especially benefit industries transporting perishable products. Higher GVWs could significantly reduce total transport costs and increase the profitability of business. This would have a positive effect on the efficiency of freight and improve competitiveness in the region.

Higher GVWs may result in less damage to the roadway with the right axle configuration. With larger payloads, the number of trips may be reduced resulting in less truck trips, which may result in less damage to the infrastructure.

Harmonizing the federal bridge law, on state and local roads and using interior and exterior bridge lengths, for the straight truck with a triple drive axle pulling a full trailer with two sets of tandem axles (eight-axle vehicle combination) may increase the legal GVW from 105,500 up to 122,000 lbs. GVW. This is a large increase in payload for this combination which is a truck of choice for many hauling in the oilfield.

Benefits of not changing current state law and using only the exterior bridge length of the federal bridge formula are as follows:

1. It is easier for the trucker to understand and follow.

2. It allows a higher gross weight on a triple axle group (48,000 lbs.).

3. It also allows for a spread axle trailer, 2 axles with a distance of at least 8 ft. apart, a legal up to 40,000 lbs. gross weight. The other benefit is it takes much less time for law enforcement to determine compliance.

Industry has modeled vehicle axle configurations using the exterior bridge length formula in order to haul more weight. Currently a triple axle group can weigh up to 48,000 lbs. when traveling on state and local roads. A negative impact on the motor carrier and shipper is that implementing the interior bridge formula rule would reduce the legal weight on a triple axle by about 6,000 lbs. However, the vehicle with a triple axle group only fully benefits if the vehicle combination has sufficient exterior bridge length.

With harmonization, the interior bridge length (measurement from the center of the first axle to the last axle) becomes one of the determining factors for gross weight legal on the triple axle. Typically a triple axle will have an interior bridge length of 8 ft., 9 ft., or 10 ft. The legal gross weight on a triple axle with those bridge length measurements are 42,000 lbs., 43,000 lbs., and 43,500 lbs., respectively.

The interior bridge formula may impact vehicles with a total of seven axles or less and that have a triple axle group. The six-axle and the seven-axle truck-tractor and semitrailer with triple axles have become the vehicles of choice for many motor carriers traveling mostly on the state and local roads system. The six-axle truck-tractor semitrailer may be reduced from 94,000 GVW to 89,000 GVW. The seven-axle truck-tractor semitrailer may be reduced from 105,500 GVW to 99,000 GVW. A six-axle and seven-axle tractor towing a shorter semitrailer will be less or minimally impacted. The shorter semitrailer results in a shorter exterior bridge length, which results in a lower legal GVW. Shorter semitrailers are typically used for the shorter haul from the field to farm or town. The six-axle and seven-axle truck-tractor with a shorter semitrailer combination traveling on the state system is already only legal to 89,000 and 99,000 lbs. GVW, respectively. With the shorter triple axle semitrailers, there are fewer vehicle combinations impacted.

A straight truck with a triple axle and sufficient exterior bridge length is can weigh up to 60,000 lbs. GVW. Some straight trucks do not have sufficient exterior bridge length (27 ft.). The average straight truck with a triple drive axle, currently sold, has an exterior bridge length of 23 ft., which results in a lower legal GVW of 57,500 lbs. To obtain the higher GVW, carriers can purchase an equipment approval permit. The $15 equipment approval permit allows a GVW up to 64,000 lbs. and the triple axle is up to 51,000 lbs. gross weight. The vehicle must meet specific requirements. With harmonization, the legal gross weight on this vehicle would typically range around 55,000 lbs., and the weight on the triple axle would range from 42,000 to 43,500 lbs.

Another example would be the three axle configuration under a trailer and/or truck (Appendix A, #4). The three-axle configuration with a tandem axle and a single axle (8 ft. from center of the last tandem axle to the center of the single axle) can weigh up to 54,000 lbs. gross weight when traveling on the state and local roads system. With harmonization, the gross weight on that same three-axle configuration would range from 48,000 to 49,000 lbs.

Higher GVWs on North Dakota's state highway system will impact truck traffic volumes on state highways. Vehicles with a GVW over 105,500 lbs. will be forced to travel on the state system and off the interstate system due to the federal law, ISTEA. ISTEA froze the maximum GVW limit to 105,500 lbs. on North Dakota's interstate system.

Currently, North Dakota issues an LCV permit in the winter, December 1 through March 7, when the road beds are frozen. Vehicles with sufficient exterior bridge length and enough axles can permit up to a GVW of 131,000 lbs. All axle weights must be legal. In order to comply with the length limits set by law (state and ISTEA), these vehicles are traveling on North Dakota state highways that are considered part of the national network.

The most common truck configuration on the nation's highways, a five-axle semi, would not be affected at all by changes in the bridge law. The truck/tractor with a spread axle trailer would be minimally affected.

Vehicles and vehicle combinations with triple axles and shorter exterior bridge lengths will be minimally or less impacted relating to GVW. The following examples show the legal GVW limits when using triple axle semitrailers ranging in length from 40 ft. to 53 ft. in length. Note: The shorter the trailer length, the lower the GVW due to a lower exterior bridge.

Triple Axles
6 Axles total

Tractor Length	Trailer Length	Total Exterior Bridge	Gross Vehicle Weight for Total Exterior Bridge	Steering/Drive Axles 11" Tires	Triple Axle Groups
18'	40'	53'	86,000	12,100/34,000	39,900
18'	48'	61'	90,500	12,100/34,000	44,400
18'	50'	63'	92,000	12,100/34,000	45,900
18'	53'	66'	93,500	12,100/34,000	47,400
20'	53'	68'	95,000 (94,100)	12,100/34,000	48,000

Table 5: Weight limits for various 6-axle vehicles

Triple Axles
7 Axles total

Tractor Length	Trailer Length	Total Exterior Bridge	Gross Vehicle Weight for Total Exterior Bridge	Steering Axle 11" Tires	Triple Axle Groups
20′	40′	56′	92,500	12,100	80,400/2 groups 40,200/group
20′	48′	64′	97,500	12,100	85,400/2 groups 42,700/group
20′	50′	66′	98,500	12,100	86,400/2 groups 43,200/group
20′	53′	69′	100,500	12,100	88,400/2 groups 44,200/group
29′	53′	78′	105,500	12,100	93,400/2 groups 46,700/ group

Table 6: Weight limits for various 7-axle vehicles

	Vehicle/axle configurations	Exterior GVW	Interior & Exterior GVW	Exterior ESALs per Truck	Interior & Exterior ESALs per Truck
#/Axles	**2 Vehicle Combinations**				
5	Single, tandem, tandem	80,000	80,000	2.379	2.379
7	Steering, triple, triple	105,500	96,000	2.219	1.483
5	Steering, tandem, single, single	86,000	86,000	4.304	4.304
9	Steering, triple, single, triple, single	105,500	129,000	5.339	4.503
	3 Vehicle Combinations				
7	Rocky Mountain Double: Steering, tandem, tandem, single, single	105,500	120,000	5.469	5.399
8	Super B Train: Steering, tandem, triple, tandem	105,500	122,000	3.364	3.026
10	Steering, tandem, triple, tandem, tandem	105,500	129,000	4.444	4.121
10	Steering, triple, tandem, tandem, tandem	105,500	128,000	4.444	4.121

Table 7: Weights limits and resulting ESALs for various long combination vehicles

Axle load equivalency factor (LEF) values were calculated by aggregating three values (Kawa, Naismith Engineering, AASHTO 93) and compared to the AASHTO 93 Appendix D LEF charts. All values were calculated with an assumed p_t value of 2.0 and a SN value of 3.0. The calculated axle LEF values were then aggregated based on axle configuration to create the total vehicle ESAL value.

	Vehicle/axle configurations	**Exterior GVW**	**Interior & Exterior GVW**	**Exterior ESALs per Truck**	**Interior & Exterior ESALs per Truck**
#/Axles	**Single Unit Vehicles**				
4	Steering, triple	60,000	54,000	1.204	0.836
5	Steering, quad	60,000	63,500	0.521	0.614
	2 Vehicle Combinations				
5	Single, tandem, tandem	80,000	80,000	2.379	2.379
6	Single, tandem, triple	94,000	88,000	2.284	1.931
7	Steering, triple, triple	105,500	96,000	2.219	1.483
5	Steering, tandem, single, single	86,000	86,000	4.304	4.304
8	Steering, triple, tandem, tandem	105,500	122,000	3.364	3.026
8	Steering, triple, quad	105,500	104,500	1.5965	1.061
8	Steering, triple, triple, single	105,500	116,000	3.779	2.993
9	Steering, triple, single, triple, single	105,500	129,000	5.339	4.503
9	Steering, triple, 5 axle	105,500	113,500	1.5555	1.047
	3 Vehicle Combinations				
7	Rocky Mountain Double: Steering, tandem, tandem, single, single	105,500	120,000	5.469	5.399
7	B-Train: Steering, tandem, tandem, tandem	105,500	114,000	3.429	3.474
8	Super B Train: Steering, tandem, triple, tandem	105,500	122,000	3.364	3.026
10	Steering, tandem, triple, tandem, tandem	105,500	129,000	4.444	4.121
10	Steering, triple, tandem, tandem, tandem	105,500	128,000	4.444	4.121

Table 8: Weights limits and resulting ESALs for a variety of trucks

Appendix A shows the implications and benefits to vehicle/vehicle combinations and axle configurations with current N.D. weight laws and with harmonization.

Summary:

Having two different rules for axle weights hampers communication, making it difficult for the drivers to keep track of the rules that apply to where they are. It is confusing for dispatchers setting up or loading trucks and is time consuming for law enforcement personnel who must deal with and educate the drivers. The North Dakota Local Technical Assistance Program (NDLTAP) has taught “Truck Weights of ND” classes across the state. Instructors indicated that it was difficult for drivers to understand that a triple axle can haul 48,000 lbs. on the state roads but has to drop to 42,000 to 43,500 lbs. (depending on bridge formula) when traveling the interstate system.

With harmonization, vehicle combinations with seven axles or more will typically benefit. With harmonization, the legal weight on a four-axle group will increase and the legal weight on a triple axle group will be reduced. A vehicle or vehicle combination with a triple axle group(s) that has sufficient exterior bridge length will be impacted. A vehicle or vehicle combination with a triple axle group(s) that does not have sufficient exterior bridge length will be minimally impacted. A five-axle truck-tractor semitrailer will not be affected at all by changes in the bridge law, and a truck/tractor with a spread axle semitrailer would be minimally affected.

Pros of rules for state roads: exterior bridge

- Easier for drivers to understand
- Allows 48,000 lbs. on triple axles
- Allows 40,000 lbs. on an 8-ft. spread axle (two single axles legal up to 20,000 lbs. each)
- Requires less time for law enforcement to verify allowable vehicle weight

Cons of rules for state roads: exterior bridge

- If loaded with 48,000 lbs. on a triple axle, vehicle is unable to travel on the interstate system
- The more axles under a vehicle combination, the shorter the exterior bridge length
- Group of four or more axles, still limited to 48,000 lbs. for that group

Pros of rules for interstate: interior bridge

- Axle groups with more than three axles are allowed to carry more weight
- Does not require a bridge length or approved equipment permit to carry the extra weight

Cons of rules for interstate: interior bridge

- When coming into North Dakota with four or more axles in a group and carrying the allowed weight, a truck would not be able to exit the interstate system legally (i.e., when a truck needs fuel)
- More time consuming for law enforcement to verify allowable vehicle weight when considering all bridge lengths

<u>If the rules were changed to enforce interior bridge on all state and federal roads</u>

Pros:

- Uniformity, less confusion
- Trucks in North Dakota could load the truck and not worry about what state or federal roads they travel.
- Axle group with four or more axles are allowed to carry more weight.

Cons:

- 8’ spread single axles lose weight - minimal
- Triple axle group legal weight is reduced by up to 6,000 lbs.
- Requires more time when law enforcement is checking for correct weights

Outreach Efforts to Various Entities:

A survey was given to the North Dakota Grain Dealers Association to determine the truck types used for grain movements and the likelihood of moving to larger truck configurations. A similar but more general survey was given to other categories of shippers. (See the following page for the survey.) The following entities were requested to complete a survey and/or provide comments on the study:

- ND Associated General Contractors
- ND Department of Commerce
- ND Highway Patrol
- North Dakota DOT
- ND Grain Dealers Association
- Johnsen Trailer Sales
- ND Motor Carriers Association
- North Dakota Port Services
- North Dakota Petroleum Council
- ND Corn Growers Association
- ND Wheat Commission
- ND Soybean Growers Association
- ND Grain Growers Association
- United Pulse Trading-AGT Foods
- ND League of Cities
- ND Township Officers Association
- ND Association of Counties
- American Crystal Sugar/Transystems
- Basin Electric Power Cooperative
- Recipients of Long Combination Vehicle Permits

Responses from shipper-related entities generally indicated that their industry would benefit from heavier GVW regulations and would move to new configurations quickly. Many said they would move to them under requirement to comply with interior and exterior bridge formula. Shippers expressed concerns that full harmonization could impact the N.D. allowance of 48,000 lbs. for triple axles, and the N.D. Legislature should be aware of this variance with other states (other states are 43,500 lbs. on a triple axle). Local jurisdictional representatives expressed concern about geometric impacts to intersections – both urban and rural. Existing local rural and urban intersections were not designed for LCV configurations.

Stakeholder Survey for Truck Size & Weight Harmonization Study

Please send your completed survey to:
Email info@ugpti.org or Fax 701.231.1945

All Individual Responses are Confidential.

Survey results will be in aggregate.

Name:

Industry and/or Facility:

1. Does your company operate its own truck fleet?

   ☐ Yes ☐ No (If you select "No" please proceed to the comment section)

2. What commodities are being hauled via truck? (please type your answers below)

3. Approximately how many total truck miles does your industry/facility travel each year?

4. If more cubic capacity is available via new truck configurations, would it be helpful to your industry?

   ☐ 1 (Not at all) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (Definitely)

5. If more weight capacity is available via new truck configurations, would it be helpful to your industry?

   ☐ 1 (Not at all) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (Definitely)

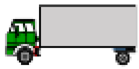
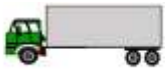
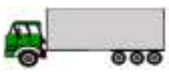
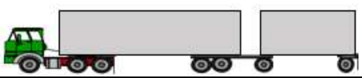
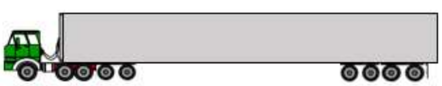
6. If North Dakota laws were changed to higher GVW but required compliance with interior and exterior bridge formula, would you invest in new or different truck configurations?

   ☐ 1 (Not at all) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (Definitely)

Please complete the table on page 2regarding current and projected truck configurations for your industry's traffic.

We welcome your comments.

7. What specific truck configuration(s) are currently being used? Please indicate the current percent of truck volume using each configuration and your expectations for truck volume with the increased truck size and weight allowances in the chart below.

Truck Configuration	Current Percent of Truck Volume	Percent of Truck Volume with a Greater Size and Weight Allowance
Single-axle 		
Tandem-axle 		
Tridem-axle 		
5-axle, one trailer 		
7-axle, one trailer 		
7-axle, two trailers 		
8-axle, one trailer 		
8-axle, two trailers 		
9-axle, one trailer 		
9-axle, two trailers 		
Other (please specify the configuration(s) and number by typing in this box)		

THANK YOU! for participating in this survey.

For any questions or comments please contact: Upper Great Plains Transportation Institute, North Dakota State University ▫ Phone: 701.231.7767

Data Mining - NDDOT Weigh-In-Motion and Classification Data to Identify LCV Corridor Usage.

The objective of data mining the NDDOT weigh-in-motion (WIM) data was to determine volumes of various truck configurations identified for this study that are not included in the standard FHWA truck classifications. The types of trucks that were being sought were LCV multi-trailer combinations identified earlier in this report. Identifying the volumes of these truck configurations is critical to determining what ESAL changes will occur with proposed changes to gross weight limits and harmonization proposals.

NDDOT collects vehicle classification data throughout the state with portable and permanent counting equipment. This information is processed into the 13 FHWA standard classifications using the axle spacing length for each truck. This information is then further simplified for public reporting down to the number of single and combination unit trucks. Unfortunately, the axle spacing length information is not retained, which is what is required to determine the truck configurations outside of the FHWA classifications. However, the standard classification data were usable to verify where in the state the preponderance of LCVs exists. The FHWA Class 13 category covers all seven-axle or greater configurations. Unfortunately, N.D. shippers commonly use tractor trailer combinations with tridems (steering, tridem, tridem), which fall into this category and can skew attempts to identify locations with LCV's. Fortunately, NDDOT also collects permanent WIM classification data at 16 WIM sites throughout the state (See Figure 7 below).

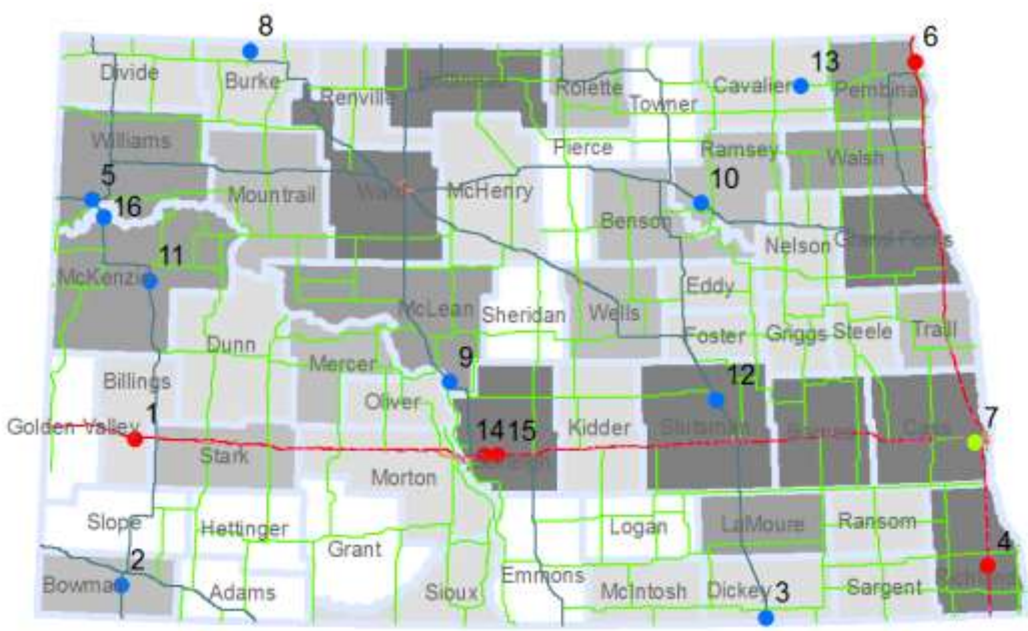


Figure 7: Permanent WIM sites in ND

With this information, data mining was performed to determine the volumes of all configurations. The volumes are then used to create factors that can be applied to portable classification data based on type of road and geographic area. There were very few stations with data available for the whole year and some stations only had data for one year or the other.

Overall, based on the data from these WIM stations, the higher percentage of LCV's are on I-94, US 85, US 2, and US 83; all in the western part of the state. Presumably this is related to energy activity and shipments. Of the studied configurations within class 10 the 10b single, tandem, and triple make up almost all of that FHWA classification. And within class 13 the 10a single, triple, triple and 10b RMD were the only configurations with a notable percentage of the total.

An additional objective of the study was analysis of seasonal trip generation. The foundation of this analysis would have been WIM data. As stated earlier, it was not possible to obtain year-round WIM data from any of the operating sites so it was not possible to derive any truck-size related annual or monthly factors.

FHWA Class	**Axles**	**Description**	**Configuration**
5	2	Single frame trucks, including camping and recreational vehicles, motor homes, etc.	
6	3	Three axles, single frame vehicles, including camping and recreational vehicles, motor homes, etc.	
7	4	Any four or more axles, single unit truck	
8	4	Any three or four axles, truck and trailer combination.	
9	5	Any five axles truck and trailer combination	**Single, tandem, tandem**
9a	**5**	**New study configuration**	**Single, quad**
10	6	Any Six or more axles truck and trailer combination.	
10a	**6**	**New study configuration**	**Single, tandem, tandem, single**
10b	**6**	**New study configuration**	**Single, tandem, triple**
11	6	Any combination of three or more units, one of which is a tractor or truck power unit having five or less axles	
12	7	Any combination of three or more units, one of which is a tractor or truck power unit having six axles	
13	7+	Any combination of three or more units, one which is tractor	
13a	**7**	**New study configuration**	**Single, triple, triple**
13b	**7**	**New study configuration**	**Single, tandem, tandem, single, single**
13c	**8**	**New study configuration**	**Single, triple, tandem, tandem**
13d	**8**	**New study configuration**	**Single, tandem, triple, tandem**
13e	**10**	**New study configuration**	**Single, tandem, triple, tandem, tandem**
13f	**10**	**New study configuration**	**Single, triple, tandem, tandem, tandem**

Table 8: FHWA Truck Classifications Descriptions

NDDOT collects vehicle classification data throughout the state with portable and permanent counting equipment. This information is processed into the 13 FHWA standard classifications using the axle spacing length for each truck (see Table 8 for FHWA truck classification descriptions). This information is then further simplified for public reporting down to the number of single and combination unit trucks. At this point the axle spacing length information is not retained, which is what is required to determine the truck configurations outside of the FHWA classifications. Fortunately, NDDOT's permanent WIM sites also collect axle spacing length along with the vehicle weights.

With this information, data mining is performed to determine the volumes of all configurations. The volumes are then used to create factors which can then be applied to portable classification data based on type of road and geographic area.

The following bar charts are the results from each station where data were available. Data were analyzed for the years 2014 and 2015. There were very few stations with data available for the whole year and some stations only had data for one year or the other. The FHWA class and study configurations are listed below on the x axis and if there were no trucks observed the class is not listed. For Class 9, 10, and 13, the percentage shown is the total for that class and includes all the sub-classes shown. The sub-classes such as 10a show the percentage of total trucks across all classes.

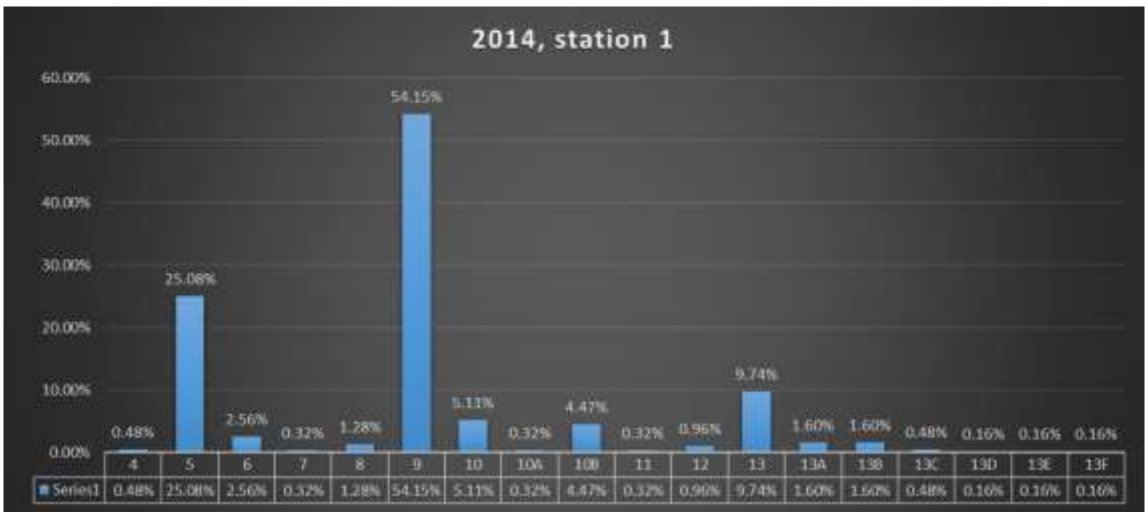


Figure 8: 2014 WIM data from Station 1

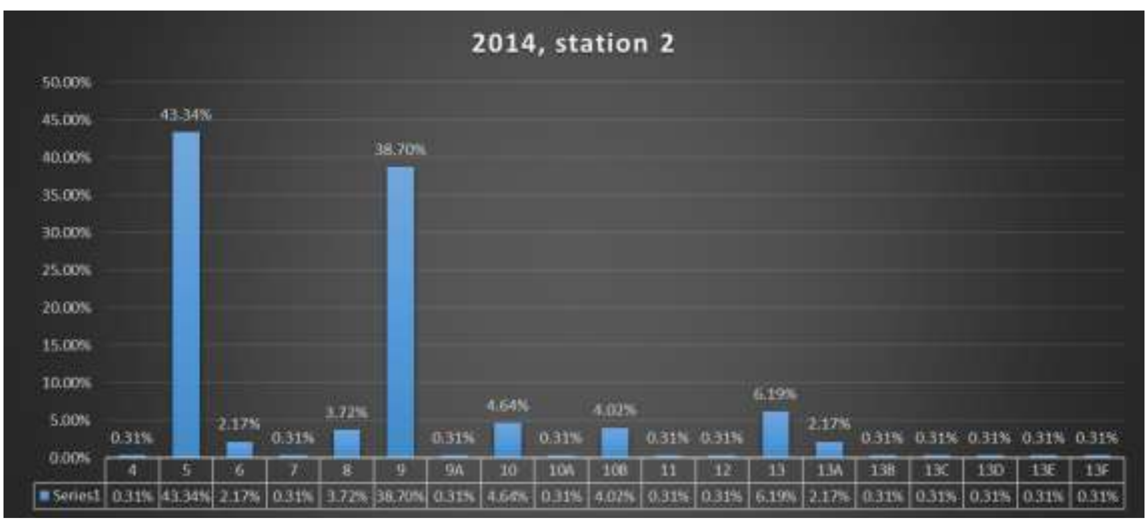


Figure 9: 2014 WIM data from Station 2

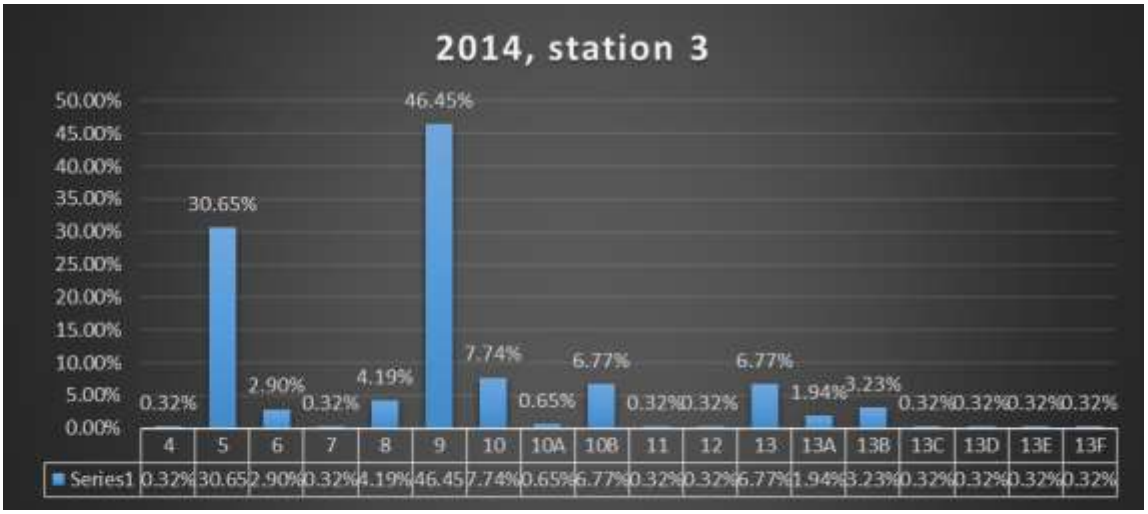


Figure 10: 2014 WIM data from Station 3

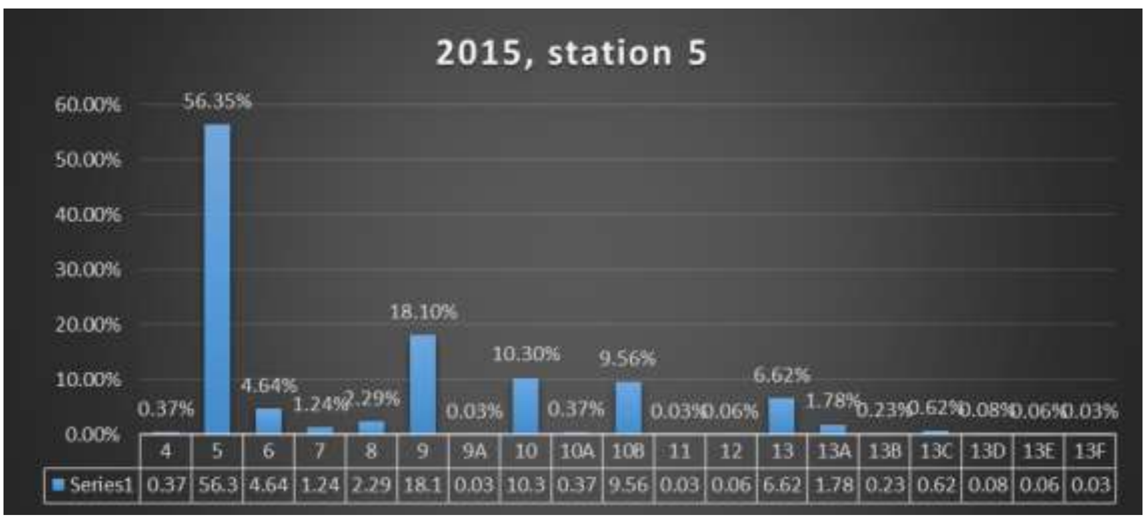


Figure 11: 2015 WIM data from Station 5

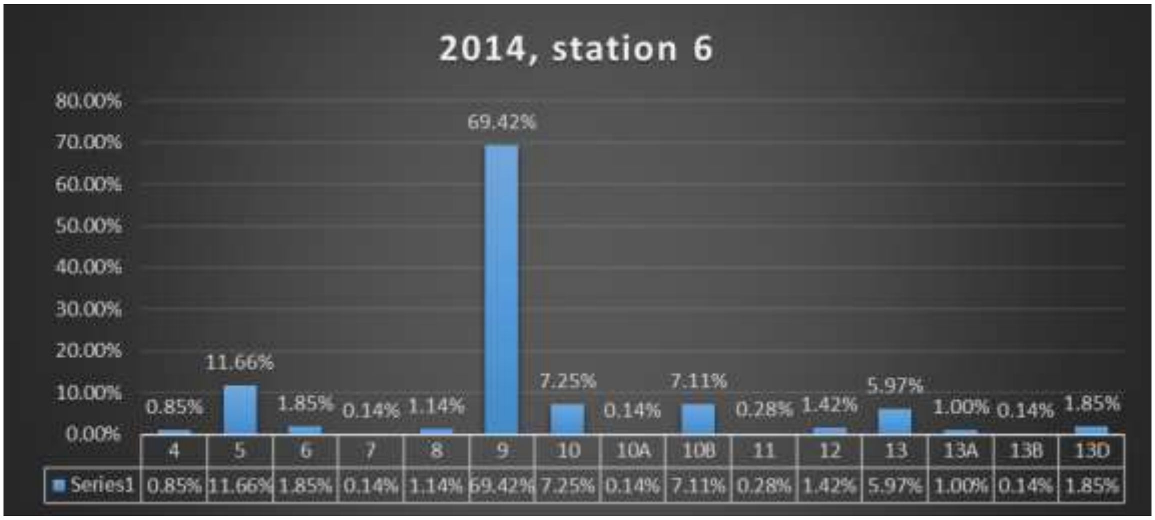


Figure 12: 2014 WIM data from Station 6

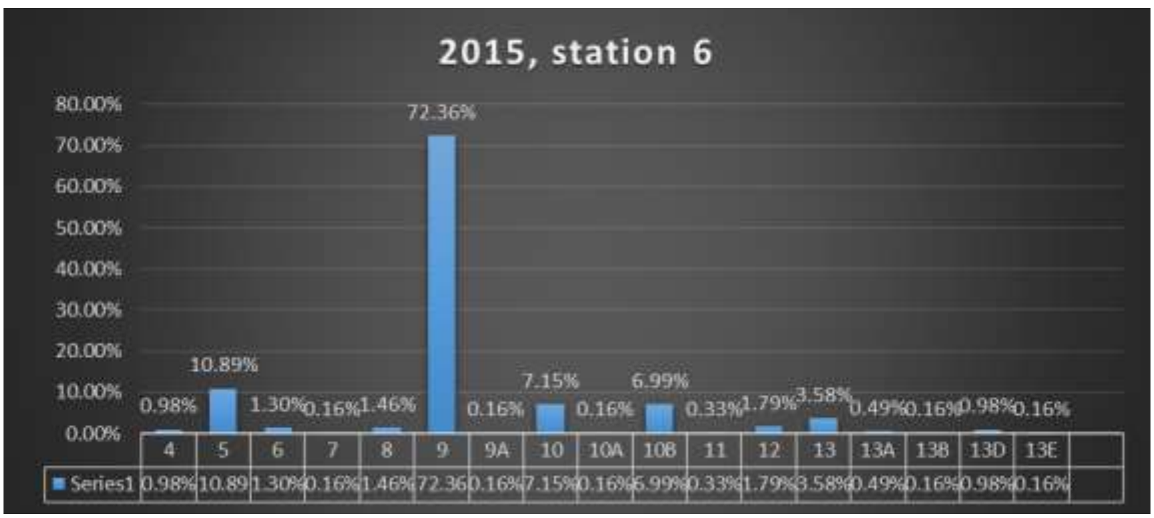


Figure 13: 2015 WIM data from Station 6

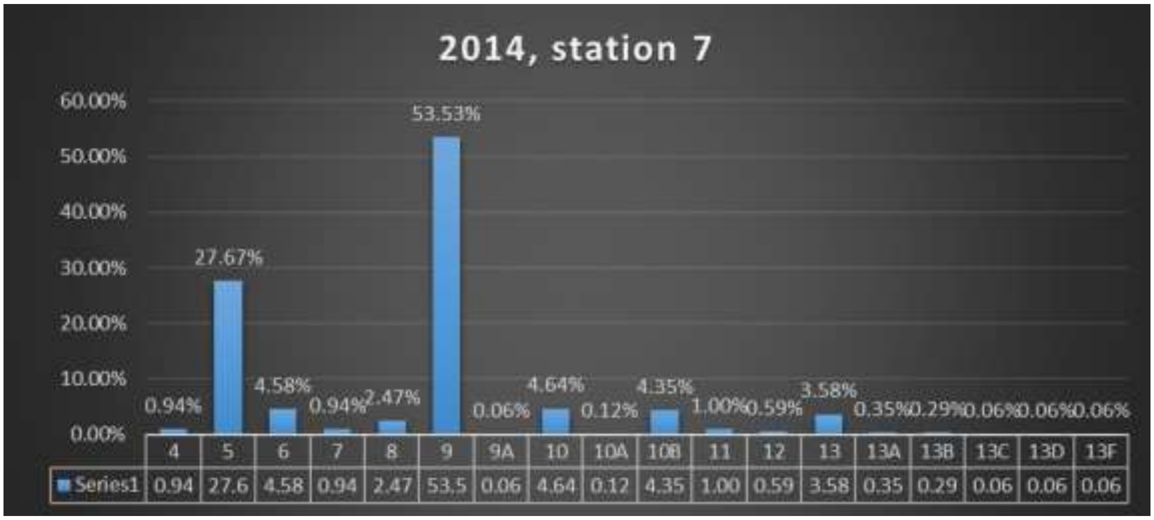


Figure 14: 2014 WIM data from Station 7

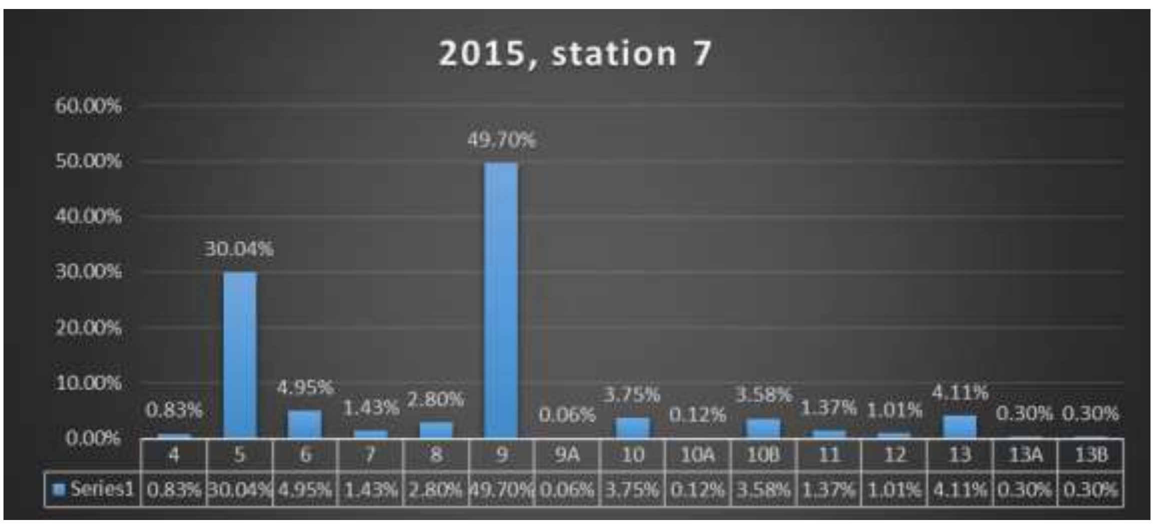


Figure 15: 2015 WIM data from Station 7

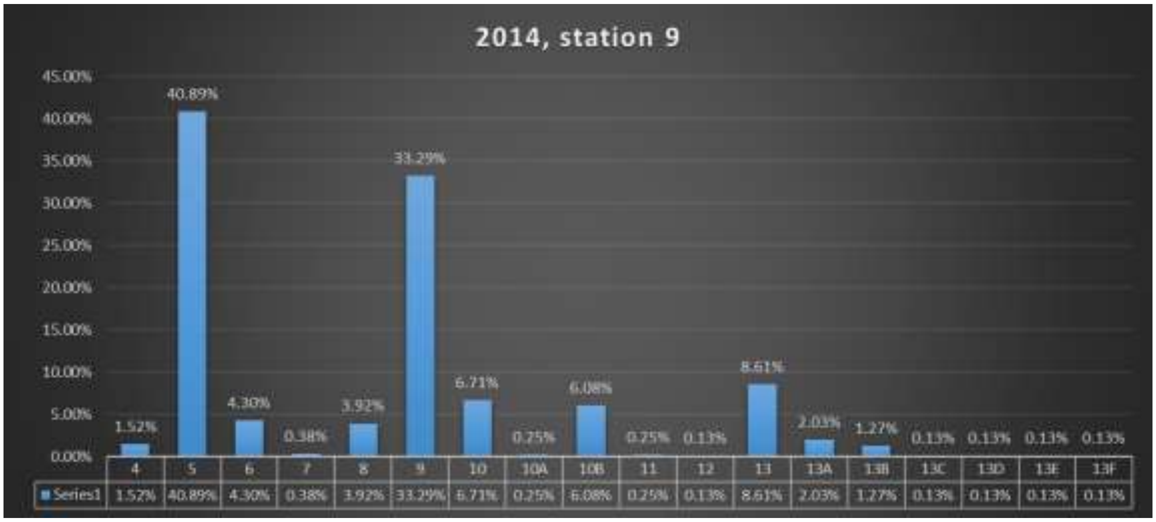


Figure 16: 2014 WIM data from Station 9

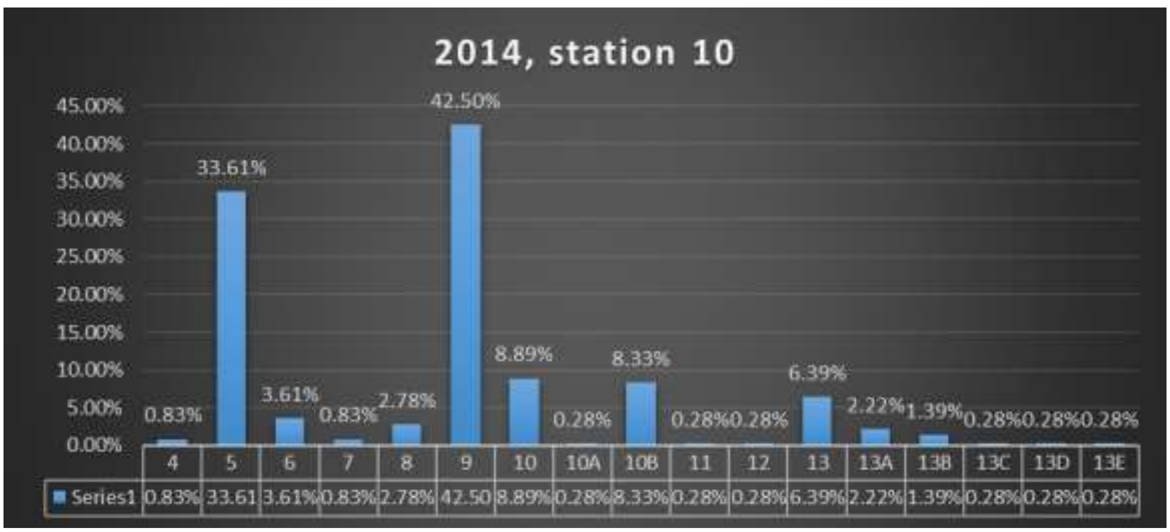


Figure 17: 2014 WIM data from Station 10

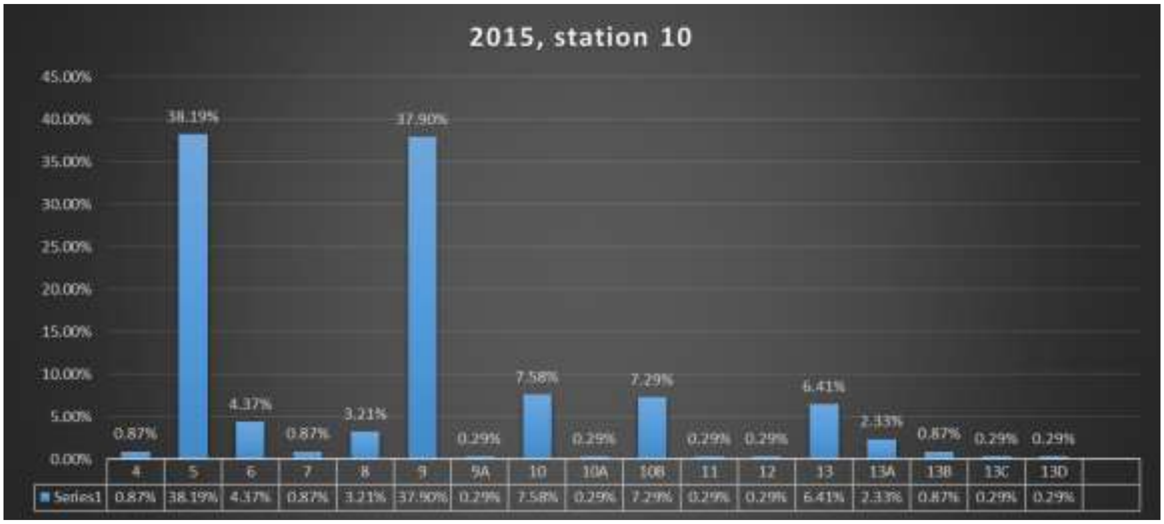


Figure 18: 2015 WIM data from Station 10

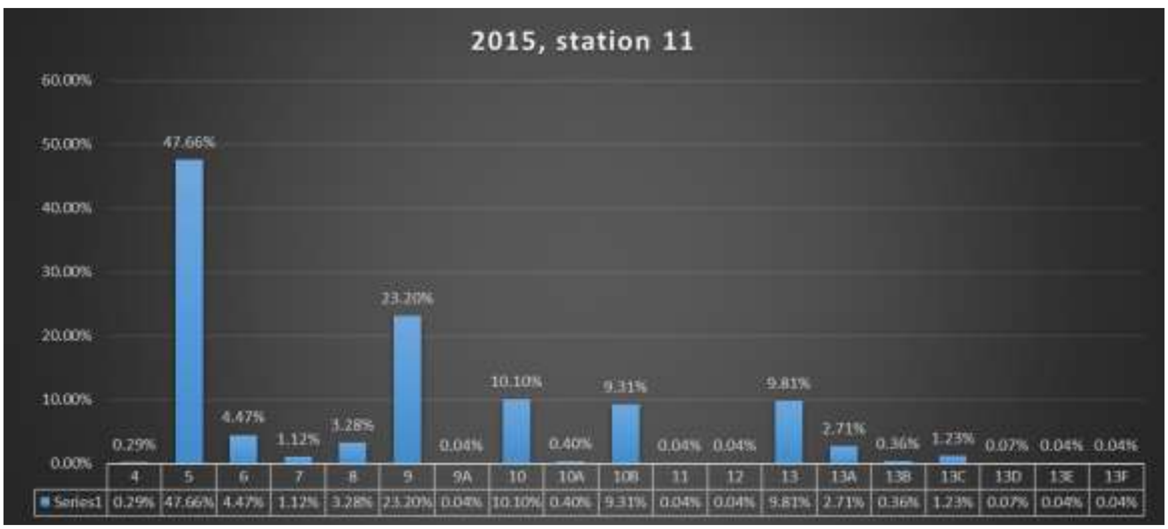


Figure 19: 2015 WIM data from Station 11

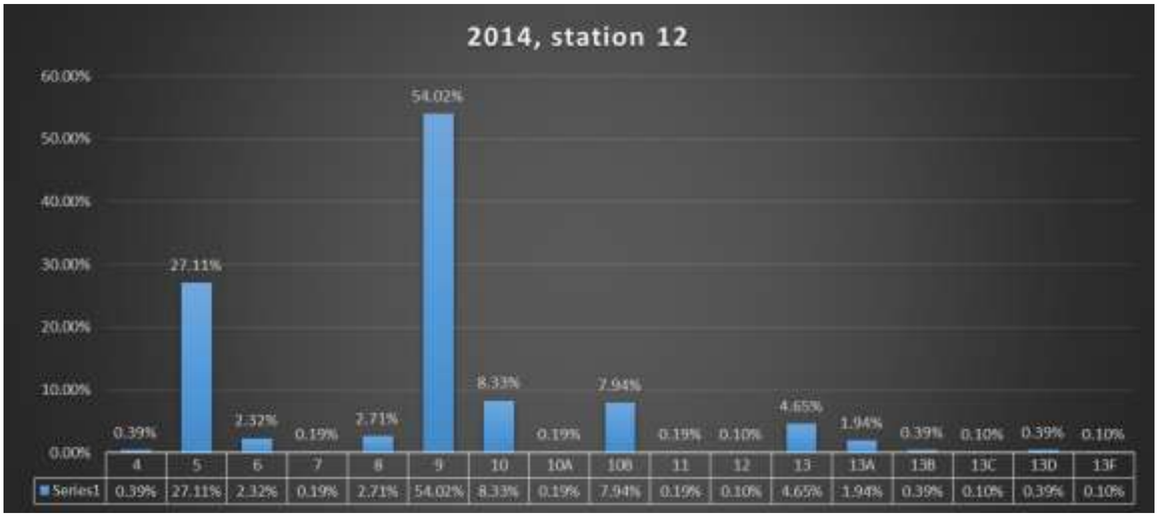


Figure 20: 2014 WIM data from Station 12

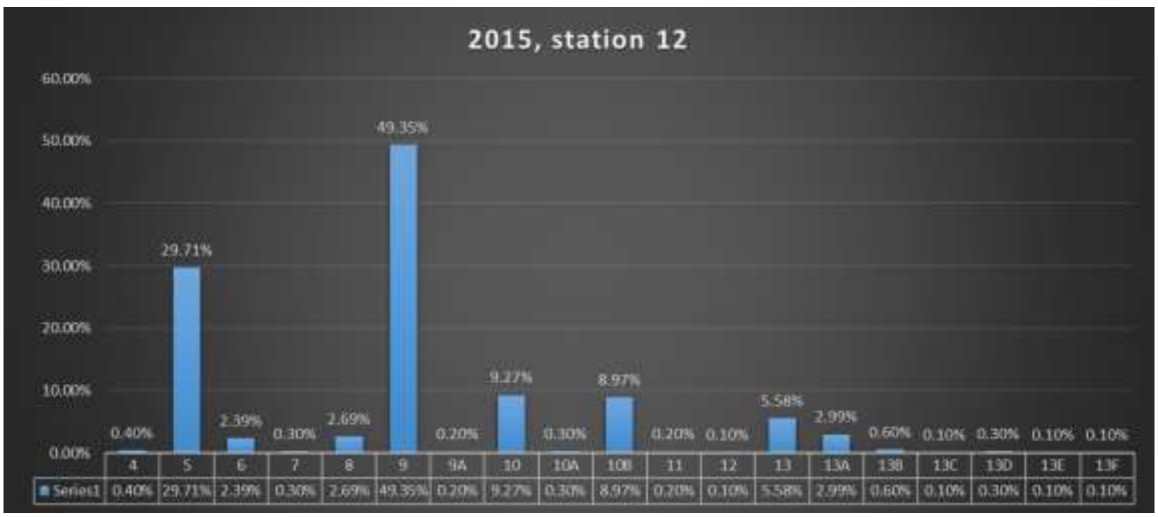


Figure 21: 2015 WIM data from Station 12

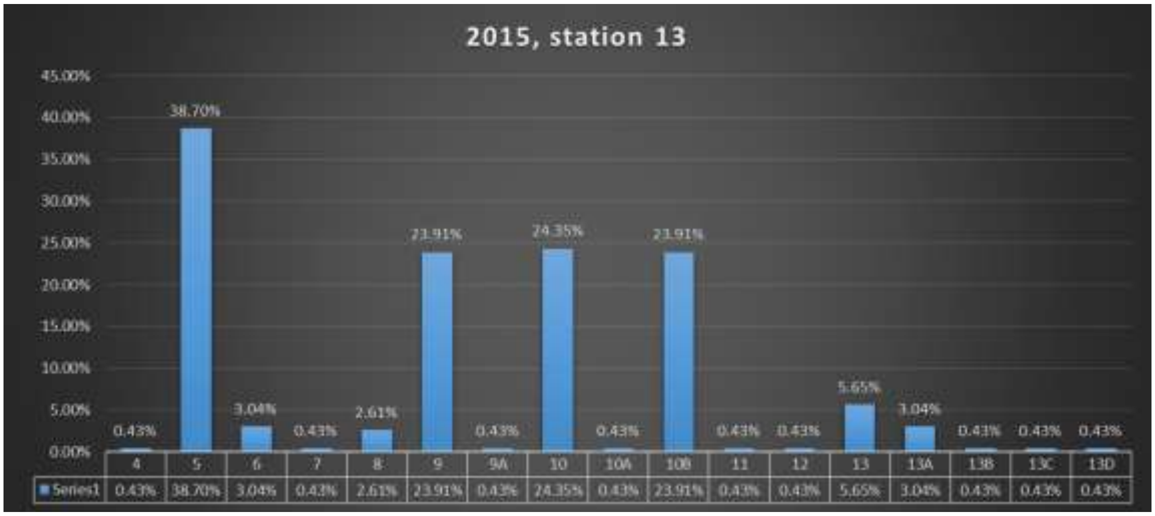


Figure 22: 2015 WIM data from Station13

Overview of Truck/Trailer Characteristics

Horsepower

In 2009, Dike Ahanotu conducted a survey of trucking firms to develop a relationship between truck configuration and horsepower requirements. Although the survey results did not present individual configurations from Class 9 to Class 13 trucks, it did present a range of reported horsepower by GVW, which is representative of the individual configurations when legally loaded. For Class 5 trucks, survey respondents indicated that the typical horsepower range was 150-199. For Class 6 and 7, the reported horsepower range was 250-299. For Classes 9 to 13, reported horsepower ratings varied from 250 to 450, with the most often reported horsepower between 350 and 399. As the GVW increased, the average reported horsepower also increased.

The widest variation in reported horsepower was at the GVW of 80,000. In this range, reported horsepower varied from 300 to 450. As the GVW increased above 80,000 lbs. the range narrowed to 350 to 450 horsepower.

The Western Uniformity Scenario Analysis presented horsepower ratings by weight/horsepower ratio. Similar to Ahanotu, similar horsepower ratings were shown for 80,000 and 129,000 lb. truck, albeit at significantly greater weight/horsepower ratings for the 129,000 configuration. The data presented in the Western Uniformity Study are presented in Table 10.

Horsepower Requirements Select Weight-to-Horsepower Ratios and Gross Vehicle Weights						
Weight/Horsepower Ratio (pounds)	**Horsepower Required for Weight-to-Horsepower Ratio in Right Column**					
	Typical 3S2* Tare Weight 30,000 lbs.	**Typical 3S2* Partial Load 60,000 lbs.**	**Maximum 3S2* Load 80,000 lbs.**	**Triples Uniformity Weight 110,000 lbs.**	**Typical Uniformity 8-axle LCV 120,000 lbs.**	**Maximum Uniformity LCV 129,000 lbs.**
150	200	400	533	733	800	860
200	150	300	400	550	600	645
250	120	240	320	440	480	516

Table 10: Horsepower Requirements for Various Weight Trucks

Fuel Consumption

Miles Per Gallon for Study Truck Configurations

Configurations	GVW (pounds)					
	40,000	60,000	80,000	100,000	120,000	140,000
Three-axle Single-Unit Truck	5.11	4.42				
Four-axle Single-Unit Truck	4.80	4.15				
Five-Axle Semitrailer		5.44	4.81	4.31		
Six-Axle Semitrailer		5.39	4.76	4.27		
Five-Axle STAA Double		5.95	5.29	4.76		
Seven-Axle Rocky Mt. Double			5.08	4.58	4.36	4.16
Eight-Axle (or more) Double			5.08	4.82	4.58	4.36
Triple-Trailer Combination			5.29	5.01	4.76	4.54

Source: Highway Revenue Forecasting Model

Table 11: MPG for Study Truck Configurations

Available at: https://www.fhwa.dot.gov/policy/otps/truck/finalreport.cfm

Note that the above data in Table 11 were generated in 2000, and technology has improved fuel consumption in heavy trucks during the past 16 years. Based on a report called "Reducing Heavy-Duty Long Haul Combination Truck Fuel Consumption and CO2 Emissions" in 2009, the average MPG for a five-axle semitrailer with an 80,000 lbs. GVW is around 7.18. Average estimated fuel economy for the newest truck models from Freightliner, International, Kenworth, Mack, Peterbilt, Volvo, and Western Star, is about 7.5 MPG. Based upon the new fuel consumption estimates, the data in the Table 12 were estimated.

GVW(pounds)	New MPG2	Fuel Consumption/Ton-mile(Gal/Ton-mile)2
105500	7.369	0.0026
122500	7.057	0.0023
105500	7.006	0.0027
120100	6.756	0.0025
105500	7.369	0.0026
123600	7.037	0.0023
105500	7.369	0.0026
129000	6.946	0.0022
105500	7.369	0.0026
129000	6.946	0.0022
60100	8.427	0.0039
63600	8.257	0.0038
105500	7.659	0.0025
112000	7.533	0.0024
60100	6.429	0.0052
55600	6.936	0.0052
94100	6.843	0.0031
89600	7.014	0.0032
105500	7.006	0.0027
99100	7.135	0.0028
86100	7.220	0.0032
86100	7.220	0.0032
105500	7.369	0.0026
106500	7.350	0.0026
105500	7.369	0.0026
106500	7.350	0.0026
80100	7.452	0.0034
80100	7.452	0.0034

Table 13: Estimated Fuel Economy of New Trucks at Various Weights

Emissions

The Environmental Protection Agency (EPA) has developed estimates for the larger truck configurations, separated into single trailer and multiple trailer configurations. For these two configurations, estimates of VOC, CO, NOx, PM2.5, and PM10 were provided. Estimates of emissions measures for each configuration are presented in the following Table 14.

Pollutant	Single Trailer Heavy Truck	Multiple Trailer Heavy Truck
VOC	0.455	0.545
CO	2.395	3.109
NOx	9.191	10.990
PM 2.5	0.215	0.238
PM 10	0.233	0.259

Table 14: Average Heavy-Duty Truck Emission Rates by GVW Class (grams per mile)

Source: Average In-Use Emissions from Heavy-Duty Trucks, Environmental Protection Agency, Office of Transportation and Air Quality, EPA420-F-08-027, October 2008

As shown in Table 14, the per-mile measures of all pollutants increase under larger truck configurations. However on a ton-mile basis, the per-ton-mile measure for all pollutants is less under larger truck configurations. This follows with fuel consumption insofar that as truck size increases, fuel consumption, and the resulting pollutants decrease on a ton-mile basis.

Origin/Destination Study of Intra and Interstate Truck Movements

The Freight Analysis Framework version 4 (FAF4) database was obtained to provide estimates of truck movements originating and terminating within North Dakota and the rest of the United States. The FAF4 database is maintained by the FHWA and the Bureau of Transportation Statistics. The FAF4 database provides estimates for tonnage and value by regions of origin and destination, commodity type, and mode. For the purpose of this analysis, not all commodities will be impacted by harmonization of truck size and weight regulations. Only commodities that are divisible and weight constrained will be impacted by any change in regulation. This section provides an overview of all commodities being shipped via truck. Specific commodity impacts are discussed in a later section.

The following Table 15 shows the volume of truck shipments by commodity, including both interstate and intrastate truck shipments. Agricultural shipments, including cereal grains and other agricultural products, coal, crude petroleum and gravel are the largest truck shipments, by tonnage.

Commodity	Tons Trucked in 2015	Commodity	Tons Trucked in 2015
Animal feed	7,922,558	Gasoline	1,648,030
Articles-base metal	1,015,741	Gravel	32,993,070
Base metals	907,460	Logs	121,703
Basic chemicals	466,157	Metallic ores	11,597
Building stone	40,128	Milled grain prods.	992,533
Cereal grains	72,675,411	Natural sands	6,182,743
Coal	5,164,899	Nonmetal min. prods.	8,687,929
Coal-n.e.c.	1,714,778	Nonmetallic minerals	210,245
Crude petroleum	482,801	Other ag prods.	41,436,271
Fertilizers	3,756,487	Waste/scrap	2,143,765
Fuel oils	4,264,635	Wood prods.	1,315,224
Total = 194,154,163			

Table 15: All Truck Shipments by Commodity

The following Tables 16 and 17 outline the volume of trade between North Dakota and the rest of the U.S. The first table presents the total truck tons terminated within the North Dakota by origin state. The tonnage estimates include all commodities. The three largest trade partners all adjoin North Dakota: Montana, Minnesota, and South Dakota. As most of these movements are bulk commodities, it is expected that as the origin and destination distance increases, a larger share of transportation is likely to move via rail, barring any commodity-specific characteristics which necessitate truck transportation.

Origin State	Tons Trucked in 2015	Origin State	Tons Trucked in 2015
Alabama	684	Nevada	2,024
Arizona	11,724	New Hampshire	399
Arkansas	6,017	New Jersey	15,360
California	29,621	New Mexico	3,756
Colorado	272,457	New York	3,820
Connecticut	13,143	North Carolina	21,472
Florida	4,890	Ohio	34,821
Georgia	4,505	Oklahoma	80,421
Idaho	115,299	Oregon	8,798
Illinois	480,832	Pennsylvania	29,297
Indiana	128,336	South Carolina	12,016
Iowa	246,022	South Dakota	3,044,723
Kansas	63,238	Tennessee	10,303
Kentucky	5,719	Texas	332,596
Louisiana	16,972	Utah	17,898
Massachusetts	613	Vermont	88
Michigan	88,259	Virginia	183
Minnesota	6,781,726	Washington	12,366
Mississippi	9,734	West Virginia	1,512
Missouri	83,040	Wisconsin	290,922
Montana	2,307,424	Wyoming	52,891
Nebraska	220,218		
Nevada	2,024		
Total = 14,866,135 Tons			

Table 16: Truck Tons Terminated in North Dakota by Origin State

The next table further describes North Dakota's trading partners within the United States, but presents tonnage which originates in North Dakota and terminates outside of the state.

Destination State	Tons Trucked in 2015	Destination State	Tons Trucked in 2015
Alabama	29,663	Montana	417,927
Arizona	642	Nebraska	96,032
Arkansas	30,377	Nevada	29
California	297,859	New Hampshire	7,308
Colorado	42,777	New Jersey	36,807
Connecticut	53,288	New Mexico	9
Florida	47,342	New York	37,293
Georgia	123,970	North Carolina	134,337
Idaho	17,203	Ohio	199,304
Illinois	394,965	Oklahoma	65,689
Indiana	189,463	Oregon	28,869
Iowa	86,099	Pennsylvania	188,366
Kansas	16,224	Rhode Island	618
Kentucky	167,454	South Carolina	5,700
Louisiana	13,649	South Dakota	1,948,968
Maryland	19,040	Tennessee	43,709
Massachusetts	27,515	Texas	77,651
Michigan	58,303	Utah	8,636
Minnesota	1,746,879	Virginia	15,556
Mississippi	59	Washington	23,253
Missouri	464,034	Wisconsin	117,347
		Wyoming	3,428
Total = 7,283,638 Tons			

Table 17: Truck Tons Originated in North Dakota by Terminating State

The following Table 18 presents the total tonnage shipped via truck within North Dakota by commodity. As before, cereal grains, other agricultural products and gravel account for the highest volume by tonnage. It is likely that these movements are relatively short in length due to the distribution of agricultural marketing facilities and aggregate locations throughout the state.

Commodity	Tons Trucked in 2015	Commodity	Tons Trucked in 2015
Animal feed	5,983,337	Gasoline	1,200,494
Articles-base metal	424,154	Gravel	30,879,400
Base metals	325,817	Logs	108,074
Basic chemicals	233,956	Metallic ores	10,865
Building stone	38,488	Milled grain prods.	685,281
Cereal grains	65,836,586	Natural sands	6,166,628
Coal	5,135,083	Nonmetal min. prods.	6,090,608
Coal-n.e.c.	915,121	Nonmetallic minerals	105,380
Crude petroleum	17,225	Other ag prods.	38,733,355
Fertilizers	2,783,729	Waste/scrap	2,115,860
Fuel oils	3,477,083	Wood prods.	737,864
Total = 172,004,389 Tons			

Table 18: Intrastate Truck Tonnage by Commodity

In addition to the intrastate movements described by the FAF4 data, an origin-destination model was developed specifically for agricultural and oil-related movements. This model was developed as part of the County, Local and Tribal Road and Bridge Needs study for the North Dakota Legislature. Agricultural movement originations were aggregated to the township level. All agricultural destinations (elevators, processors, transload facilities) were modeled at the physical location. Oil-related movements were modeled at the spacing unit (1,280 acre) level and destinations were modeled at the physical location. Volumes estimated were based upon the current rig level of 30 operating rigs. Existing production was indexed by the proportion of gathering pipelines to estimate truck trips and trip lengths as a result of well production.

Cost Per Ton Mile of Various Truck Configurations

The UGPTI Truck Cost Model (TCM) was used to estimate total truck costs in three configurations: 80,000, 105,500, and 129,000 lbs. The TCM is an engineering-economics model which estimates individual truck cost components based on variations in truck configuration, tare weight, payload, speed, and utilization. The TCM separately estimates variable-cost (distance-related) and fixed-cost components.

Inputs to the TCM include trip specific components and cost components. Trip components include volume of commodity, travel speed, trip distance, percent loaded and empty miles, wait time, truck type, truck configuration, GVW, payload, and tare weight. Cost components include fuel cost, interest rate, opportunity cost, sales tax rate, license and registration, labor cost (waiting and driving), and management and overhead, tractor and trailer prices, useful life, tire prices, and annual utilization. For comparison, truck costs were estimated for two common configurations and the maximum allowable weight under harmonization being 129,000 lb. The following table presents the per-mile costs for these three truck configurations.

	GVW		
	80,000	**105,500**	**129,000**
Variable Costs	**Per Mile**		
Fuel Consumption	$ 0.41	$ 0.45	$ 0.48
Maintenance	$ 0.09	$ 0.10	$ 0.12
Tire Wear	$ 0.05	$ 0.07	$ 0.08
Labor - Driving	$ 0.33	$ 0.33	$ 0.33
Labor - Waiting	$ 0.15	$ 0.15	$ 0.15
Total Variable Costs	**$ 1.02**	**$ 1.10**	**$ 1.16**
Fixed Costs	**Per Mile**		
Equipment Cost	$ 0.48	$ 0.48	$ 0.59
Insurance	$ 0.09	$ 0.09	$ 0.09
License & Reg.	$ 0.02	$ 0.02	$ 0.02
Sales Tax	$ 0.02	$ 0.02	$ 0.03
Opportunity Cost	$ 0.18	$ 0.18	$ 0.24
Overhead	$ 0.10	$ 0.10	$ 0.10
Total Fixed Costs	**$ 0.90**	**$ 0.90**	**$ 1.06**
Total Cost	**$ 1.92**	**$ 2.00**	**$ 2.22**

Table 19: Per-mile costs for 80,000, 105,500 and 129,000 lb. Truck Configurations

The 80,000 lb. configuration has a total cost of $1.92 per mile. Due to increases in fuel consumption per mile and slight increases in equipment cost, the 105,500 lb. configuration has a total cost of $2.00 per mile. Further increases in fuel consumption, tire wear, and equipment cost result in a cost of $2.22 per mile for the 129,000 lb. configuration. As expected, as the truck GVW increases, the per-mile cost of transportation will increase. However, for an accurate comparison of the economic efficiency of these three truck configurations considering payload, a ton-mile comparison is required. Table 20 presents the average costs per ton-mile by cost component for the three truck configurations.

	GVW		
	80,000	**105,500**	**129,000**
Variable Costs	**Per Ton-Mile**		
Fuel Consumption	$ 0.016	$ 0.013	$ 0.011
Maintenance	$ 0.003	$ 0.003	$ 0.003
Tire Wear	$ 0.002	$ 0.002	$ 0.002
Labor - Driving	$ 0.013	$ 0.010	$ 0.008
Labor - Waiting	$ 0.006	$ 0.004	$ 0.004
Total Variable Costs	**$ 0.041**	**$ 0.032**	**$ 0.028**
Fixed Costs	**Per Ton-Mile**		
Equipment Cost	$ 0.019	$ 0.014	$ 0.014
Insurance	$ 0.004	$ 0.003	$ 0.002
License & Reg.	$ 0.001	$ 0.001	$ 0.000
Sales Tax	$ 0.001	$ 0.001	$ 0.001
Opportunity Cost	$ 0.007	$ 0.005	$ 0.006
Overhead	$ 0.004	$ 0.003	$ 0.002
Total Fixed Costs	**$ 0.036**	**$ 0.026**	**$ 0.025**
Total Cost	**$ 0.077**	**$ 0.057**	**$ 0.053**

Table 20: Per-mile costs for 80,000, 105,500 and 129,000 lb. Truck Configurations

Due to the relative increases in payload as GVW increases, the ton-mile costs decrease as the vehicle GVW increases. This is due to a number of factors. First, fuel consumption increases at a lesser rate than the rate of GVW increase. Labor costs decrease on a ton-mile basis as well, as the labor cost is spread over additional tonnage at consistent travel speeds. Fixed costs also decrease on a ton-mile basis as equipment cost is not proportional to payload.

Pavement Cost Analysis for Various Truck Configurations

Truck Volumes:

The FAF4 database was used to provide estimates of truck movements which were likely to move to a larger configuration given harmonization of truck size and weight regulations with Montana and South Dakota. Due to existing regulations in other states, only traffic which originated or terminated in Washington, Oregon, Idaho, Montana, South Dakota or North Dakota is considered as potentially changing. Moreover, only commodities that are weight constrained and divisible are included in the analysis.

The truck configurations in use outside of North Dakota are unknown. Shipments originating in western states which currently allow 129,000 lbs. have two options upon entering North Dakota. First, the second trailer may be disengaged, allowing for legal hauls under North Dakota's current regulatory environment. Second, the GVW for the entire trip may be decreased, thereby allowing the shipment to travel seamlessly between North Dakota and surrounding states. As the configuration outside of North Dakota is unknown, the ESAL factors are only applied to North Dakota highways. Additionally, in later sections describing benefits of harmonization, user benefits which accrue in states outside of North Dakota are not estimated.

The next table outlines the commodities that were shipped by truck in 2015 that are likely to benefit under truck size and weight harmonization. It should be noted that in this table, all movements are considered to be eligible to move up to a higher GVW due to the commodity characteristics. Many of these shipments originate or terminate on local roadways, and shipments may not be navigable due to roadway geometry or other operational limitations. As noted above, each of these shipments either originates, terminates or originates and terminates within North Dakota and Idaho, Montana, Oregon, South Dakota, and Washington.

The likelihood of these shipments occurring in larger truck configurations depends on:

1. Origin location roadways
2. Destination location roadways
3. Required facilities for loading/unloading

For example, cereal grains generally originate at fields served by county or township roads. If the roadway geometry is not amenable to longer truck configurations, the likelihood of adopting those configurations is minimal. Most of these shipments terminate at grain elevators or processors which are often located on a federal aid county road, state highway, or U.S. highways. Most elevators would be able to accommodate longer combination vehicles using existing loading/unloading equipment. This shipment would then be origin-constrained, resulting in a truck configuration which is less than 129,000 lbs. For this reason, the estimates presented in Table 21 assume that the existing infrastructure is sufficient to handle LCVs at 129,000 lbs.

Commodity	Tons Shipped	Current Configuration	129000 lb.
Animal feed	7,922,558	226,359	188,632
Articles-base metal	1,015,741	29,021	24,184
Base metals	907,460	25,927	21,606
Basic chemicals	466,157	18,646	11,099
Building stone	40,128	1,147	955
Cereal grains	72,675,411	2,907,016	1,730,367
Coal	5,164,899	147,569	122,974
Coal-n.e.c.	1,714,778	48,994	40,828
Crude petroleum	482,801	13,794	11,495
Fertilizers	3,756,487	107,328	89,440
Fuel oils	4,264,635	121,847	101,539
Gasoline	1,648,030	47,087	39,239
Gravel	32,993,070	1,319,723	785,549
Logs	121,703	4,868	2,898
Metallic ores	11,597	331	276
Milled grain prods.	992,533	28,358	23,632
Natural sands	6,182,743	176,650	147,208
Nonmetal min. prods.	8,687,929	248,227	206,855
Nonmetallic minerals	210,245	6,007	5,006
Other ag prods.	41,436,271	1,657,451	986,578
Waste/scrap	2,143,765	85,751	51,042
Wood prods.	1,315,224	37,578	31,315
Total	**194,154,163**	**7,259,678**	**4,622,718**

Table 21: Weight-Constrained, Divisible Shipments with Potential to Move to Larger Truck Configurations

Table 22 on the following page outlines the weight-constrained, divisible shipments which meet the likelihood criteria for moving to larger truck configurations. In this scenario, agricultural movement and gravel shipments are adjusted due to the origin or destination roadway criteria.

Commodity	Tons Shipped	Current Configuration	129000 lb.
Animal feed	7,922,558	226,359	188,632
Articles-base metal	1,015,741	29,021	24,184
Base metals	907,460	25,927	21,606
Basic chemicals	466,157	18,646	11,099
Building stone	40,128	1,147	955
Cereal grains	21,802,623	872,105	519,110
Coal	5,164,899	147,569	122,974
Coal-n.e.c.	1,714,778	48,994	40,828
Crude petroleum	482,801	13,794	11,495
Fertilizers	3,756,487	107,328	89,440
Fuel oils	4,264,635	121,847	101,539
Gasoline	1,648,030	47,087	39,239
Gravel	16,496,535	659,861	392,775
Logs	121,703	4,868	2,898
Metallic ores	11,597	331	276
Milled grain prods.	992,533	28,358	23,632
Natural sands	6,182,743	176,650	147,208
Nonmetal min. prods.	8,687,929	248,227	206,855
Nonmetallic minerals	210,245	6,007	5,006
Other ag prods.	12,430,881	497,235	295,973
Waste/scrap	2,143,765	85,751	51,042
Wood prods.	1,315,224	37,578	31,315
Total	**97,779,450**	**3,404,689**	**2,328,082**

Table 22: Weight-Constrained, Divisible Shipments Likely to Move to Larger Truck Configurations

Pavement impacts are estimated by considering the difference in required trucks and the difference in ESAL factors for each of the truck configurations in question. A standard five-axle configuration has an ESAL factor of 2.4. A 105,500 lb. truck has an ESAL factor of 3.36. The most ESAL-efficient configuration, which would be allowed to haul at 129,000 lbs., is the steering, tandem, triple, tandem, tandem, which has an ESAL factor of 4.121. ESAL factors for all truck types considered in the study are presented in Table 23 on the following page.

	Vehicle/axle configurations	Exterior GVW	Interior & Exterior GVW	Exterior ESALs per Truck	Interior & Exterior ESALs per Truck
#/Axles	**2 Vehicle Combinations**				
5	Single, tandem, tandem	80,000	80,000	2.379	2.379
7	Steering, triple, triple	105,500	96,000	2.219	1.483
5	Steering, tandem, single, single	86,000	86,000	4.304	4.304
9	Steering, triple, single, triple, single	105,500	129,000	5.339	4.503
	3 Vehicle Combinations				
7	Rocky Mountain Double: Steering, tandem, tandem, single, single	105,500	120,000	5.469	5.399
8	Super B Train: Steering, tandem, triple, tandem	105,500	122,000	3.364	3.026
10	Steering, tandem, triple, tandem, tandem	105,500	129,000	4.444	4.121
10	Steering, triple, tandem, tandem, tandem	105,500	128,000	4.444	4.121

Table 23: ESAL Factors and GVW by Truck Configuration and Measurement Criteria

ESAL Cost per Mile:

To calculate the cost to the roadway system, UGPTI has developed cost per ESAL mile values for three highway classifications. Each cost is derived from 2014 NDDOT construction values and 2015 NDDOT traffic count values. For the interstate and U.S. highway systems, an assumed 1,500 trucks/day equates to an ESAL design load of 26.2 million. At a structural overlay cost (a conservative construction practice) of $550,000 per mile, the design cost per ESAL is just above $0.02 per mile. For this study, we will use a value of $0.03 per ESAL mile to include additional costs for maintenance over the 20-year design window.

Using a similar analysis, a system cost for the state highway corridors is $0.07/ESAL mile and county major corridors a cost of $0.40/ESAL mile. Both of these corridors were analyzed using a thin lift overlay (less than 3" in depth) to account for the lower traffic volumes they carry. These two corridors, however, have higher costs per mile with the lower construction costs compared to the interstate system due to the significantly lower design ESAL loads.

<u>Assumptions are shown below</u>

Interstate/US Highway system: Cost: $550,000/Mile (Structural Overlay), Count: 1500 Trucks/Day (US 2 Near Williston, I-94 Near Tower City), ESALs/DAY: 3600, ESALs Design (20 Years): $26.2 million. Cost: 550,000/26200000 = $0.021 per ESAL/Mile

-> Use $0.03/ESAL Mile value, since no maintenance costs are included in this value.

State (Minor) Corridors: Cost: $375,000/Mile (Minor Asphalt Overlay), Count: 400 Trucks/Day (ND 1 North of VC, ND 18 near Amenia), ESALs/DAY: 960, ESALs Design (20 Years): $7,000,000. Cost: 375,000/700000 = $0.053 per ESAL/Mile

-> Use $0.07/ESAL Mile, no maintenance

County Corridors: Cost: $375,000/Mile (Minor asphalt overlay), Count: 60 Trucks/Day, ESALs/DAY: 144, ESALs Design: $1,050,000. Cost: 375,000/1,050,000 = $0.357 per ESAL/Mile

-> Use $0.40/ESAL Mile, no maintenance

Using the truck change estimates above, a weighted average cost per ESAL mile was calculated based on reported VMT by classification. The resulting weighted average cost was $0.16 per ESAL mile. Under the scenario for all movements, an estimated 18.6 million ESALS would occur given current truck configurations, and with a change to a larger configuration, a total of 19.0 million ESALS are estimated for a net increase of 401,000 ESALS. Under the likely scenario, the net increase in ESALs was 204,871. Table 24 on the following page presents the ESAL and cost estimates under both scenarios.

	All Movements	Likely Movements
Current 80kip and 105.5kip movements	18,643,864	9,386,827
ESAL 129kip	19,045,599	9,591,698
Change	401,734	204,871
ESALs @ 100 Miles	22,770,262	17,426,596
Weighted Average Cost per ESAL/mi*	$0.16	
Estimated Annual Pavement Impact	$3,643,242	$2,788,255
***Cost is weighted by VMT by Classification**		

Table 24: ESAL Estimates and Annualized Pavement Impacts

At the weighted average cost of $0.16 per ESAL mile the all movements scenario results in an annual pavement impact of $3.6 million. Under the likely movements scenario, the annual pavement impact was $2.8 million.

Bridge Cost Analysis for Various Truck Configurations

Because of the advancing age of the bridge system in North Dakota and a standard design age of 50-75 years for bridges, there is a backlog of work that will need to be completed to update the highway system in the upcoming years. A recent study for NDDOT by UGPTI showed the backlog of state system bridge replacements and maintenance to be $163 million based on bridge condition. Likewise, the 2016 Assessment of ND County and Local Road Needs showed a similar bridge condition backlog of $449 million.

Over the years there have been changes in bridge design standards to account for the evolution of heavier truck configurations. Prior to 1975, the maximum GVW (GVW) on the interstate was 72,000 lbs. with single axles having a maximum weight of 18,000 lbs. This is equivalent to the HS-20 design load in the AASHTO bridge design manual. These were the truck and axle weights used for the Illinois Road Test, which was the basis for pavement design in the late 20th century. In 1975, as a result of the 1973 Oil Embargo/Crisis and the high price of fuel, Congress increased the maximum GVW to 80,000 lbs. As these changes occurred, the design vehicle for bridge design also changed as it became more common to use the HS25 and eventually the HL-93 rating for state system bridges. Figure 22 shows how existing bridges in North Dakota relate to the period before and after 1975. Figure 23 shows the most common design vehicles or standards used over the years. A discussion of how NDDOT design practices compares with neighboring states in allowing 129,000 GVW is presented later in this section.

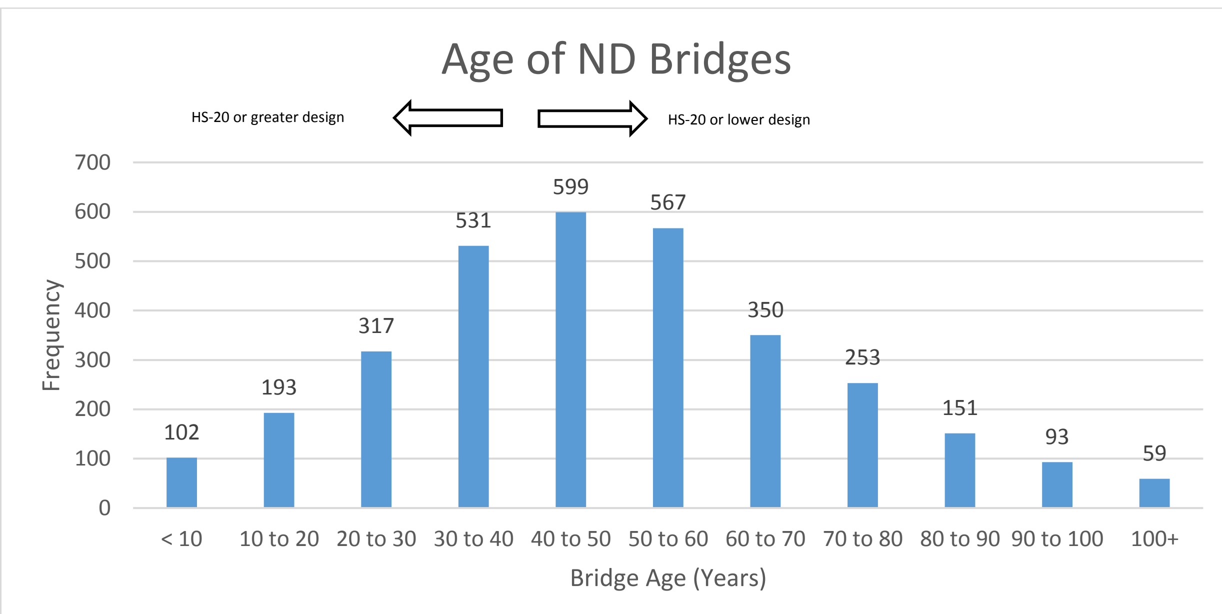


Figure 22: Chart showing age breakdown of ND Bridges

With the increase in maximum GVW allowed on the highway system, the existing bridge system was not upgraded, (but was analyzed to ensure safety) and new designs were updated to a higher design load. Figure 24 shows the design loads that are listed in the National Bridge Inventory (NBI) for all N.D. bridges. As per figure 24, approximately 10% of all bridges in North Dakota were designed for a vehicle higher than the previous standard of 72,000 lbs. GVW. However, existing bridges with an HS-20 lane loading may have a higher GVW capacity than the 72,000 lb. weight based on bridge span and how the lane load is calculated.

Over the years of design and assessment of bridges, the Federal Highway Administration and NDDOT have developed and implemented an additional load rating practice where bridge plans exist. This allows jurisdictions to evaluate if a particular bridge is able to accommodate a particular truck configuration. The resulting rating concept will be discussed later in the sections covering inventory and operating ratings.

Figure 23: Bridge Design Vehicles

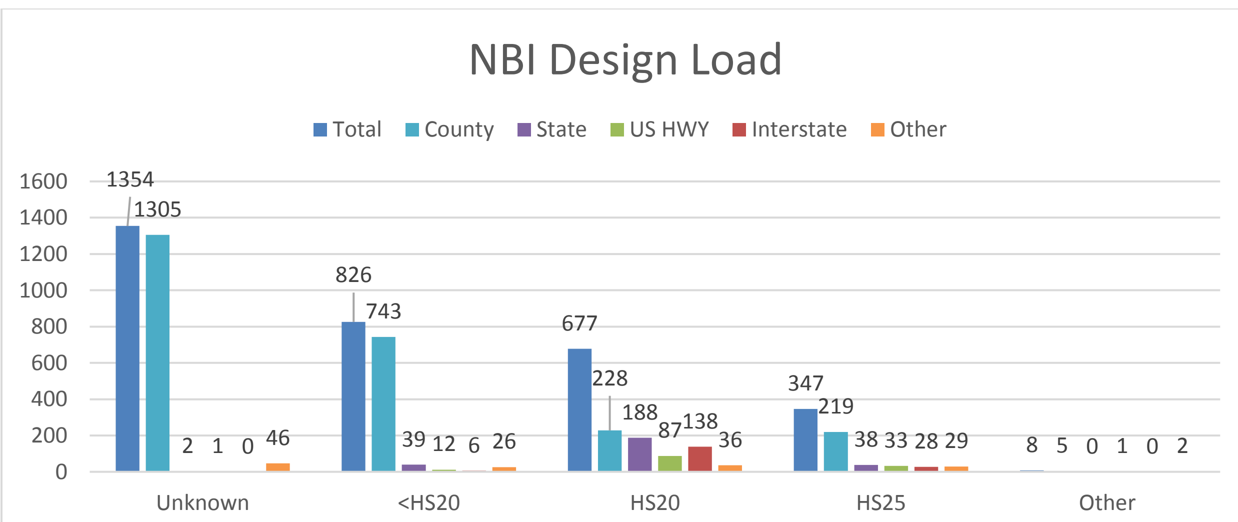


Figure 24: Design Load listed in NBI for ND Bridges

For this study, an analysis of the number of bridges in need of repair or replacement based on load ratings was conducted. Currently in North Dakota, 729 bridges are posted. A "posted" bridge means that the existing bridge has been deemed unable to handle a standard 40-ton load by NDDOT or the local municipality, and is therefore restricted to trucks of a smaller size. These bridges are mostly located on the township and county systems. The cost to replace every one of these bridges would be $358.1 million. An additional 167 bridges in the NBI inventory are not posted but have an operating rating listed below

40 tons. These bridges would cost an additional $96.1 million to replace. Using these two categories, the total load-related backlog of bridge replacement and maintenance is approximately $454.2 million. The state system load-related backlog consists of four structures valued at $1.8 million. None of the state system backlog structures are on interstate or U.S. highways. As mentioned earlier, the state system and the county/township systems have bridge condition backlogs of $163 million and $449 million, respectively. These backlog costs are not included in the following total system costs to implement a larger GVW unless the bridges also are posted for less than a standard 40-ton load.

Figure 25: Existing Posted Bridge – North of Portland, ND.
Source: Google Earth

For the increased GVW bridge impact analysis, the NBI information for North Dakota was acquired for the 2015 inspection season. This inventory includes all bridges that are over 20 ft. in length in the state, which is a total of 4,401 bridges statewide. After consulting with NDDOT, structures classified as culverts in the NBI were removed. This removed 1,003 structures from analysis. The inventory was further pared down so that the 373 bridges that were on “minimum maintenance roadways,” or roadways that were on dirt trails minimally maintained by the township, were removed from the study. The resulting total of 3,006 bridges was included in the final analysis of the non-state category. Additionally, all 21 bridges crossing the Red River into Minnesota were not removed from the database but considered exempt from larger truck weights due to Minnesota regulations in place.

When the database was finalized, the age, cost to replace, and posting status were determined for each county bridge that had issues with any of the loads generated by one of the eight test vehicles (See appendix A). As per legislative intent, NDDOT staff partnered with UGPTI staff to perform a more rigorous analysis of state system bridges using AASHTO VIRTIS. This software is similar to software used for the USDOT study, and allows for a more in-depth member-by-member analysis of all statewide bridges for which plans are available. This extra information and analysis beyond the NBIS data (span length, overall capacity, etc.) allows the DOT to take a more nuanced approach to understanding the full capacity of each individual bridge, rather than the broader approach taken by UGPTI. Because of the data required to conduct a VIRTIS analysis of a bridge, the DOT was only able to analyze the existing state-maintained bridge system.

A similar approach was not possible for the county system, so UGPTI staff used a more general approach using existing NBI data for analyzing bridge impacts. The analysis approach taken by UGPTI for county bridges used an expansion and modification of the concepts presented in the Minnesota Truck Size and Weight Study and the FHWA Western Uniformity Study. These studies pointed out that axle spacing is as important as axle weight in designing bridges. In Figure 26A, the stress on bridge members as a longer truck rolls across is much less than that caused by a short vehicle as shown in Figure 26B, even though both trucks have the same total weight and individual axle weights. The weight of the longer vehicle is spread out, while the weight of the shorter vehicle is concentrated on a smaller area. Due to the analyzed truck layouts, long span bridges where a single span will hold an entire truck of 129,000 lbs. must be given close review. Replacement was deemed to be the only option for deficient bridges due to the lack of strengthening options for these bridges. With the longer layouts of longer combination vehicles and heavier vehicles, many shorter bridges in North Dakota were not affected by the increased loading.

For bridges slated for replacement, NDDOT and UGPTI used similar cost estimating procedures. The cost to replace for each bridge followed a convention similar to that used in the 2013 Legislative County Needs study. When a bridge was less than 40-ft. long, it was slated for a replacement by a single box culvert at a fixed cost of $400,000. If the bridge was more than 40-ft. long, but less than 50 ft., the replacement for it would be a multi-barrel box culvert at a fixed cost of $600,000. If the bridge was over 50-ft. long, its length was multiplied by a factor of 1.7 to account for longer modern bridge design, the deck surface area was calculated and the multiplied by the fixed cost of $250/square ft. On state system bridges, NDDOT staff used a factor of 1.5 for bridges over water and a factor of 1.2 for all other bridges.

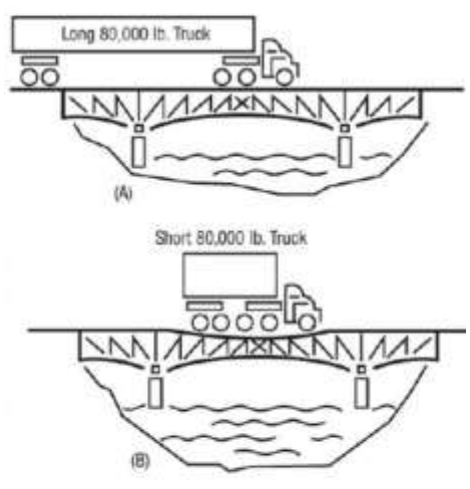


Figure 26: Effects of Truck/Trailer Length on Bridge Loading

To determine the sufficiency of each bridge according to inventory and operating ratings, each of the eight design trucks was analyzed for multiple different truck span lengths, and was then compared to the load capacity and bridge span length listed in the NBI (For testing layouts, see Appendix). For example, a five-axle, 80,000-lb. truck would pass over a bridge in three different loading scenarios. The first scenario would be the entire length of the truck at 53 ft., with the entire 40-ton loading bearing on the bridge. The second scenario would be the front tractor with a length of 17 ft. passing over the bridge with a 23-ton load bearing on the bridge. Finally, a third, smaller scenario of the final two wheels 4 ft. apart carrying 17 tons would also be bearing on the bridge. If a bridge is able to handle all three of these load cases according to its corresponding inventory rating and operating rating, the bridge would be considered able to handle the loading scenario. If there was an inability to carry these increased loads, the bridge would be flagged for replacement at the costs previously discussed. This process was carried out for all eight truck configurations, and the inability to handle any one of the eight load cases was cause for replacement.

The bridge load rating scale of inventory rating (IR) was chosen for baseline comparison because of how it is addressed in the NBI. The inventory rating is cited as the loading that can be applied to the existing structure for an indefinite period of time. The inventory rating is generally used to assess a bridge's capability to accept a maximum load on a day-to-day basis with no damage to the bridge structure, and includes the ability for a bridge to handle trucks going head to head over the structure. The operating rating (OR) is the load level, which is considered the absolute maximum permissible load, such as a single pass oversize permit. According to AASHTO guidelines, allowing an unlimited number of vehicles to pass over the bridge at the operating level may shorten the life of the bridge. Analysis was completed for two rating scenarios, the IR and OR of each individual bridge for local bridges. The NDDOT analysis only included bridges that were insufficient for IR scenarios, as OR capacity was not a major factor in state system bridges. Any bridge that is listed by the NBI as "closed" was not analyzed for structural capacity, and not slated for replacement.

Table 25 shows the breakdown of the different state classification systems and the replacement costs of insufficient bridges that would be incurred by an increase of maximum GVW. Table 26 shows similar data for local entities. For this analysis, if an existing bridge was posted according to the NBI, it automatically would be flagged for replacement. However, if a bridge had a low sufficiency rating but was not posted for existing loads, the bridge was not automatically flagged for a replacement. Note that the costs do not include the previously mentioned existing backlog of $454.2 million, of which $1.8 million is on the state system.

		Inventory Rating Analysis Findings	
Roadway Class	Total Count	Count	Full Replacement Cost (Millions)
Interstate – Mainline (NDDOT Supplied)	232	66	$229.2
Interregional (NDDOT Supplied, includes		62	$260.9

overpasses)			
State Corridor (NDDOT Supplied, includes overpasses)		38	$104.4
District Corridor (NDDOT Supplied, includes overpasses)		29	$75.8
District Collector (NDDOT Supplied)		20	$35.8
DOT Total	**711**	**215**	**$706.1**

Table 25: Impacts to State bridges as result of Harmonization to 129,000 lbs.

		Inventory Rating Analysis Findings		**Operating Rating Analysis Findings**	
Roadway Class	Total Count	Count	Full Replacement Cost (Millions)	Count	Full Replacement Cost (Millions)
County – CMC (UGPTI Analyzed)	535	363	$411.32	92	$89.84
County Non-CMC (UGPTI Analyzed)	1,632	1,152	$845.92	625	$361.05
County Total	**2,167**	**1,515**	**$1,257.24**	**717**	**$450.89**
Urban (UGPTI Analyzed)	89	59	$203.77	18	$56.38
Federal Land (UGPTI Analyzed)	27	19	$18.93	10	$10.99
Other (UGPTI Analyzed)	12	10	$12.58	4	$3.01
Other Total	**128**	**88**	**$252.76**	**32**	**$74.36**

Table 26: Impacts to Local bridges as result of Harmonization to 129,000 lbs.

This analysis shows increased needs for all roadway classifications due to harmonization. Note that the costs shown above are a global cost to update the system. To further refine a bridge replacement schedule, corridor studies should be completed. Similar to the Idaho Pilot study, this would allow NDDOT to have a better understanding of the amount of 129,000-lb. trucks that have passed through each corridor and have a better understanding of the utilization of the corridors.

Also note that bridges with an inventory rating below 129,000 lbs. may see more rapid deterioration and may require more monitoring and inspection with increased truck loadings. A recent case study is the Lewis and Clark Bridge over the Missouri River on US 85. As oil-related traffic increased 5 to 10 fold, the bridge was exposed to loading cycles far in excess of the original anticipated loading cycles, and bridge beams (especially welds) deteriorated much faster than in the past. The deterioration was identified during the regular bridge safety inspections, which occur every two years. NDDOT increased the frequency of bridge inspections and moved to quarterly inspections. If bridges are exposed to 129,000 lbs.

in the near future, this US 85 example might be a good example of the accelerated bridge deterioration that may occur.

NDDOT staff members have also conferred with South Dakota DOT and Montana DOT regarding their design practices since adoption of the 129,000-lb. allowable load. South Dakota responded that it has not formally changed its design load as these loads still need to meet the bridge formula. SDDOT is looking at adding an S.D. specific Strength II live load, but does not have anything definite yet. Montana similarly responded for design, and they continue to use the typical HL 93 live load, which is the design load used by NDDOT.

To ease the replacement schedule, some county bridges may be able to have their inventory rating and operating rating re-calculated. For example, in 2012 the Cass County Highway Department conducted a load rating test. BDI of Boulder, CO, was hired to conduct load ratings of two existing Cass County bridges. Both bridges were concrete post-tensioned girder bridges built in the 1970s, and had sufficiency ratings well above the 50.0 threshold for federal bridge funding for a replacement. However, both bridges were posted for loading because of lost plans. Since there were no existing plans, NDDOT engineers conservatively rated the bridges to ensure they would be able to carry all loads for an indefinite time and to minimize the risk of failure. To conduct the load rating, BDI brought portable ground penetrating radar (GPR) equipment along with strain gauges to the bridge sites. The strain gauges were attached to the bridge, and then a test load was driven over the bridge at different speeds. The strain gauges recorded the stresses and strains within the bridge, and then the bridge beams were scanned with the GPR equipment to understand where the reinforcing steel was located. The load rating of the bridge was then back calculated using the strain readings and the GPR data. These load ratings were accepted by NDDOT and the bridge postings were lifted. This procedure cost the county less than $60,000 and saved two bridges from being replaced at a much higher cost.

Initial analysis for this procedure has been conducted for the county bridge system. A bridge was flagged for a possible load testing if it was an existing bridge that was missing original plans and was pre-cast, pre-stressed, post-tensioned, or cast-in-place concrete construction. A total of 129 bridges met these criteria, which would cost $3.9 million to inspect and load test at a cost of $30,000 per bridge.

Connectivity to Local Jurisdictions

With an allowed increase in truck length comes additional stress to intersections and intersection radii. With the increased length of trailers to allow heavier weights and higher axles spacing, additional trailer offtracking will occur. Offtracking is the radial offset between the centerline of the front axle and the path of a following axle (NCHRP Report 505). More importantly, the swept path width is the difference in wheel paths between the outside front tractor tire and the inside rear trailer tire. Swept path width controls the design of the intersection radius, which increases with increased trailer length.

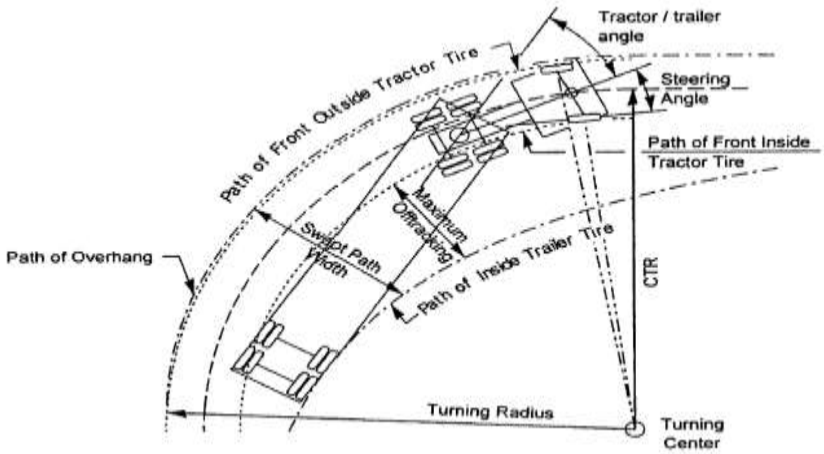


Figure 28: Definition of Swept Path and Offtracking -Source – 2004 AASHTO Green book

With the increase in vehicle length, swept path width increases. According to AASHTO, as standard 53-ft. interstate semi-trailer (AASHTO WB-67) has a minimum design turn radius of 44.8 ft. For comparison, a Rocky Mountain Double (AASHTO WB-92D) has a design turning radius of 82.0 ft., an increase of nearly 86% over the standard interstate trailer. This creates a burden on the existing two-lane highway network (state, county and township) by requiring larger intersection radii to lessen the need for a longer vehicle to track into an opposing lane to complete a right turn. If this radius is not increased, the longer vehicles are required to swing out into the opposing lane before or during the right hand turn to allow for the rear wheels to remain on the road top and not drop into the inslope or ditch.

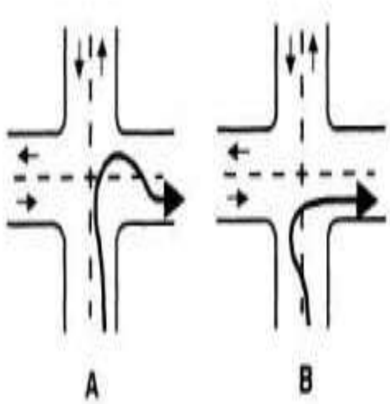


Figure 29: Illustration of Long Vehicle Paths around Tight Corner Radius

Swinging wide through an oncoming lane could provide up to an additional lane-width (about 10 ft. on many township roads) to the corner radius. On low traffic rural roadways, turning into the opposing lane does not present as much of a problem for larger trucks, but on higher traffic rural roadways it creates a traffic hazard in opposing lanes or a traffic bottleneck behind the turning vehicle.

Within cities, offtracking can become damaging to traffic signals and curbs or dangerous to pedestrian traffic. Many urban intersections may also have a centerline barrier stripe on the road, which by law prohibits vehicles from crossing the barrier stripe. Additionally, traffic signal timing may need to be modified to accommodate longer travel paths and longer vehicles around the larger radius turns. Increasing the corner radii of a signalized urban intersection will also increase a pedestrian's walk distance across an intersection, which might require a longer "WALK" pedestrian signal phase. Heavier trucks may also experience slower acceleration. All of these issues can contribute to reductions in the vehicular capacity of a signalized intersection.

Current design standards for intersection radii vary from jurisdiction to jurisdiction. Below is a typical county/township intersection as taken from Google Earth:

Figure 30: Typical County/Township Road Intersection Showing Tight Corner Radii

A state highway intersection which must currently accommodate long combination vehicles (trucks with 2 or more trailers) looks like the intersection below:

Figure 31: Typical State/County Highway Intersection Showing Larger Corner Radii
Source: Google Earth

N.D. state law allows a maximum vehicle length of 75 ft. unless otherwise posted. Most counties have a 25-30-ft. standard radius for County Major Collector (CMC) and township intersections. This is an insufficient radius for an existing WB-67 truck to successfully complete a right turn without offtracking into an opposing lane. However, this radius is also too narrow for a WB-92D truck to complete a right turn on a 20-ft. wide township roadway. To even allow for a WB-92D to complete a right-hand turn with less than 20 ft. of offtracking (complete a turn on a 20-ft. wide road), a minimum 75-ft. radius must be provided at the intersection (NCHRP 505). This inability to support longer vehicle turning creates a systemic problem across all township roadways.

When increasing the radius of a rural intersection, there are many factors that need to be considered. To increase the radius, fill must be placed in the existing radius to extend out the base of the roadway. Gravel or pavement must also be extended outward to allow for the longer truck path to continue on a roadway surface. Many times, this widening also requires the underlying culverts to be extended (or replaced if in poor condition) to account for the additional width of the intersection. Additional affected intersection characteristics include increased right of way (ROW) requirements, utility relocations, and fence line adjustments.

A sample of seven townships spread throughout the state was evaluated to determine the scale of intersection needs, based on identifying rural truck trip generators. Each sample township was evaluated by viewing aerial photography via Google Earth to identity on-farm storage subject to large truck hauling offsite, as well as rural commercial/industrial truck traffic generators. Note that mineral development and production (gravel, oil & gas) was difficult to assess via Google Earth due to the 2013 date of imagery. Examples of on-farm storage and oil wells are shown in the aerial views of Figure 32.

Figure 32: Examples of On-farm Storage and Oil Wells Source: Google Earth

Rural trip generators considerations included the following:

- Identified local truck generators, then looked at the township road system to identify likely truck routes.
- Identified intersections subject to turning trucks, assuming they would need to accommodate larger truck geometrics.

- Intersections were not individually evaluated for site-specific geometric improvements.

The analysis of a sample township is shown in Figure 33, indicating the number of intersections that would likely experience longer combination vehicles if the rural truck generators took advantage of a truck harmonization effort that allowed the larger trucks. In Figure 33, note that the circles represent rural truck generators, while the green triangles indicate intersections subject to larger truck turning movements.

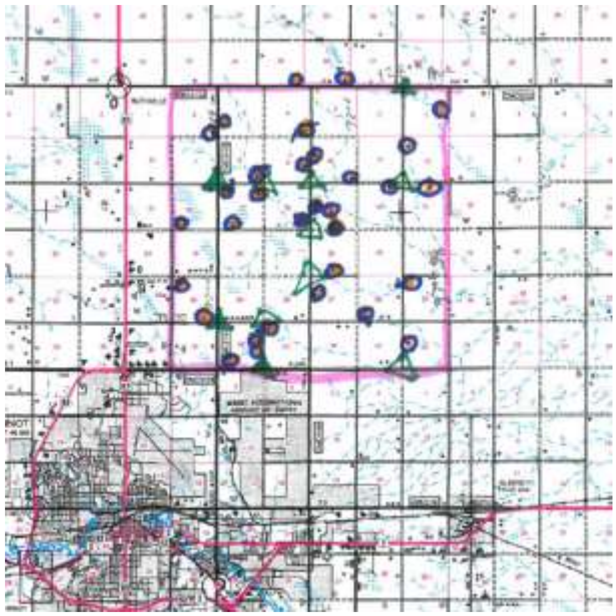


Figure 33: Example of Township Trip Generators and Intersection Needs

Table 29 shows the results of the rural intersection upgrade evaluation, indicating an average of 38% of the sampled township intersections may experience larger trucks; and therefore are assumed to require geometric improvements to the intersections.

Rural Intersection Upgrade Evaluation						
County	**Intersections in Sampled TWP***	**Number of Impacted Intersections**				
		TWP	CMC	State	**Total**	**%**
Cass	37	11	3	0	14	38%
Traill	36	9	0	0	9	25%

Kidder	17	1	0	4	5	29%
Ward	35	7	4	0	11	31%
Stark	25.5	6	2	0	8	31%
Mountrail	28	12	0	3	15	54%
Williams	20	11	0	0	11	55%
AVERAGE	**28.4**	**8.1**	**1.3**	**1.0**	**10.4**	**38%**

Table 29: Rural Intersection Upgrade Evaluation
* perimeter intersections were divided by 2 to avoid duplication

Increasing an intersection radius comes with high costs. It is not a linear relationship, with costs increasing exponentially with each increase in the radius. Increasing a radius from 25 ft. to 75 ft. costs over double the cost of increasing a radius from 25 to 50 ft. Increasing township radii will incur a large cost to the system, since there are over 50,000 intersections on the county and township system across North Dakota. A more practical improvement plan may be to only upgrade intersection radii where existing shippers travel, rather than to improve all intersections regardless of shippers' needs.

For example, cattle country tends to have much less tonnage being shipped to market than an area dominated by corn or other high tonnage crops. A blanket approach to intersection improvements might invest in improvements that may not be used. Another concept evident in oil and gas producing counties as well as wind farms, is where the companies involved in mineral or energy development often fund and/or undertake specific road and intersection improvements and maintenance to maximize the economics of moving their equipment and products.

Assuming basic material costs (Table 30), bringing intersections to proper radii will cost $3,080 to increase one corner radius from 25 ft. to 50 ft., $7,264 to increase one corner radius from 25 ft. to 75 ft., and $10,751 to increase one corner radius from 25 ft. to 100 ft.

Material	**Cost**	**Unit**
Gravel	$ 25.00	Ton
Clay Fill	$ 3.00	CY
Culvert	$ 150.00	LF
End Section	$ 250.00	EA
Utility	$ 1,000.00	Post

Fence	$ 10.00	LF
ROW	$ 500.00	Min Payment

Table 30: Material Cost Assumptions for Intersection Upgrades

Extrapolating the sampled township data with 1,946 townships in North Dakota yields 21,000 intersections that could potentially require geometric upgrades. Assuming half of the upgraded intersections will need one corner radius improved, one-fourth need two corner radii improved, and one-fourth will need four corner radii improved yields a total improvement cost estimate of $306,607,300 based on the required minimum increase to a 75-ft. radius. However, other multi-trailer combinations vehicles require less turning radius than the RMD, and could be accommodated with a 50-ft.intersection corner radius at a lower total improvement cost estimate of $130,203,100. While urban intersection improvements would generally have a higher and more variable cost, no information was available to estimate urban intersection needs and costs.

Summary

Allowing longer and heavier trucks on our state's roads creates connectivity issues with local urban, county, and township roads. A majority of those local roads are not designed to accommodate longer trucks turning at intersections. The county road intersections are typically designed with a 25-ft. to 30-ft. corner radius, or even less on the many township and urban roads. Harmonizing truck weight and length regulations with adjacent states could require up to 75-ft. corner radii to accommodate the largest turning radius multi-trailer vehicles such as a Rocky Mountain Double (RMD), due to the offtracking of the rear axle. In rural areas, the longer trucks must often swing wide around the intersection corner to avoid dropping the trailer wheels into the ditch, encroaching into the oncoming traffic lanes while making the turn. Swinging wide through an oncoming lane could provide up to an additional lane-width (about 10 ft. on many township roads) to the corner radius. In areas of low traffic volumes and adequate sight distance this is not much of an issue. However, in higher traffic volume areas this can create conflicts at intersections.

In many urban areas, intersecting roads may have a solid centerline barrier stripe, whereby the law prohibits vehicles from crossing a solid centerline barrier stripe. Trucks in urban areas can cause damage by offtracking of the rear trailer wheels driving over the street corners and breaking the sidewalks, damaging signal systems, signs, light poles, and other street furniture. Additionally, heavier and longer trucks in urban areas can impact traffic signal timing and traffic flow, creating minor reductions in traffic capacity.

A sample of rural township intersections showed the average cost to improve one rural intersection corner radius from 25 ft. to 75 ft. is $7,264. Extrapolating the sampled township data with 1,946 townships in North Dakota yields 21,001 intersections that could potentially require geometric upgrades. Assuming half of the upgraded intersections will need one corner radius improved, one-fourth need two corner radii improved, and one-fourth will need four corner radii improved yields a total improvement cost estimate of $306,607,300 based on the required minimum increase to a 75-ft. radius. However, other multi-trailer combinations vehicles require less turning radius than the RMD, and could be accommodated with a 50-ft. intersection corner radius at a lower total improvement cost estimate of $130,203,100. While urban intersection improvements would generally have a higher and more variable cost, no information was available to estimate urban intersection needs and costs.

A more practical improvement plan may be to only upgrade intersection radii where existing shippers travel, rather than to improve all intersections regardless of shippers' needs. For example, cattle country tends to have much less tonnage being shipped to market than an area dominated by corn or other high tonnage crops. A blanket approach to intersection improvements might invest in improvements that may not be used. Another concept evident in oil and gas producing counties as well as wind farms, is where the companies involved in mineral or energy development often fund and/or undertake specific road and intersection improvements and maintenance to maximize the economics of moving their equipment and products.

Crash Projections for Various Truck Configurations

Public safety is paramount in decisions to introduce larger trucks into traffic corridors. Several studies have sought to assess safety implications for large truck configurations based on factors such as crash involvement and enforcement activities, but a review showed these studies were largely non-transferable or critically flawed with regard to their methods (Adams et al. 2009, Campbell et al. 1988, Idaho Department of Transportation 2013, Montufar et al. 2007, Sowards et al. 2013).[5] The safety component discussed in the literature review section, the recent USDOT "Comprehensive Truck Size and Weight Limits Study," had the most comprehensive and current analysis. The study focused on relative crash rate and severity costs, simulated stability and control, and inspection violation likelihood. Crash cost estimates require risk calculation. The truck configuration including load status, and traffic count including vehicle configuration detail, are required to accurately develop representative estimates of crash incidence among the various truck configuration and road class location combinations. Unfortunately, findings were indeterminate with regard to crash costs for the larger trucks because of insufficient data in the truck configuration, traffic collection, crash reporting, and citation records. Lack of any individual truck weight detail and very limited vehicle configuration detail in reporting by states prohibited compilation of robust crash event or inspection datasets that could be used to make inferences about U.S. fleet safety related to truck size and weight properties. Discussions are underway in North Dakota to expand reporting detail for truck units in law enforcement crash and inspection reports, and potentially in state and local traffic data collection processes. These enhancements would permit the state to conduct more robust safety assessment with regard to the larger truck safety performance. The FHWA simulation outcomes do suggest an education program related to load center and tire properties may be beneficial.

[5] **References**

Adams, Teresa M., Jason Bittner, and Ernie Wittwer. 2009. Wisconsin Truck Size and Weight Study. National Center for Freight & Infrastructure Research & Education, Department of Civil and Environmental Engineering, University of Wisconsin, Madison, Project 02-01.

Campbell, Kenneth L., David. F. Blower, R. Guy Gattis, and Arthur C. Wolfe. 1988. Analysis of accident rates of heavy-duty vehicles. Final report. Ann Arbor, Mich., University of Michigan, Transportation Research Institute.

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Potential Rail Diversion Analysis

Due to long distances to major markets, the state's farm production moves largely by rail; however, depending on origin-destination the state's short line railroads have developed intrastate hauls on their system to accommodate local movements of grain. Similar hauls have also been offered for aggregate and some heavy loads as opportunities arise but are generally minor in the overall scope of the state's freight movements. A share these shipments could be diverted to 129,000-lb. trucks. However, the extent of this diversion is largely dependent upon the highway network over which the larger trucks are allowed to operate. Other diversions of grain traffic are possible, but less likely.

According to the North Dakota Grain and Oilseed Transportation Statistics Report (2014-15) summary of the state's licensed grain facilities' shipments, approximately 52 million bushels of grains and oilseeds were terminated in North Dakota by railroads. This volume terminated in North Dakota attributed only 8% of annual grain and oilseed shipments. The vast majority of these bushels consist of shipments from elevators to plants or smaller elevators to shuttle-train terminal facilities.

Although service factors have an influence in mode choice, the predominant factor is economics. A cost comparison between rail and truck shipping options suggest limited diversion from rail to the larger trucks for major markets. For example, the variable cost to transport grain in a 129,000-lb. double trailer truck is roughly 2.93 cents per ton-mile, if the truck has a full backhaul. With no backhaul, the cost is roughly 5.86 cents per ton-mile.[6] In comparison, the cost per ton-mile to ship grain in shuttle trains ranges from 1.83 cents to 1.62 cents for market distances of 500 to 2,000 miles.[7] According to the North Dakota waybill sample, the median distance for grain shipments from North Dakota by rail was 1,437 miles in 2014. Roughly 25% of grain shipments travel more than 1,600 miles by rail. According to UGPTI's Grain & Oilseed Transportation Statistics, less than 40% of the crops produced in North Dakota move west. The remainder moves east and southeast. Several inferences may be drawn from these comparisons.

- For long distance truck movements of grain, trucks would need to be loaded both directions. This may be problematic if traditional equipment such as hopper trailers is used.
- Without a backhaul, the cost to haul grain in 129,000-lb. double trailer trucks would be at least 3.2 times greater than the cost in shuttle trains
- Less than 40% of grains shipped from North Dakota by rail would be affected by harmonization, as the remainder is shipped east or south—where harmonization would not impact truck economics.

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[6] The truck costs have been computed using the Upper Great Plains Transportation Institute Truck Cost Model (TCM).

[7] Rail costs have been estimated using the Uniform Railroad Costing System for the Western Region of the United States.

The other large rail movement within the state is lignite coal. It is doubtful that a 15% reduction in trucking cost would divert this traffic, given the existing infrastructure investments in place for rail loading and unloading. Again, the potential impacts depend upon the highway network over which the larger trucks are allowed to operate.

URCS Grain Shuttle Train Cost 2014				
	Variable Cost			
Miles	**Per Train**	**Per Car**	**Per Ton**	**Per Ton-Mile**
500	$112,525	$1,023	$9.13	$0.0183
1,500	$208,273	$1,893	$16.91	$0.0113
1,500	$304,021	$2,764	$24.68	$0.0165
2,000	$399,769	$3,634	$32.45	$0.0162

Truck Variable Costs for 129,000-lb Combination			
Distance	**Per Truck**	**Per Ton**	**Per Ton Mile**
500	$615	$14.64	$0.0293
1000	$1,230	$29.29	$0.0293
1500	$1,845	$43.93	$0.0293
2000	$2,460	$58.57	$0.0293

Distance of Rail Grain Movements from 2014 Waybill Sample	
Weighted Miles	
Mean	1,260
Median	1,437
Mode	1,745

Distance of Rail Grain Movements from 2014 Waybill Sample	
Weighted Miles	
Level	**Quantile**
100% Max	2,869

Distance of Rail Grain Movements from 2014 Waybill Sample	
Weighted Miles	
Level	**Quantile**
99%	2,285
95%	1,838
90%	1,727
75% Q3	1,602
50% Median	1,437
25% Q1	883
10%	508
5%	285
1%	45
0% Min	1

Summary

The state's farm production moves largely by rail because of long distances to major markets. However, depending on origin-destination, the state's short-line railroads have developed intrastate hauls on their system to accommodate limited movement of grain, aggregate, and heavy loads as opportunities arise. This activity is generally minor in the overall scope of the state's freight movements. For instance, grain terminated in North Dakota attributed only 8% of annual grain and oilseed shipments by elevators last year. Although service factors do influence mode choice, the predominant factor is economics. A cost comparison between trainload and 129,000-lb. truck shipping options suggests limited diversion from rail to the larger trucks for major markets. Beyond agriculture, the other large rail movement within the state is lignite coal. It is doubtful that a 15% reduction in trucking cost, estimated with the 129,000-lb. truck, would divert this traffic given the existing infrastructure in place for rail loading and unloading. A share of the current rail shipments could potentially be moved in larger trucks, but the extent of any diversion is largely dependent upon market demand locations and the highway network over which the larger trucks are allowed to operate.

Impacts to Registration, Permitting and Enforcement Administrative Processes

Five government entities were ask to participate in a survey on potential costs to their department should North Dakota harmonize weight laws with adjacent jurisdictions. The government agencies were the North Dakota Department of Transportation (NDDOT) Motor Vehicle Division (MVD), the North Dakota Highway Patrol (NDHP) Permit Office, the North Dakota Highway Patrol (NDHP) Motor Carrier Division (MCD), the North Dakota Association of Oil and Gas Producing Counties (NDAOGC) Uniform County Permit System (UCPS), and the Upper Great Plains Transportation Institute (UGPTI) – North Dakota Local Technical Assistance Program (NDLTAP). Currently the software systems are programmed for a legal GVW up to 105,500 lbs. and only exterior bridge length is used when travel is on the N.D. state and local roads system. The survey questions varied because each government entity provides different services.

NDDOT Motor Vehicle Division

Director Mark Nelson and Tami St. Vincent responded to the survey questions:

1. Will NDDOT need to change the fee schedule for allowing registered GVW's in excess of 105,000 lbs.?
   Response: The fee schedule would need to be updated and approved legislatively. It appears that under our current fee schedule the weight increased for each 4,000# increments is in that .92-.94 increase per weight change.

2. Will NDDOT need to make software changes to allow registered GVW's in excess of 105,500 lbs.?
   Response: At this time, we can only provide a ballpark figure and in talking to our IT division the cost would be estimated to be no more than $50,000 for software changes and staff time.

3. Will there be an increase in revenue for allowing registered GVW's in excess of 105,500 lbs.?
   Response: Unknown as to how many trucks would actually increase their weights to a higher level? If one would make assumptions you could use percentages of trucks currently at 6,245 and multiply by the percent increases in question #1

4. How many ND truck registrations are for 105,500 lbs.?
   Response: 6,245

5. Do you anticipate any other software or staff time costs – reduced or increased?
   Response: Not at this time.

Summary

Currently, the vehicle registration fee schedule is for up to 105,500 lbs. GVW. To change the fee schedule allowing for registered GVWs in excess of 105,500 lbs. would require legislative approval. Under the current fee schedule the weight increase for each 4,000- lb. increment is in that .92 to .94 increase per weight change.

The estimated cost to make software updates for a registered GVW over 105,500 lbs., and the staff time needed for programming and testing, was no more than $50,000.

It is unknown if there would be an increase in revenue generated in vehicle registration. It is dependent on if or what the legislature determines. Currently there are 6,245 North Dakota vehicles registered for 105,500 lbs. It is unknown how many carriers would increase the registered GVW on their vehicles. It is also unknown to what GVW a carrier would increase a vehicle to.

NDHP Motor Carrier Division

Sixteen troopers with the NDHP Motor Carrier Division responded to the questions posed in the survey.

1. How much time is needed to educate the ND public on the application of the interior bridge formula?
   Response: Most troopers believed it would take some time. At a minimum it would increase the current time spent with a carrier by 15 minutes. Many carriers do not understand how the interior bridge formula works because it does not apply to the state and local roads they travel on.

2. How much additional time would be needed per stop when a trooper is weighing a truck to check the interior bridge distances/formula?
   Response: The majority of troopers anticipate the stop time would increase by 5 to 10 percent. Currently the average stop time ranges from 45 to 60 minutes. An increase of 5 to 10 percent could possibly increase the stop time by 10 to 15 minutes.

3. Would there be a reduction in number of weighing based stops if multiple vehicle combinations were allowed to go to 129,000 lbs. GVW?
   Response: Over half of the troopers believed the number of stops would not decrease. Troopers stop vehicles to check both axle weights and GVWs.

4. Would there be an increase or decrease in staff time needed for education if ND's GVW increased to 129,000 lbs.?
   Response: The majority of troopers believe staff time needed for education would increase initially.

5. Are there any anticipated software update costs and staff time costs?
   Response: The majority of troopers believed there would be both software and staff time costs for programming the current systems. They were unable to provide those estimates.

Summary

With harmonization, increasing the N.D. legal GVW to 129,000 lbs. and requiring vehicles to comply with the interior bridge formula will increase the time a trooper spends per stop by a minimum of 15 minutes. This would apply to stops for weight enforcement and education. The increase in time is dependent on the individual carrier and vehicle's axle configuration. The troopers do not foresee a reduction in weighing based stops. Troopers stop vehicles to check both axle weights and GVWs. The majority of troopers believe the increase in time will be needed only at the initial passage of a new law. The estimated cost for software updates, or staff time needed for programming and testing, is unknown at this time.

NDHP Permit Office

Jackie Darr, NDHP Permit Office completed questions relating to the Automated Permit and Routing System, and Brad Darr, NDDOT Maintenance Division completed questions relating to the Automated Routing System.

Currently the NDHP's automated permit and routing systems recognizes the legal GVW at 105,500 lbs. With harmonization, the systems would need to be updated, dependent on what the legislature passes.

1. What percent of staff time per month is dedicated to permits issued for overweight movements between 105,500 to 129,000 lbs.?
   Response: Currently total staff time would be approximately 1 percent or less. Majority of permits at 129,000 lbs. GVW are auto issued by the Automated Permit/Routing system.

2. Would the automated permit/routing software need to be updated if ND increased the legal GVW to 129,000 lbs. and incorporated the interior bridge formula on all ND roads?
   Response: Yes, software updates would be needed. Dependent on the outcome, the GVW limits on the highway system, the bridge formula, and the NDDOT would be looking at updating almost all the paper and automated routing maps. The estimated cost to update the permit software and to test the system is $20,000. The estimated cost to update the routing software is no less than $15,000. Approximately 8 – 10 weeks to complete and test the routing component is needed as there are thousands of road segments that may be affected. The staff time costs are unknown and dependent on the severity of the change.

3. What would be the software costs if ND law required vehicles hauling divisible loads over 105,500 lbs. up to 129,000 lbs. GVW to comply with interior/exterior bridge formula laws and restricted travel only on designated state highways?
   Response: The approximate costs to update the permit software are $15,000 and the routing software is $10,000. The cost for staff time is unknown and dependent on the severity of the change and time needed for testing.

4. How much revenue is currently generated from permits for non-divisible vehicle and load movements with a GVW from 105,500 to 129,000 lbs.?
   Response: $955,150

5. Would the number of permits issued decrease?
   Response: The Permit Office believes the number of permits purchased will decrease. If the legal GVW increases to 129,000 lbs., believe the use of double trailers will increase. With a higher legal GVW, a vehicle hauling an oversize load would possibly haul multiple pieces for one movement but stay within legal axle and GVW limits.

   Revenues generated by the interstate permit may go down. Because the legal GVW on the interstate system would be lower than the legal gross vehicle on the state highway system, ND may see higher truck volumes on the state system. On the interstate system, the legal GVW cannot exceed 105,500 lbs. In 2015, revenue generated by interstate permits issued was $1.7 million. By May 2016, interstate permits purchased generated $770,000.

6. Revenue generated from permits between 105,500 to 129,000 lbs. for divisible loads?

Response: In 2015, the LCV permit generated $6,240. This permit may go away if ND increased the legal GVW to 129,000 lbs.

7. Percent of staff time per month dedicated to ton mile permits for movements up to 129,000 lbs. GVW?
   Response: Estimate 1 percent or less. Majority of ton mile fees are auto issued. In 2015, a total of 19,145 permits with a GVW ranging from 0 – 129,000 lbs. were assessed ton mile fees.

8. Do you anticipate additional time in the first year of implementation to educate the public on the interior and exterior bridge formula change? If yes, how much?
   Response: Yes, additional time would be required to educate industry on the new guidelines. Do not think it would be limited to the first year. Enforcement (state, local, and county) would have to be taught as well. It is all dependent on how quickly they learn. A lot of time is spent on the phone and with walk-in customers explaining how the new inner and outer bridge formula works. The motor carrier industry currently traveling on the interstate system has a better understanding of the formula. We would pull or change the LCV permit I believe. We would have to train industry the permit is no longer required or that it now requires interior and exterior bridge formula compliance.

9. Anticipate any other software or staff time costs – reduced or increased?
   Response: Everything would be increased costs to the state. Policies would need to reflect changes and updates. Time employees spends make the changes. All current handouts would be destroyed and new ones made. Websites would have to be updated with all new information.

Summary

With harmonization, the NDHP Automated Permit and Routing Systems would have to be updated to reflect the law changes. The cost estimates to update the software systems would range from $35,000 to $60,000, dependent on the changes. The cost estimates for staff time spent on programming and testing is unknown. It is dependent on the severity of the change. Other software or staff time costs would be increased costs to the state. Updates would have to be made to policies, maps, and websites.

It is believed that the number of permits for oversize divisible load movements and the number of interstate permits purchased will decrease. Carriers hauling oversize divisible load movements will use double trailers, thus you will see fewer permits issued. Carriers will stay off the interstate system, which has a legal GVW to 105,500 lbs. with a permit and will move to travel on state highways where the legal GVW limit would be higher. In both these instances, the result is a loss of revenues.

In the event the LCV permit is eliminated, there would result in a revenue loss of $6,240. Currently, the NDHP issues an LCV permit during the winter months of December, January, and February. The permit authorizes a vehicle with sufficient axles and exterior bridge length to carry a GVW up to 131,000 lbs. It is possible the legislature would require vehicles that exceed 105,500 lbs. and traveling on designated highways are required to obtain an LCV permit. This would be done in an effort to regulate these movements. If this scenario came to fruition, additional revenues would be generated.

Currently, non-divisible vehicle and load movements that exceed the legal GVW of 105,500 lbs. are subject to ton mile fees. With a higher legal GVW limit, there could be a loss in revenue generated from ton mile fees assessed on movements made in the spring of the year. This would apply to movements with a GVW ranging from 105,500 lbs. up to 129,000 lbs.

NDAOGPC – Uniform County Permit System

Janet Sanford, Team Works Consulting Services and Brent responded to the survey questions on potential costs incurred with Truck Harmonization.

1. If the legislature allowed a change to the GVW of 129,000 lbs., how would the Uniform County Permit (UCP) system need to be modified?
   a. Would there have to be changes made to the UCP system if those counties agreed to a higher GVW of 129,000 lbs.? If yes, what would be the approximate programming cost if nay to your permit system?
   b. If the counties decided they would allow 129,000 lbs. on some roads through a permit process, what would be the cost of adding a new permit to your system?....again approximate programming costs?
   c. Would a change to GVW 129,000 lbs. require additional users (i.e., county superintendent or road supervisors) additional permitting work?

An estimated cost range of $12,500 to $20,000 for the County Permit System, depending on how the change would be set up.

Summary

The survey questions were sent to Janet on April 8. On April 14, Janet, Brent, and I conversed about the questions posed. I explained that we were looking for estimated costs to their permit system in the event the counties agreed to allow a higher GVW. Even though they were given a very short timeline to respond, Janet was able to provide an estimated cost of $12,500 to $20,000 for the Uniform County Permit System, depending on how the change would be set up.

UGPTI/North Dakota Local Technical Assistance Program

Megan Bouret with UGPTI and Leanna Emmer with NDLTAP responded the questions posed.

The ND Online Truck Weight Calculator was programmed for a maximum legal GVW of 105,500 lbs. It was also programmed to use only the exterior bridge formula when the user selects state highways and uses interior and exterior bridge formula when the user selects the interstate system. With truck harmonization, the legal GVW may be increased and apply to all state highways or designated state highways. The interior and exterior bridge formula may apply to all vehicles on all highways or only to vehicles that exceed 105,500 lbs. GVW not to exceed 129,000 lbs. The following questions and scenarios were sent to Megan.

1. Could you give me a rough estimate of what it would cost to rewrite part of the ND On-line Truck Weight Calculator? Trying to get programming costs for possibly having to update the calculator.

a. Interstate highways (use interior and exterior bridge lengths, and 550 lbs. per inch of tire width except on the steering axle.) In other words...nothing changes – NO COST
   State highways (use exterior bridge length only, 550 lbs. per inch of tire width up to 105,500 lbs. GVW, allow up to 48,000 lbs. on a triple axle) – in other words...nothing changes – NO COST
   State – from 105,501 to 129,000 lbs. (use interior and exterior bridge lengths and 550 lbs. per inch tire width) - COST $$
   OR

b. Interstate highways – No changes – NO COST
State Highways – use both interior and exterior bridge lengths, use 550 lbs. per inch of tire width on all axles to include the steering axle, (triple axle no longer allowed up to 48,000 lbs.), GVW is 129,000 lbs. COST $$ If possible, please also provide staff time costs for testing.

For either option, we estimate 20 hours of development time and 8 hours of testing. The cost would approximately be $500. Enhancements to the Calculation Results PDF and LTAP staff time testing would also be needed – total estimated cost could be approximately $2,500

Summary
Currently, the Online Truck Weight Calculator does weight calculations for up to 105,500 lbs. With truck harmonization, the software changes to truck weight calculator would be necessary. Depending on what the legislature determines relating to truck harmonization, the estimated cost for software changes and staff time for programming and testing is approximately $2,500.

Summary

NDDOT Motor Vehicle Division

To change the current vehicle registration fee schedule (for up to 105,500 lbs. GVW) and to allow GVW in excess of 105,500 lbs. would require legislative approval. Under the current fee schedule, the weight increase for each 4,000-lb. increment is in that .92 to .94 increase per weight change.

The estimated cost to make software updates for a registered GVW over 105,500 lbs., and the staff time needed for programming and testing was no more than $50,000.

Revenue impacts from vehicle registration are unknown and dependent on if or what the legislature determines. Currently there are 6,245 North Dakota vehicles registered for 105,500 lbs. It is unknown how many or to what extent carriers would increase the registered GVW of their vehicles.

NDHP Motor Carrier Division

With harmonization, increasing the N.D. legal GVW to 129,000 lbs. and requiring vehicles to comply with the interior bridge formula will increase the time a trooper spends per stop by 5% -10%, or a minimum of 15 minutes. This would apply to stops for checking axle weights, GVW, and education. The increase in time is dependent on the individual carrier and vehicle's axle configuration, with an initial increase in time spent on education with the drivers. The troopers do not foresee a reduction in weighing based stops. The cost for software updates and staff time needed for programming and testing is unknown at this time.

NDHP Permit Office

With harmonization, the NDHP Automated Permit and Routing Systems would have to be updated to reflect the law changes. Updates would have to be made to policies, maps, handouts and websites. The cost estimates to update the software systems would range from $35,000 to $60,000, dependent on the changes. The cost estimates for staff time spent on programming and testing is unknown. It is dependent on the severity of the change. Other software or staff time costs would be increased costs to the state.

The estimated cost to update the permit software and to test the system is $20,000. The estimated cost to update the routing software is no less than $15,000. Approximately 8 – 10 weeks to complete and test the routing component is needed as there are thousands of road segments that may be affected. The staff time costs are unknown and dependent on the severity of the change.

It is believed that the number of permits for oversize divisible load movements and the number of interstate permits purchased will decrease. Carriers hauling oversize divisible load movements will likely use double trailers, resulting in fewer permits issued. Carriers exceeding 105,500 lbs. will stay off the interstate system (limited to 105,500 lbs. GVW with a permit) and will travel on state highways where the legal GVW would be higher. In both these instances, the result is a loss of revenue.

In the event the LCV permit is eliminated, there would result in a revenue loss of $6,240. Currently the NDHP issues LCV winter permits for 131,000-lb. GVW. The N.D. Legislature could require vehicles exceeding 105,500 lbs. and traveling on designated highways to obtain an LCV permit in an effort to regulate these movements. If this scenario came to fruition, additional revenues would be generated.

Currently non-divisible load movements that exceed the legal GVW of 105,500 lbs. are subject to ton mile fees. A higher legal GVW could result in revenue lost from ton mile fees.

NDAOGPC – Uniform County Permit System

The estimated cost of upgrading the Uniform County Permit System is $12,500 to $20,000, depending on how the change would be set up.

Upper Great Plains Transportation Institute (UGPTI)/North Dakota Local Technical Assistance Program (NDLTAP)

The current Online Truck Weight Calculator does weight calculations for up to 105,500 lbs., and would require software changes to accommodate truck harmonization. Depending on what the N.D. Legislature determines relating to truck harmonization, the estimated cost for software changes and staff time for programming and testing is approximately $2,500.

Economic Benefits Analysis– Regional Economic Modeling Inc.

Direct Economic Impacts to Shippers

As discussed in previous sections, increasing truck GVW provides cost benefits to shippers due to lower per ton-mile trucking costs as well as fewer total trips due to increased payloads. The decrease in ton-mile costs reduces the total cost of front haul shipments. The reduction in total trips also saves the cost of the return trip. The direct economic impacts were estimated for the two scenarios presented in the pavement impact section of this report.

Under the all movements scenario, the total truck trips were 7.26 million and 4.62 under the current and 129,000 lb. scenarios respectively. The net reduction in total truck trips was 2.64 million. Using trip length estimates, the truck mile reduction totals 110 million miles. Using a weighted average per-mile trucking cost and inclusion of the empty return trip, the estimated cost savings to shippers under the all movements scenario is $285.1 million annually.

In the likely scenario, the total truck trips were 3.4 million under current configurations and 2.3 million under the 129,000 lbs. configuration. The net decrease in truck miles was estimated at 63.2 million miles. Using a weighted average per-mile trucking cost and inclusion of the empty return trip, the estimated cost savings to shippers in the likely scenario is $139.7 million annually.

Regional Economic Impacts

The direct impacts to shippers presented above represent a reduction in transportation costs in different industries within the state. In addition to the shipper cost savings, estimated increases in construction costs due to bridge rehabilitation and replacement and slight increases in pavement impacts represent an increase in final demand for the construction industry within the state. To estimate the secondary impacts of shipper cost savings and construction expenditures, the REMI Policy Insight model was utilized.

The estimated annual bridge replacement need in addition to the increase in pavement impacts totals $189.7 annually. Once all infrastructure is improved to allow for the 129,000 lb. configuration, an annual direct benefit to shippers of $285.1 million annually is estimated. Because it is likely that, due to the high number of required improvements, it would take the full 20-year analysis period to implement all of the improvements. Because of this timeframe, the shipper benefits would be fully realized only at the final year of the analysis. However, fractional benefits would be realized in the preceding years incrementally.

Multiplier

The REMI Policy Insight model was adjusted to account for additional construction spending by increasing exogenous final demand for construction by $189.7 million annually. The industry-specific transportation cost savings were implemented beginning in 2016 through 2037 in a linear manner. The resulting net increase in North Dakota's GDP is $8.1 billion over the 20-year analysis period. The initial GDP change is minimal due to the limitations on shipper savings in the near term. The resulting multiplier for the investments is 2.1. The Congressional Budget Office (CBO) multipliers for direct investment range from 0.5 to 2.5, with an average of 1.8. The Council of Economic Advisors (CEA) multiplier estimate for direct investment is 1.5.

Sources:

An Economic Analysis of Transportation Infrastructure Investment, White House, July 2014

The Short- and Long-Term Impact of Infrastructure Investments on Employment and Economic Activity in the U.S. Economy, Economic Policy Institute, July 1, 2014.

Appendix A

1. Straight truck with a steering axle and a triple drive axle.

IMPACTED: -2,600 to -4,500 LBS

Current Rules ND – Non Interstate | Gross Vehicle Weight- 60,100 lbs.

12100 48000

Harmonization w/ MT & SD 10'

12100 **43500** **Gross Vehicle Weight - 55,600 lbs.**

(As pictured above)

Current Rules – The current rule weights above show a vehicle in the best case scenario. The vehicle above would need an exterior bridge length of 28 feet for a GVW of 60,100 pounds. A shorter exterior bridge length reduces the legal gross vehicle weight, which will result in less of an impact. Currently the average truck sold has an exterior bridge length of 23 feet, which allows for a maximum legal GVW of 57,500 pounds.

2. Truck/tractor with a steering axle and a tandem drive axle towing a triple axle semi-trailer

IMPACTED: -1,000 to -4,500 LBS

Current Rules ND - Non Interstate | Gross Vehicle Weight – 94,100 lbs.

12100 | 34000 | 48000

Harmonization w/ MT & SD

12100 | **34000** | **43500**

Gross Vehicle Weight – 89,600 lbs.
(As pictured above)

Current Rules: The length of semitrailers used in the state ranges from 40 feet to 53 feet. A shorter semitrailer will result in a shorter exterior bridge length. The shorter the exterior bridge length the lower the legal gross vehicle weight which results in no or less of an impact. With a 48 foot semitrailer and 18 foot tractor, the exterior bridge length would be around 61 feet. The maximum legal GVW with an exterior bridge length of 61 feet is 90,500 pounds. With a 50 foot triple axle semitrailer and 18 foot tractor, the exterior bridge length would be around 63 feet. The legal GVW could not exceed 92,000 pounds. The current rule weights above show a vehicle in the best case scenario.

3. Truck/tractor with a steering axle and a triple drive axle towing a triple axle semi-trailer.

IMPACTED: -1,000 to -6,400 LBS

Current Rules ND - Non Interstate   Gross Vehicle Weight- 105,500 lbs.

12100   48000   48000

Harmonization w/ MT & SD

12100   43500   43500

Gross Vehicle Weight- 99,100 lbs.
(As pictured above)

Current Rules: The length of semitrailers used in the state ranges from 40 feet to 53 feet. A shorter semitrailer will result in a shorter exterior bridge length. The shorter the exterior bridge length the lower the legal gross vehicle weight, which will result in no or less of an impact. With a 50 foot semitrailer and 20 foot tractor, the exterior bridge length would be around 66 feet. With 66 feet the maximum legal GVW is 98,500 pounds. With a 53 foot trailer, the exterior bridge length would be around 69 feet. The maximum GVW with 69' is 100,500 pounds. The current rule weights above show a vehicle in the best case scenario, and would require an exterior bridge length of 78 feet using a 29 foot tractor??

4. Truck/tractor with a steering axle and a tandem drive axle towing a three-axle semitrailer (tandem axle and single axle)

IMPACTED: -2,900 TO -8,900 LBS.

Current Rules ND- Non Interstate — Gross Vehicle Weight- 100,000 lbs.

12,100 34,000 34,000 20,000

Harmonization w/ MT & SD

12,100 34,000 --------- 45,000 ----------

Gross Vehicle Weight – 91,100 lbs.

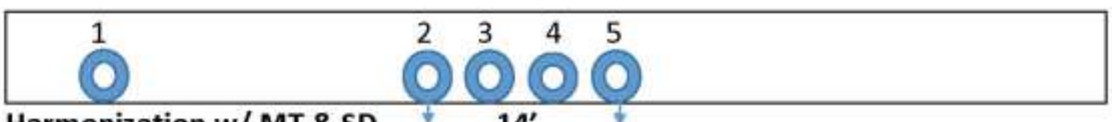
Current Rules: The vehicle above would be required to have an exterior bridge length of 77 feet for a legal GVW of 100,000 pounds. Typically the vehicle would not meet the 77 feet exterior bridge length requirement. With a 53 foot semitrailer and 18 foot tractor, the exterior bridge length would be around 67 to 68 feet. With a 67 to 68 foot exterior bridge length, the legal GVW is 94,000 to 95,000 pounds respectively. With a shorter semitrailer, the exterior bridge length would be shorter which would result in a lower legal GVW. The current rule weights above show a vehicle in the best case scenario.

5. Straight truck with steering axle and quad drive axles.

Benefit: +3,500 LBS

<u>Current Rules ND- Non Interstate</u> Gross Vehicle Weight- 60,100 lbs.

12100 48000



<u>Harmonization w/ MT & SD</u> **14'**

12100 **51500** **Gross Vehicle Weight- 63,600 lbs.**

(As pictured above)

6. Straight truck with a steering axle and a triple drive axle towing a full trailer with two sets of tandem axles.

Benefit: +17,000 LBS

<u>Current Rules ND- Non Interstate</u> Gross Vehicle Weight- 105,500 lbs.

12100	48000	34000	34000

<u>Harmonization w/ MT & SD</u>

12100	**43500**	**34000**	**34000**

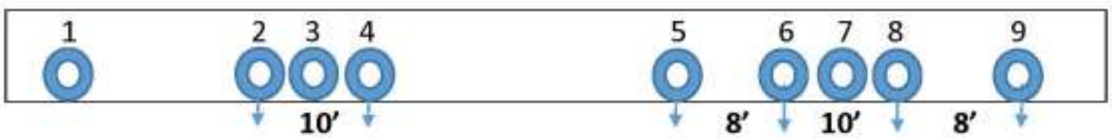
Gross Vehicle Weight – 123,500 lbs.
(As pictured above)

7. Truck/tractor with triple drive axles towing a semi-trailer with 5 axles (single-triple-single)

Benefit: +6.500 LBS

<u>Current Rules ND- Non Interstate</u> Gross Vehicle Weight – 105,500 lbs.

12100 48000 20000 48000 20000



<u>Harmonization w/ MT & SD</u>

12100 43500

64500 (as shown above)

Gross Vehicle Weight – 112,000 lbs.

(53'trailer length and axle configuration limit GVW from reaching 120,100 lbs.)

8. Truck/tractor with a steering axle and a tandem drive axle towing a tandem axle semi-trailer and a full trailer with two sets of single axles. (Rocky Mountain Double)

Benefit: +14,600 LBS

Current Rules ND- Non Interstate — Gross Vehicle Weight – 105,500 lbs.

12100	34000	34000	20000	20000

Harmonization w/ MT & SD

12100	**34000**	**34000**	**20000**	**20000**

Gross Vehicle Weight – 120,100 lbs.

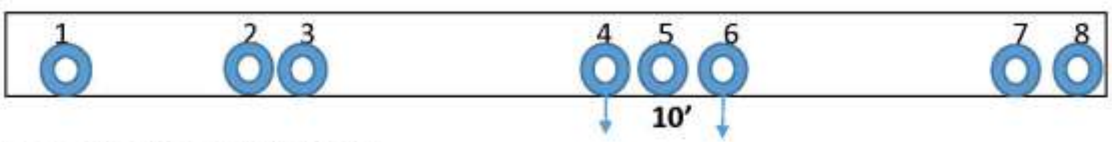
(As pictured above allowing for 100' of cargo carrying capacity on the national network)

9. Truck/tractor with a steering axle and a tandem drive axle towing a triple axle semi-trailer and a tandem axle semi-trailer. (Super B Train)

Benefit: +18,100 LBS

Current Rules ND - Non Interstate   Gross Vehicle Weight – 105,500 lbs.

12100   34000   48000   34000



Harmonization w/ MT & SD

12100   34000   43500   34000

Gross Vehicle Weight – 123,600 lbs.

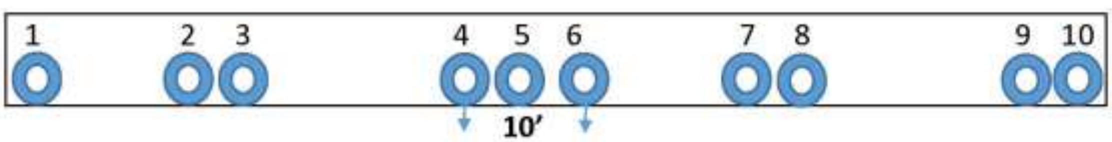
(As pictured above)

10.Truck/tractor with a steering axle and a tandem drive axle towing a triple axle semi-trailer and a full trailer with two sets of tandem axles.

Benefit: +23,500 LBS

<u>Current Rules ND- Non Interstate</u> Gross Vehicle Weight – 105,500 lbs.

12100 34000 48000 34000 34000



<u>Harmonization w/ MT & SD</u>

12100 34000 43500 34000 34000

Gross Vehicle Weight – 129,000 lbs.

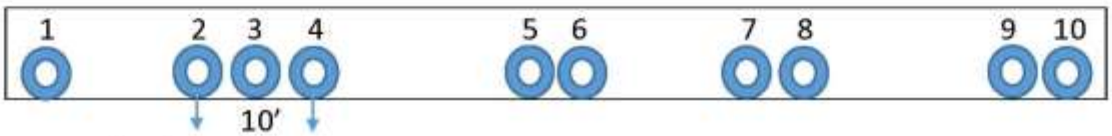
(As pictured above allowing for 100' of cargo carrying capacity on the national network)

11. Truck/tractor with a steering axle and a triple drive axle towing a tandem axle semi-trailer and a full trailer with two sets of tandem axles.

Benefit: +23,500 LBS

Current Rules ND- Non Interstate — Gross Vehicle Weight – 105,500 lbs.

12100	48000	34000	34000	34000



Harmonization w/ MT & SD

12100	**43500**	**34000**	**34000**	**34000**

Gross Vehicle Weight – 129,000 lbs.

(As pictured above allowing for 100' of cargo carrying capacity on the national network)

12. Truck/tractor with a steering axle and a tandem drive axle towing a tandem axle semi-trailer.

Minimal/No Impact or Benefit:

<u>Current Rules ND - Non Interstate</u> Gross Vehicle Weight- 80,100 lbs.

12100 34000 34000

<u>Harmonization w/ MT & SD</u>

12100 34000 34000

Gross Vehicle Weight- 80,100 lbs.

(As pictured above)

13. Truck/tractor with a steering axle and a tandem drive axle towing a semi-trailer with spread axles.

Minimal/No Impact or Benefit:

<u>Current Rules ND - Non Interstate</u> Gross Vehicle Weight – 86,100 lbs.

12100	34000	20000	20000

<u>Harmonization w/ MT & SD</u> **8'**

12100	**34000**	**19000**	**19000**

Gross Vehicle Weight- 84,100 lbs.
(As pictured above)

12100	**34000**	**20000**	**20000**

Gross Vehicle Weight- 86,100 lbs.
(Needs minimum of 10' to get 20000 per axle)

14. Truck/tractor with a steering axle and a triple drive axle towing a semi-trailer with quad axles.

Minimal/No Impact or Benefit:

<u>Current Rules ND- Non Interstate</u> Gross Vehicle Weight – 105,500 lbs.

12100 48000 48000

<u>Harmonization w/ MT & SD</u>

12100 43500 51500

Gross Vehicle Weight – 106,500 lbs.

(As pictured above with a 53’ semi-trailer)

15. Truck/tractor with a steering axle and a triple drive axle towing a semi-trailer with a triple axle and single axle.

Minimal/No Impact or Benefit:

<u>Current Rules ND- Non Interstate</u> Gross Vehicle Weight – 105,500 lbs.

12100 48000 48000 20000

<u>Harmonization w/ MT & SD</u>

12100 43500 54000

Gross Vehicle Weight – 106,500 lbs.

(As pictured above with a 53' semi-trailer)