North Dakota Strategic Freight Analysis

North Dakota Department of Transportation

North Dakota Strategic Freight Study on Motor Carrier Issues

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Developed for North Dakota Department of Transportation

By

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EXECUTIVE SUMMARY

Introduction

Truck transportation plays a vital role in North Dakota's economy and any impediment to freight movement hinders economic performance and growth. This section explores the regulatory environment motor carriers and shippers face when moving freight by truck within North Dakota. Regulations at the local, county, state and national level are not static and change with the policies set forth by legislators and the will of business and concerned citizens. This section also discusses North Dakota's Highway Performance Classification System (HPCS), truck size and weight regulations, permitting policies, traffic flow impediments, highway damage implications during spring thaw and the economic implications of load restrictions for shippers and motor carriers.

Justification

TransAction Initiative 6 states, *"North Dakota will analyze the economic impacts of load limits and the benefits of establishing a statewide program to coordinate the administration of load limits."* Initiative 6 also states, *"Each year, thousands of farms and businesses are affected by load limits. Load limits restrict the weight a vehicle can legally carry. They are placed on roads, bridges, airport runways, and rail lines by the operating authority when the infrastructure isn't strong enough to support normal weight. Parallel state and county roads with similar characteristics may have different load restrictions, or may have load restrictions put into effect at different times. Some load limits are continual, and others are seasonal. Bridge load restrictions are not always compatible with roadway load restrictions, and load restrictions on a roadway may vary. Many variables affect how, when, and why load limits are determined, including sub-grade depth, drainage, surface type, surface thickness, soil strength, subsoil temperature and moisture content."* These statements emphasize the difficulties businesses face in trying to ship within the state.

Objectives

This study's objectives are to:

1) analyze the economic impacts of load limits and the benefits of establishing a statewide program to coordinate the administration of load limits,
2) provide information on truck size and weight regulations as well as state and county permitting regulations and costs,
3) evaluate costs associated with impediments to freight flow, including county road restrictions and seasonal load restrictions, and
4) provide information on the economic impacts of restriction free routes within the state.

Summary

This study discusses truck size and weight regulations and permitting policies and their affects on motor carriers and shippers. The focus is on intrastate motor carrier movements of freight.

North Dakota has developed a Highway Performance Classification System (HPCS) consisting of five levels[1] based on traffic volume, capacity, safety, reliability, travel speeds, and convertibility of major traffic generators. On the Interstate and Interregional Corridors, NDDOT has established the goal of unrestricted (restricted by legal load) and height restriction free to 16[2] feet. This step of identifying levels of service that the state will try to provide and maintain is crucial to maintaining, stimulating, and diversifying economic growth.

This study analyzed the economic impacts of load limits and the benefits for establishing a statewide program to coordinate the administration of permitting. Truck size and weight regulations and state and local permitting policies and costs for various types of permits in North Dakota are examined. Permitting information was gathered from the state's 53 counties. The information gathered identified 16 counties in the western portion of the state which are part of the North Dakota Association of Oil and Gas Producing Counties (NDAOGPC) uniform permitting system and four counties in the southeastern part of the state that have developed multiple county permit systems. Examining the permit policies in each of the 53 counties reveals inconsistencies that prohibit seamless freight transportation.

The study found that motor carriers may encounter different conditions that impede travel as they strive to move freight. Congestion, load restrictions (seasonal or other), construction, speed limits, non-controlled highway access, bridge restrictions, height and width restrictions and enforcement activity all impede the seamless movement of freight. Case studies were developed in the report that provide insight as to how speed limits and traffic signals influence travel time as well as costs associated with delays for trucks and automobiles. NDDOT is striving to mitigate impediments that interfere with the free flow of goods by promoting efficiency in the motor carrier industry that potentially save businesses time and money.

The case studies contained in this report provide a cost analysis approach to evaluate concerns about impediments to freight flow, including year round and seasonal load restrictions. Load restrictions are used as a highway preservation strategy to reduce load damage caused by heavy axle loads. The results of other studies suggest that an alternative to gross vehicle weight restrictions may be to restrict loadings by axle weight. Other strategies may be to design key corridors to handle heavier loads and reduce the

[1] HPCS five levels include: Interstate System, Interregional System, State Corridor, District Corridor, and District Collector.
[2] At the time of this report, current height restrictions are 14 feet. The goal of NDDOT is to increase the height restrictions to 16 feet on the Interstate and Interregional systems.

time period of restrictions as most damage occurs during the maximum thaw period that is approximately 30 days.

An evaluation of the economic impacts for eliminating seasonal restrictions on higher truck traffic routes within the state provides evidence that higher load limits could significantly reduce total transportation costs and increase profitability of companies. Further, this could have positive effects on the efficiency of freight flows and competitiveness of our region.

Key Findings

Truck size and weight laws are continually evolving in North Dakota and the reader should note that regulations are subject to change. The conclusions and recommendations that follow have been developed from the most current regulatory information available at the time of this report.

- Differences that exist in state and local motor carrier regulations and permitting processes impede the intrastate flow of goods.

- Uniform regulatory and permitting processes would enhance the seamless movement of freight within the state.

- Harmonizing state and local truck size and weight regulations and permitting processes would reduce confusion, promote regulatory compliance and most importantly improve commerce.

- State leadership may be necessary to promote local uniform truck size and weight regulations and permitting.

- Maintaining the efficient movement of freight and traffic through the minimal use of speed restrictions and traffic signals can enhance the local and regional economy.

- Costs associated with extended travel time can be viewed as an opportunity cost. For instance a trucking cost or rate may be used to evaluate costs associated with speed limit and signal delays. An estimated hourly cost for operating a 5 axle semi is a good proxy for rates. The Truck Costing Model developed by UGPTI in 2002[3] estimated the hourly rate of a commercial 5 axle semi at 86 dollars per hour.

- Examining the different truck counts, inferences can be made about costs associated with delays. Truck traffic counts vary on the route segments, so it is difficult to estimate the impact of delay for the entire route. However, case

[3] (Software Model) Berwick, M. and Farooq, M. *Truck Costing Model for Transportation Managers, 2002-03.* Mountain Plains Consortium No. 03-152. Upper Great Plains Transportation Institute, North Dakota State University, Fargo, August 2003.

studies examined in this report found opportunity costs associated with delays from 10,000 dollars to 12,000 dollars daily and 3.6 million dollars to 4.4 million dollars per year. Other costs not included in the brief analysis could be increased inventory costs for businesses because of these delays.

- Seasonal load restrictions are an impediment to traffic flow. These restrictions are put in place to preserve the highway during spring thaw when the road infrastructure is most susceptible to damage by heavy trucks.

- Load restrictions are a highway preservation strategy used to reduce seasonal damage that occurs because of heavy axle loads on a thawing road infrastructure.

- The results of previous analysis suggest that an alternative to gross vehicle weight (GVW) restrictions may be restricting axle loads. Other conclusions may be to design key corridors to handle heavier loads and reduce the time period of restrictions as most damage occurs during the maximum thaw period that is approximately 30 days.

- The economics for shippers and the motor carrier industry lean toward higher gross vehicle weights, especially for perishable products such as potatoes and sugar beets. Some products can be transported after spring restrictions are removed, but other perishable products have to be transported while restrictions are in place to prevent spoilage.

- Results of case studies show that load restrictions increase truck costs. The case studies show that truck costs more than double with a No. 2 restriction versus a Class A restriction.

- Higher load limits could significantly reduce total transportation costs and increase profitability of companies. This could have positive effects on the efficiency of freight flows and competitiveness of our region.

INTRODUCTION

Truck transportation plays a vital role in North Dakota's economy and any impediment to freight movement hinders economic performance and growth. This section explores the regulatory environment motor carriers and shippers face when moving freight by truck within North Dakota. Regulations at the local, county, state and national level are not static and change with the policies set forth by legislators and the will of business and concerned citizens.

JUSTIFICATION

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NORTH DAKOTA'S HIGHWAY PERFORMANCE CLASSIFICATION SYSTEM

Because of the vastness of the North Dakota highway system and the costs of maintaining the whole system to the same level, prioritizing maintenance and levels of maintenance have become necessary. The North Dakota Department of Transportation (NDDOT) developed the Highway Performance Classification System (HPCS).

The principles of the HPCS are:

"First, not all highways function in the same manner or need to provide the same level of service, therefore, not all highways need to be built or maintained to the same standards. Second, limited resources make it impossible to provide the same level of service on every highway in the state. Third, it is imperative to adopt a long-range strategy that provides a focus for the consistent application of engineering standards in order to

achieve the department's highway performance objectives. Finally, our state highway system is dynamic, and over time, highway classifications may change. In other words, the HPCS tries to match the level of highway performance to the demand on the roadway."[4]

The HPCS has five levels based on traffic volume, capacity, safety, reliability, travel speeds, and convertibility of major traffic generators. The five levels are the Interstate System, Interregional System, State Corridor, District Corridor, and District Collector. Particularly, Interstate and Interregional systems play an important role for efficient freight movement and a competitive regional economy due largely to large traffic volumes. The efficient Interstate and Interregional systems can reduce freight travel time, bring major cities closer together, and increase the regional economy. According to the description of the HPCS, both Interstate and Interregional systems maintain a high degree of reliability and mobility. They also support international, national, regional, statewide trade, and economic activity. They generally serve long-distance, interstate and intrastate traffic for freight movement.

NDDOT established the goal of seasonally unrestricted (restricted by legal load) and height restriction free to 16[5] feet on the Interstate and Interregional systems. This allows efficient freight flow on North Dakota highways.

NORTH DAKOTA TRUCK SIZE AND WEIGHT REGULATIONS

Section 39-12 of the North Dakota Century Code (NDCC) defines size, width and height regulations on state highways. Under NDCC Section 39-12-01 state and local authorities classify public highways and roads under their respective jurisdictions and limitations as to the weight and load of vehicles thereon.

The U.S. Federal Truck Size and Weight Laws (Title 23) define size and weight regulations on the Interstate System and National Network (NN). Title 23 explains "Grandfather Provisions" which provide exemptions to federal truck size and weight regulations by allowing certain truck types and movements that were in effect prior to July 1, 1956.

Bridge Formula and State Maximum Gross Vehicle Weight

In 1975, States were allowed to keep "grandfathered" weight limits. The grandfathered limits are higher than those established for the Interstate System. The difference between bridge formula B on the Interstate System and the grandfathered limits is the way measurements are conducted between axles. The grandfathered limits measure the two extreme axles of any vehicle or combination of vehicles. Bridge Formula B, used on the Interstate System, provides that any two or more consecutive axles may not exceed the weight computed by the formula even though single axle, tandem axles, and gross weight are within legal limits.

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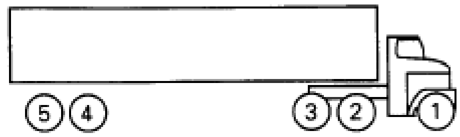
[4] www.state.nd.us/dot/divisions/planning/hwyclassification.html

[5] At the time of this report, current height restrictions are 14 feet. The goal of NDDOT is to increase the height restrictions to 16 feet on the Interstate and Interregional systems.

Figure 1. 5-Axle Semi (Source: Federal Highway Administration)



In other words, the axle group that includes the entire truck (outer bridge) must comply with the Bridge Formula and the interior combinations of axles, such as the "tractor bridge" (axles 1, 2, and 3) and "trailer bridge" (axles 2, 3, 4 and 5) must also be in compliance with the weights computed by the Bridge Formula[6] (Figure 1). Federal law (23 U. S.C. 127) includes one exception to the bridge formula. Federal law (23 U. S.C. 127) states that two consecutive sets of tandem may carry 34,000 pounds each if the overall distance between the first and last axles of these tandems is 36 feet or more. For example, a five-axle tractor semi-trailer combination may carry 34,000 pounds both on the tractor tandem (axles 2 and 3) and the trailer tandem (axles 4 and 5), provided axles 2 and 5 are spaced at least 36 feet apart (Figure 1). Without this exception, the Bridge Formula would allow an actual weight of only 66,000 to 67,500 pounds on tandems spaced 36 to 38 feet apart[7].

Due to the grandfather provisions (Title 23), North Dakota's maximum gross vehicle weight on state highways is 105,500 pounds unless otherwise posted. On all other highways the maximum gross vehicle weight is 80,000 pounds unless designated for more, not to exceed 105,500 pounds.

Vehicle Height, Width, and Length

The legal vehicle height in North Dakota is 14 feet whether loaded or unloaded, unless bridge or underpass structures are not 14 feet in height. The legal vehicle width is 8 feet 6 inches on all highways in the state. Legal vehicle lengths vary depending on whether the vehicle is a single unit or combination of two, three, or four units. Single units with two or more axles including the load thereon cannot exceed 50 feet. A combination of two, three, or four units including the load thereon cannot exceed 75 feet on non-designated highways. A combination of two, three, or four units including the load thereon may exceed 75 feet in length but cannot exceed 95 feet or 110 feet in overall length when traveling on four-lane divided highways or on highways designated by local authorities. Exceptions to these limitations and further detailed information on North Dakota's legal size and weight restrictions can be found in Appendix 1.

State Permit Policies

The following types of permits can be purchased by motor carriers for movements within the state: Trip, Fuel, Interstate, LCV, Seasonal, 10% Weight Exemption, Combine, and Self-issue Interstate. All over-dimensional and overweight permits have specific conditions that apply to all types of loads. Oversize/overweight permits are required on the Interstate System, state highways, and county roads. Over-dimensional vehicles are

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[6] Bridge Formula Weights, Federal Highway Administration, January 1994.
[7] Bridge Formula Weights, Exception to Formula and Bridge Table, Federal Highway Administration, January 1994.

required to display a minimum 12” X 12” red or orange flags on the traffic side front and rear of the vehicle. When an over-dimensional length exceeds 75 feet, an 18” X 84” “Oversize Load” sign is required on the rear of the vehicle. All over-dimensional loads are required to travel during daylight hours only. North Dakota state law also restricts overall widths of loads or vehicles exceeding 16 feet during weekend and holidays. Overweight vehicles or loads are not allowed to travel on flexible pavements when atmospheric temperatures are 85 degrees Fahrenheit or above. If the gross vehicle weight (GVW) is more than 120,000 pounds or more than 5000 pounds over legal axle weight limits, the vehicle may not exceed 40 miles per hour. Overweight permits are issued only to vehicles hauling a single piece or **non-divisible** loads within the state. When non-divisible loads exceed 150,000 pounds, a graduated permit fee schedule exists for each single trip. The fee schedule for non-divisible loads in excess of 150,000 pounds can be found in Appendix 2.

Single trip permits are required for legal size divisible load vehicles exceeding the federal gross vehicle weight cap of 80,000 pounds on the Interstate System. The fee for a receipt issued “Interstate Only” permit is $10. A self-issue “Interstate Only” permit is also available for half the price of the receipt issued permit ($5). More detailed information on permit costs and specific conditions can be found in Appendix 2.

Seasonal Restrictions and Permits

During the spring, warmer temperatures cause frost in the ground to melt thus reducing the maximum allowable weight which can be carried over the roadway. Signs are posted on highways most vulnerable, indicating a lower weight road. The North Dakota Department of Transportation also posts detailed information on a website[8] showing a map of where and when spring restrictions are in effect. The following table shows spring load restriction maximum weights by type of restriction: Class A, No. 1, No. 2 , and by Legal Weight.

Table 1. North Dakota Spring Load Restriction Types

Spring Load Restriction	Single Axle (lbs.)	Tandem Axle (lbs.)	Tridem Axle (lbs.)	Gross Weight (lbs.)
Class A (8-ton)*	18,000	32,000	42,000	105,500
No. 1 (7-ton)*	15,000	30,000	36,000	80,000
No. 2 (6-ton)*	12,000	24,000	30,000	65,000

* North Dakota is in the process of changing its classification system and signage. Class A, No. 1, and No.2 restrictions will be changed to 8-ton, 7-ton, and 6-ton restriction types.

The purpose of the permit system during seasonal restrictions is to establish guidelines when seasonal permits will be issued for commercial haystack and hay bale movers, overwidth and/or overweight self-propelled fertilizer spreaders, overwidth and/or overweight self-propelled agricultural chemical applicators, overwidth hay grinders,

[8] www.state.nd.us/dot/roadreport/loadlimit/loadlimitinfo.asp

overwidth grain cleaners, and overwidth forage harvesters that are exempt from width limitations so they can be moved upon the highways of the state of North Dakota.

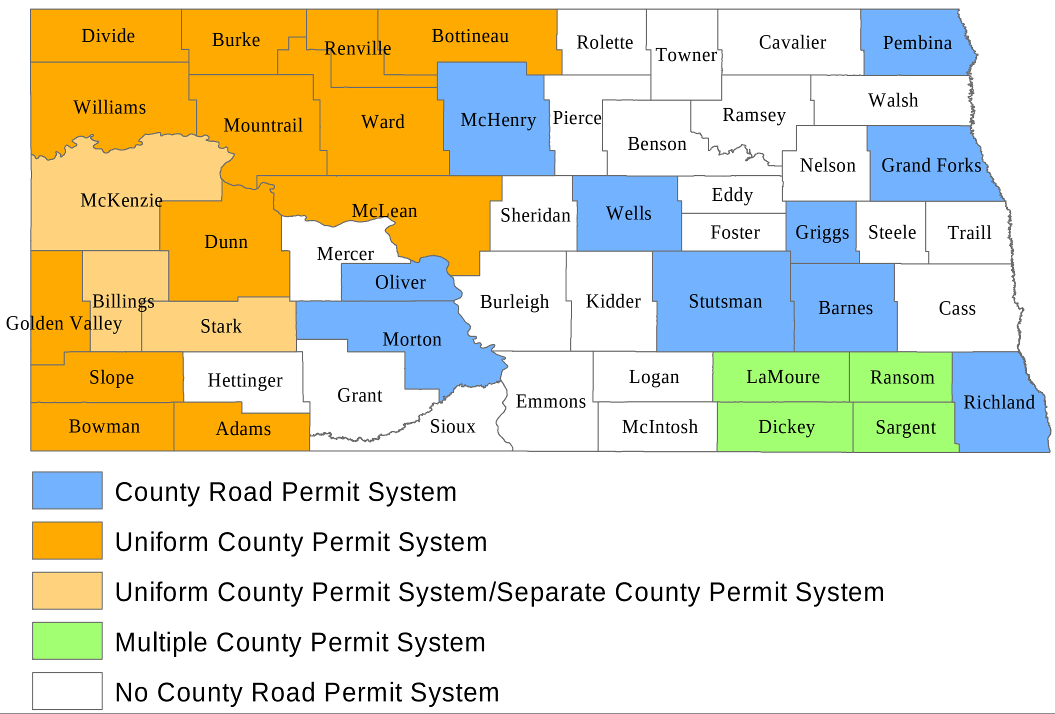
During the winter months, when the underlying road surface is hardened by frost, North Dakota allows load limits on designated highways to increase by as much as ten percent. Carriers that desire to move loads during the ten percent winter weight increase may obtain a seasonal permit for such movements. More information on North Dakota's seasonal permit policies can be found in Appendix 3.

County Truck Size and Weight Regulations and Permitting

The following section introduces permit policies of the 53 counties in North Dakota. Representatives from each county in North Dakota were contacted by email and telephone and asked to discuss their county permitting policies and costs. The representatives included: county sheriffs, county auditors, and county highway superintendents. County representatives were asked to describe their current permit issuing system as well as the costs associated with acquiring a permit on county roads.

Figure 2 shows a color coded map for counties that currently issue (blue) or do not issue (white) permits on county roads in their jurisdiction. The map also shows which counties are members of the Uniform County Permit System (orange and light orange) or a Multiple County Permit System (green).

Figure 2. County Permit Systems in North Dakota



Sixteen of the listed counties use a "Uniform County Permitting System" which is part of the North Dakota Association of Oil & Gas Producing Counties (NDAOGPC). Only paying members that belong to the NDAOGPC are allowed to participate in the Uniform County Permitting System. Three counties among the 16 NDAOGPC members (Billings, McKenzie, and Stark) issue their own overload/overweight permits aside from the uniform county permit. The three counties are identified in light orange (Figure 2).

Four counties in the southeastern part of the state have developed a "multiple county" permit system. These counties are identified in green (Figure 2) and include: Dickey, LaMoure, Ransom and Sargent. On all county highways within the multiple county permit system, the gross vehicle weight may not exceed 105,500 pounds. The gross weight limitation does not apply to equipment the commissioners or highway department approve for exemption (non-divisible loads). However, the exemption may not exceed 105,500 pounds. The primary difference between the multiple county permit policy and the state permit policy is the maximum weight allowed on triple axle truck and trailer configurations. The maximum weight for triple axle truck and trailer configurations or "triple-triples" may not exceed 96,000 pounds on county roads which limits the configuration to 42,000 pounds per triple axle grouping with proper axle spacing whereas the state maximum is 48,000 pounds per triple axle grouping with proper axle spacing.

Table 2 shows permitting policies for each county in North Dakota. Ten counties in the state have developed permitting policies and fees associated with overweight movements specifically for county roads under their jurisdiction. Twenty-three counties in the state follow the same maximum gross vehicle weight guidelines as adjacent state roads (Class A, No. 1, and No. 2 load restrictions[9]). These counties are identified with an "N/A" or no available individual county road permit policy. Cass and Steele counties are currently developing new permitting systems on county roads. According to county highway superintendents, Cass and Steele counties may have policies in place as soon as summer 2005.

[9] North Dakota is in the process of changing its classification system and signage. Class A, No. 1, and No.2 restrictions will be changed to 8-ton, 7-ton, and 6-ton restriction types.

Table 2. Permit Policies and Costs in North Dakota Counties

County	Permit Policy / Cost
Adams	NDAOGPC Uniform County Permitting System. Single Trip $10.
Barnes	$20 Single day overweight (over 80,000 pounds) permit. Harvest permit is $50 and at the discretion of the county road superintendent. During spring load restrictions, there is a $10 fee for movements that do not exceed 80,000 pounds. The spring permit can only be purchased for special circumstances.
Benson	N/A
Billings	NDAOGPC Uniform County Permitting System. Single Trip $10.
Bottineau	NDAOGPC Uniform County Permitting System. Single Trip overweight $10.
Bowman	NDAOGPC Uniform County Permitting System. Single Trip $10.
Burke	NDAOGPC Uniform County Permitting System. Single Trip $10.
Burleigh	N/A - Issues spot overweight permits mostly on a verbal, no fee basis, for specific haul events, as opposed to blanket or continuous waivers.
Cass	N/A - A new policy is currently being developed
Cavalier	N/A - Follows state permitting guidelines.
Dickey	Shares a permitting system with three other counties: LaMoure, Ransom, and Sargent. $10 single trip overweight valid for 30 days. $50 harvest permit is valid for 30 days. $150 seasonal permit is valid December to March 7th.
Divide	NDAOGPC Uniform County Permitting System. Single Trip $10.
Dunn	NDAOGPC Uniform County Permitting System. Single Trip $10.
Eddy	N/A
Emmons	N/A
Foster	N/A
Golden Valley	NDAOGPC Uniform County Permitting System. Single Trip $10.
Grand Forks	$25 oversize/overweight single trip permit. There is a 10% weight exemption on county roads for the movement of all farm products and solid wastes from the field to the point of storage.
Grant	N/A
Griggs	$20 indivisible loads for 7 days. $100 season permit can be used after spring load restrictions are lifted and until limits are again placed in the following spring.
Hettinger	N/A
Kidder	N/A
LaMoure	Shares a permitting system with three other counties: Dickey, Ransom, and Sargent. $10 single trip overweight valid for 30 days. $50 harvest permit is valid for 30 days. $150 seasonal permit is valid December to March 7th.
Logan	N/A
McHenry	Single trip permit $5 per day. Harvest permit is $50 per two month time period.
McIntosh	N/A
McKenzie	NDAOGPC Uniform County Permitting System. Single Trip $10. The county also offers its own permits. The fee schedule coincides with the NDDOT's.
McLean	NDAOGPC Uniform County Permitting System. Single Trip $10.
Mercer	N/A
Morton	Single trip permit $15 per day.
Mountrail	NDAOGPC Uniform County Permitting System. Single Trip $10.
Nelson	N/A
Oliver	Overwidth $25 per axle. Overlength and overweight permits are $25 each. $15 Mobile home moving permit. The county also offers $100 per year blanket permits for power and construction companies operating in the county.
Pembina	The county offers a 10% overload permit year round except for spring break-up.
Pierce	N/A
Ramsey	N/A

Table 2. Permit Policies and Costs in North Dakota Counties (Continued)

County	Permit Policy / Cost
Ransom	Shares a permitting system with three other counties: Dickey, LaMoure, and Sargent. $10 single trip overweight valid for 30 days. $50 harvest permit is valid for 30 days. $150 seasonal permit is valid December to March 7th.
Renville	NDAOGPC Uniform County Permitting System. Single Trip overweight $10.
Richland	$10 over 80,000 pounds. $25 over 105,500 pounds. A single trip permit book of 20 permits is available for $100. Annual permit is $100/ per year for contractors/construction. Harvest permit 10% over legal weight permit is $50 per month or $75 per season. Winter premium permit $50 per month.
Rolette	N/A
Sargent	Shares a permitting system with three other counties: Dickey, LaMoure, and Ransom. $10 single trip overweight valid for 30 days. $50 harvest permit is valid for 30 days. $150 seasonal permit is valid December to March 7th.
Sheridan	N/A
Sioux	N/A
Slope	NDAOGPC Uniform County Permitting System. Single Trip $10.
Stark	NDAOGPC Uniform County Permitting System. Single Trip $10.
Steele	N/A The county may adopt new policy in June 2005.
Stutsman	$35 permit fee for overweight.
Towner	N/A
Traill	N/A- The county's guidelines coincide with NDDOT guidelines but the county does not allow 10% overload.
Walsh	N/A
Ward	NDAOGPC Uniform County Permitting System. Single Trip $10.
Wells	Single trip permit fee $10 per day.
Williams	NDAOGPC Uniform County Permitting System. Single Trip $10.

North Dakota Association of Oil & Gas Producing Counties Permitting Fees

The following information was obtained from the NDAOGPC's Permit Section Operator. A single trip permit must be obtained from the Permit Section Operator for all overweight vehicles traveling within the uniform permit system counties. Ten counties associated with the uniform county permit system; Bottineau, Burke, Divide, Dunn, McLean, McKenzie, Mountrail, Renville, Ward, and Williams use a flat fee of $10.00[10] for all overweight movements. Six counties in the uniform system; Adams, Billings, Bowman,

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[10] All over-width loads but not overweight must obtain a $10.00 permit.

All overweight loads on county roads over 130,000 pounds or 20 feet wide are to be cleared through the Bowman county sheriff to have the sheriff paged prior to the load being hauled. These loads may require an escort from the sheriff's department.

Any overweight or over-dimension trip made on **restricted roads** without oral permission from the sheriff in addition to a trip permit will be in violation. The charges for overloads will revert back to the original load limits. Restricted roads are posted. The Marmarth Road, Rhame Road, Griffin Road, Circle K Road, Scranton Road, and the Gascoyne Road all require oral Authorization from the Sheriff in addition to the permit.
Escort fees by the sheriff's department are $30.00 per hour.

Uniform Permits are not authority to use county roads during weight restrictions (Frost Law). This applies to any overloads on county roads.

Golden Valley, Slope and Stark have a graduated fee schedule based on the extent the vehicle is overweight.

Tables 3, 4, and 5 indicate the graduated permit fee schedule for the six counties in the uniform county permit system based on maximum gross vehicle weights for tractor trailers, oil well workover rigs, cranes, and earth moving equipment respectively.

Bowman and Slope counties share the same fee schedules for tractor trailers as do Billings and Stark counties. Adams County has the same fee schedule as Billings and Stark counties for tractor trailers except at 195,001-200,000 pounds the fee is $200. Golden Valley county tractor trailer fees differ from the other five counties at weights above 105,000 pounds (Table 3).

Table 3. North Dakota Association of Oil & Gas Producing Counties Uniform County Permit System Fee Schedule for Tractor Trailers (NDAOGPC Permit Operator, 2005).

Tractor Trailers	Adams	Billings	Bowman	Golden Valley	Slope	Stark
0 - 105,499	10	10	10	10	10	10
105,500 - 110,000				20		
110,001 - 115,000				30		
115,001 - 120,000				40		
120,001 - 125,000	10	10	30	50	30	10
125,001 - 130,000	20	20	40	60	40	20
130,001 - 135,000	30	30	50	70	50	30
135,001 - 140,000	40	40	60	80	60	40
140,001 - 145,000	50	50	100	90	100	50
145,001 - 150,000	60	60	110	100	110	60
150,001 - 155,000	70	70	120	100	120	70
155,001 - 160,000	80	80	130	100	130	80
160,001 - 165,000	90	90	140	100	140	90
165,001 - 170,000	100	100	150	100	150	100
170,001 - 175,000	110	110	160	100	160	110
175,001 - 180,000	120	120	170	100	170	120
180,001 - 185,000	130	130	180	100	180	130
185,001 - 190,000	140	140	190	100	190	140
190,001 - 195,000	150	150	200	100	200	150
195,001 - 200,000	200	160	210	100	210	160
Over 200,000	$1/mile	$1/mile	$5/mile	100	$5/mile	$1/mile

Four counties (Adams, Billings, Golden Valley, and Stark) share the same graduated fee schedule for workover rigs and cranes. The remaining two counties (Bowman and Slope) also share the same graduated fee schedules for workover rigs and cranes. Bowman and Slope counties at some weights on the graduated scale are more than double than the fees of the other four counties (Table 4)

Table 4. North Dakota Association of Oil & Gas Producing Counties Uniform County Permit System Fee Schedule for Workover Rigs and Cranes (NDAOGPC Permit Operator, 2005).

Workover Rigs & Cranes	Adams	Billings	Bowman	Golden Valley	Slope	Stark
40,000 - 60,000	10	10	20	10	20	10
60,001 - 100,000	20	20	30	20	30	20
100,001 - 110,000	30	30	50	30	50	30
110,001 - 115,000	40	40	60	40	60	40
115,001 - 120,000	50	50	70	50	70	50
120,001 - 125,000	50	50	80	50	80	50
125,000 - 130,000	50	50	90	50	90	50
130,001 - 135,000	50	50	100	50	100	50
135,001 - 140,000	50	50	110	50	110	50
140,001 - 145,000	50	50	120	50	120	50
145,001 - 150,000	50	50	130	50	130	50
150,001 - 155,000	50	50	140	50	140	50
155,001 - 160,000	50	50	150	50	150	50
160,001 - 165,000	50	50	160	50	160	50
165,001 - 170,000	50	50	170	50	170	50
170,001 and over	50	50	180	50	180	50

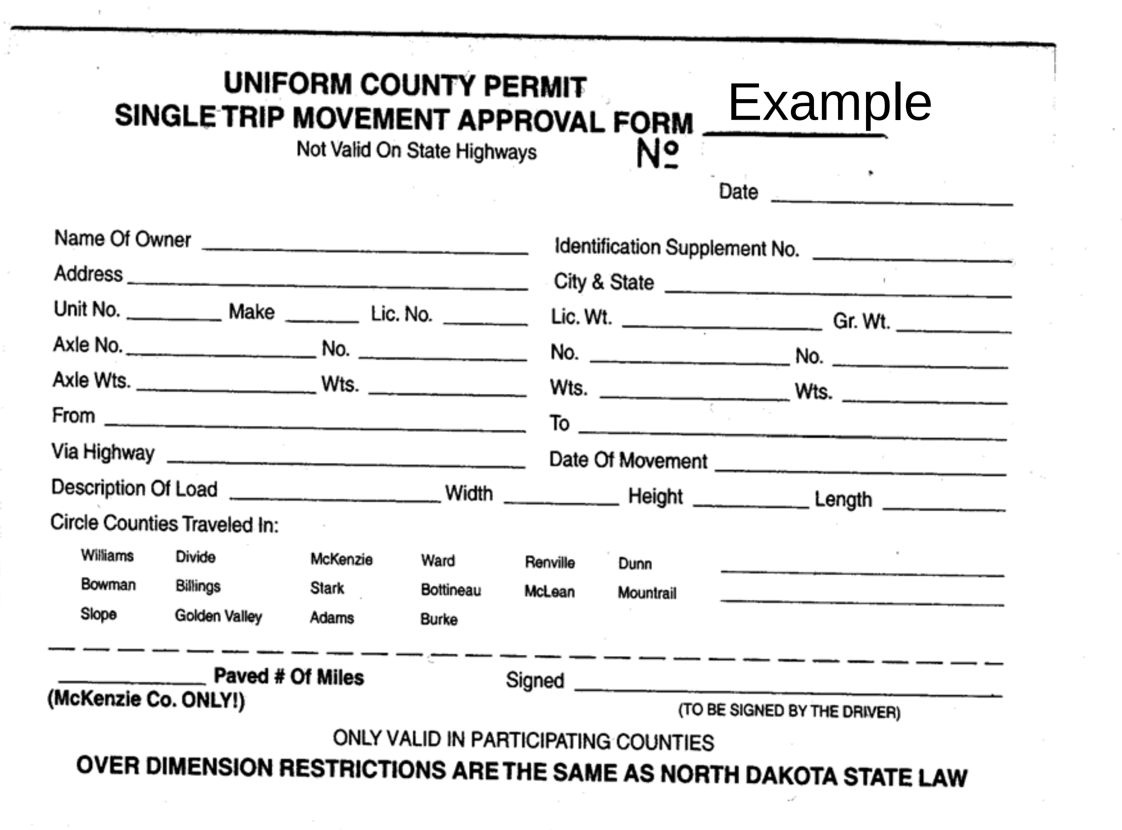
All six counties (Adams, Billings, Bowman, Golden Valley, Slope, and Stark) share the same graduated fees for earth moving equipment (Table 5).

Table 5. North Dakota Association of Oil & Gas Producing Counties Uniform County Permit System Fee Schedule for Earth Moving Equipment (NDAOGPC Permit Operator, 2005).

Earth Moving Equipment	Adams	Billings	Bowman	Golden Valley	Slope	Stark
40,000 - 70,000	10	10	10	10	10	10
70,001 - 90,000	20	20	20	20	20	20

Figure 3 shows an example of the uniform county permit single trip movement approval form. The single trip movement approval form is valid in the sixteen participating NDAOGPCs. Completing the form is relatively straight forward. The owner/operator acquiring the permit is asked to fill in information such as address, make of vehicle, license plate number, number of axles, axle weights, description of load, dimensions of load, date of movement, and the origin and destination of the movement. The owner/operator is also asked to circle the counties in which the movement will take place. If the movement takes place in McKenzie County, the owner/operator is asked the number of paved miles traveled within the county. The form is then signed by the driver and processed through the NDAOGPC Permit Section Operator's office in Watford City, North Dakota. As stated on the bottom of the form, over dimension restrictions are the same as North Dakota law.

Figure 3. NDAOGPC Uniform County Permit Example



UNIFORM COUNTY PERMIT
SINGLE TRIP MOVEMENT APPROVAL FORM Example
Not Valid On State Highways
Nº
Date ____________

Name Of Owner ____________ Identification Supplement No. ____________
Address ____________ City & State ____________
Unit No. ______ Make ______ Lic. No. ______ Lic. Wt. ______ Gr. Wt. ______
Axle No. ______ No. ______ No. ______ No. ______
Axle Wts. ______ Wts. ______ Wts. ______ Wts. ______
From ____________ To ____________
Via Highway ____________ Date Of Movement ____________
Description Of Load ______ Width ______ Height ______ Length ______
Circle Counties Traveled In:

Williams	Divide	McKenzie	Ward	Renville	Dunn
Bowman	Billings	Stark	Bottineau	McLean	Mountrail
Slope	Golden Valley	Adams	Burke		

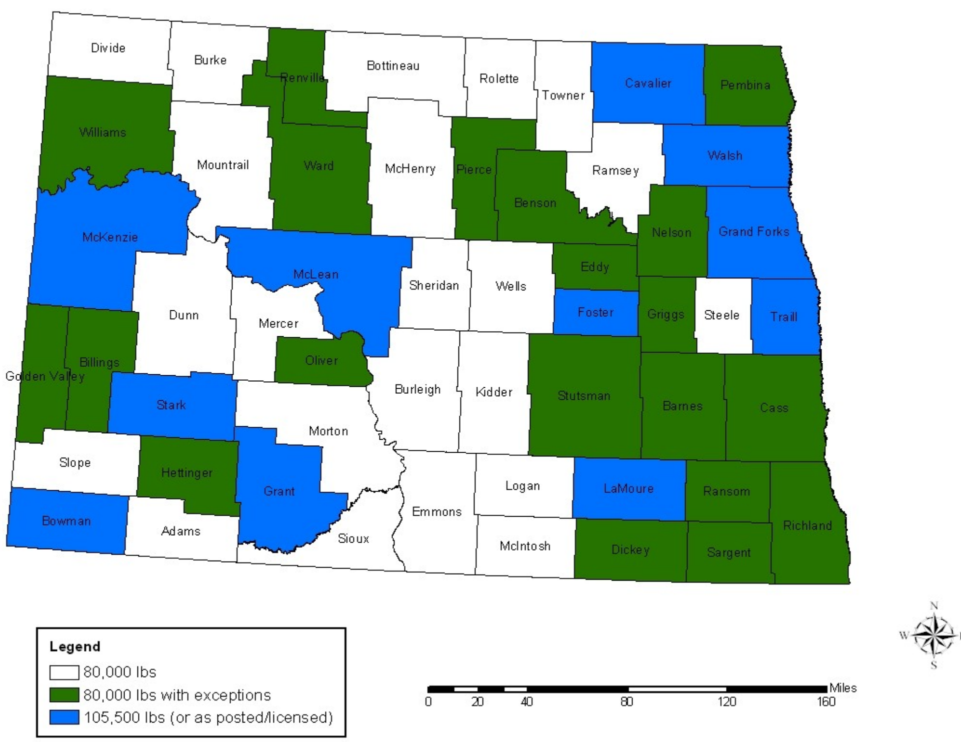
______ Paved # Of Miles
(McKenzie Co. ONLY!)
Signed ____________
(TO BE SIGNED BY THE DRIVER)

ONLY VALID IN PARTICIPATING COUNTIES
OVER DIMENSION RESTRICTIONS ARE THE SAME AS NORTH DAKOTA STATE LAW

Eleven counties in the state allow 105,500 GVW limits on their roads. Twenty counties have 80,000 pound maximum weight limits with exceptions, and twenty-two counties have 80,000 pound maximum weight limits on county roads. Exceptions to the maximum weight limits include specific roads available for higher maximum weights and permitting (NDDOT Survey, 2002).

Figure 4 is somewhat contradictory to Figure 2 in terms of exceptions to 80,000 pound weight limitations. For example, Dunn County (located in the west central part of North Dakota) shows an 80,000 pound weight limit (Figure 4). Current information indicates Dunn County as a part of the Uniform County Permit System, in which case, Dunn could be categorized with the counties that have 80,000 pound limits with exceptions. Six other counties could also be categorized with the counties that have 80,000 pound limits with exceptions due to their participation in the Uniform County Permit System including: Adams, Slope, Mountrail, Divide, Burke, and Bottineau. Change in county regulations and the permitting process is ongoing along with the changing will of county committees or commissions.

Figure 4. Weight Limits on County Roads (Source NDDOT, January 2003)



County regulations are not uniform causing confusion, and in some cases carriers find it difficult to comply. Some improvements have been made where multiple counties have banded together for a uniform permitting process, however differences in regulations in neighboring counties still exist.

Differences that exist in county motor carrier regulations and permitting processes can impede the flow of goods from city to city, county to county, and/or for some products out of the state. A uniform policy similar to the regulations set forth by the state regulators would provide for seamless freight movements throughout and maybe eventually out of the state. Harmonizing regulations and the permitting process would reduce confusion, promote compliance with the regulations and most importantly promote commerce. County cooperation could be led from a state transportation planning process promoting uniform regulations.

TRAFFIC FLOW IMPEDIMENTS

Motor carriers may encounter different conditions that impede travel as they strive to move freight. Congestion, load restrictions (seasonal or other), construction, speed limit, non-controlled access, bridge restrictions, overhead or height restrictions and enforcement activity or weigh scales. NDDOT is striving to mitigate impediments that interfere with the free flow of goods by promoting efficiency in the motor carrier industry potentially saving businesses time and dollars as a result. This section of the report will provide information on impediments and costs associated with those impediments.

Speed Limits

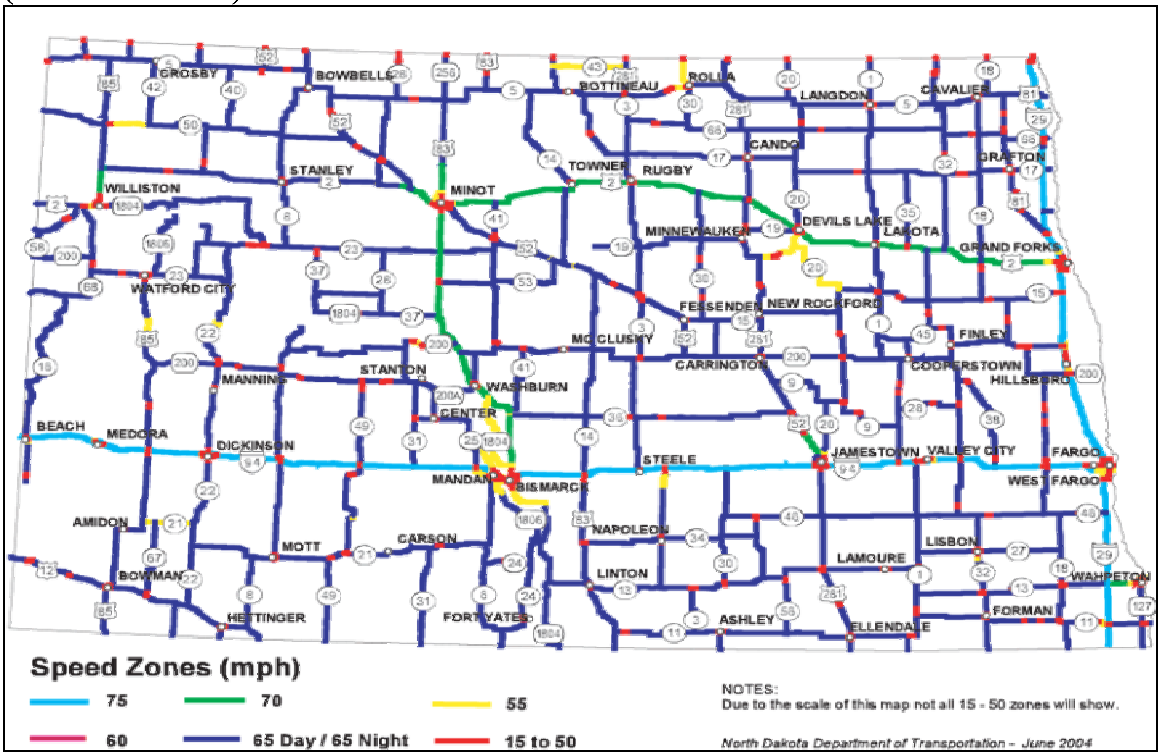
NDDOT sets speed limits on state highways. The maximum speed limit is determined based on safe and reasonable speed under road, traffic, and weather conditions.

The 2003 Legislative Update established the following speed limits on North Dakota highways:

- 55 miles per hour on gravel, dirt, loose surface highways and paved two-lane county and township highways where no speed limit is posted,
- 65 miles per hour on paved two-lane highways if posted for that speed,
- 70 miles per hour on paved and divided-multilane highways, and
- 75 miles per hour on access-controlled, paved and divided, multilane interstate highways.

Figure 5 shows the speed limits on highways in North Dakota. As the figure shows, the Interstate System (blue line) has a 75 mile per hour maximum speed limit and selected U.S. highways (green line) have 70 mile per hour speed limits. State highways generally have 65 mile per hour speed limits.

Figure 5. Speed Limit on Highways in North Dakota (June 2004).
(Source: NDDOT)



Speed limits can affect highway safety. Speed limits can increase or reduce traffic crashes, injuries/fatalities, and the crash costs based on traffic density, weather and various other factors. The speed limit allows drivers to react to an immediate risk and the ability to steer safely around curves on highways. To establish safe and reasonable speed limits, prioritize maintenance levels, and provide for restricted by legal load highways, the NDDOT developed the HPCS as previously described in this document.

Two case studies were developed using US-2 and US-83 to show how the reductions in the speed limit and stops for traffic signals influence travel time. Current travel time is compared with alternative speed limits and traffic signal times. The case studies also include truck volume data on the highway segments.

Case Study 1: North Dakota Speed Limit and Traffic Signal Impediments U.S. Highway 2
The first route chosen was U.S. Highway 2 from the Montana state line to Grand Forks, ND. As the figure shows, paved and divided-multilane highways from Minot, ND to Grand Forks, ND have 70 mile per hour maximum speed limits (green line). U.S. Highway 2 from the Montana state line to Minot, ND has mostly 60 and 65 mile per hour speed limits with 4 lane sections north of Williston and west of Minot at 70 miles per hour. Sections of U.S. Highway 2 traveling through Williston, Ray, Minot, Devils Lake, and Grand Forks, ND are restricted to 40 miles per hour or lower on intercity highways. Interestingly, a 70 mile per hour zone generally has high daily truck traffic, ranging from an average 437 trucks per day to 879 trucks per day. For the 60 or 65 mile per hour zones, average daily truck traffic is between 199 and 391. The study used 2001 annual average daily truck data from NDDOT.

Figure 6. Average Daily Truck Traffic for U.S. Highway 2 from Montana State Line to Grand Forks, ND (Source: NDDOT).

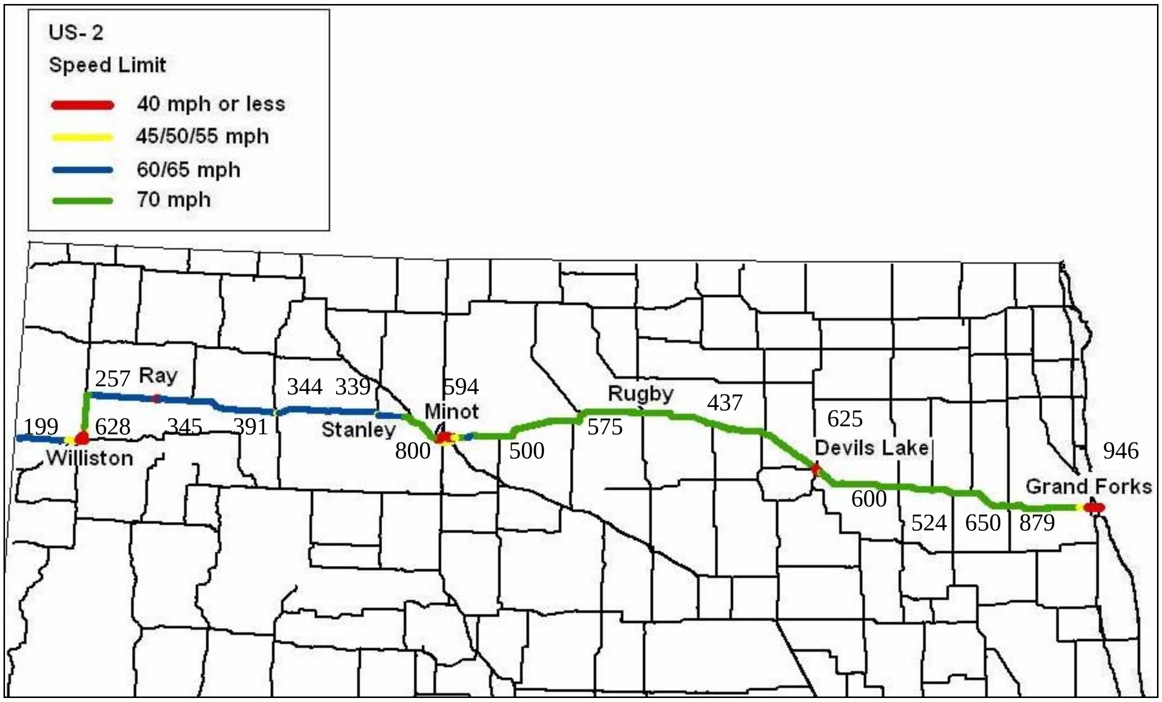


Table 6 provides distance, speed limit, and travel time for the highway segments from the Montana state line to Grand Forks, ND. The table also shows average speed weighted by segment distance. The average weighted speed is 67 miles per hour for the total route (353 miles) from the Montana border to Grand Forks, ND. If a truck travels at the maximum speed limit on US-2, the total travel time is 5 hours and 23 minutes.

Table 6. Distance, Maximum Speed Limit, and Travel Time for U.S. Highway 2 from Montana State Line to Grand Forks, ND (Source: NDDOT).

Route Segment	Distance (Miles)	Maximum Speed Limit (Miles/hr)	Travel Time (Minutes)
MONTANA STATE LINE To JCT US 85	14.3 miles	65 miles/hr	13.2 min.
JCT US 85	0.9 miles	45 miles/hr	1.2 min.
	3.5 miles	55 miles/hr	3.8 min.
WILLISTON	1.3 miles	40 miles/hr	2.0 min.
	0.6 miles	35 miles/hr	1.0 min.
	1.9 miles	45 miles/hr	2.5 min.
	0.1 miles	55 miles/hr	0.1 min.
	10.4 miles	70 miles/hr	8.9 min.
	19.9 miles	65 miles/hr	18.4 min.
RAY	0.2 miles	45 miles/hr	0.3 min.
	0.8 miles	35 miles/hr	1.4 min.
	0.2 miles	45 miles/hr	0.3 min.
RAY TO STANLEY	35.9 miles	65 miles/hr	33.1 min.
STANLEY	0.7 miles	55 miles/hr	0.8 min.
STANLEY TO BERTHOLD	30.1 miles	65 miles/hr	27.8 min.
BERTHOLD	0.7 miles	55 miles/hr	0.8 min.
BERTHOLD TO 4-LANE	7.6 miles	65 miles/hr	7.0 min.
JCT 52 TO MINOT	9.8 miles	70 miles/hr	8.4 min.
MINOT	5.0 miles	50 miles/hr	6.0 min.
	3.2 miles	55 miles/hr	3.5 min.
MINOT TO SURREY	2.9 miles	70 miles/hr	2.5 min.
SURREY	1.2 miles	60 miles/hr	1.2 min.
SURREY TO RUGBY	54.6 miles	70 miles/hr	46.8 min.
RUGBY	0.1 miles	55 miles/hr	0.1 min.
	1.3 miles	45 miles/hr	1.7 min.
	0.1 miles	55 miles/hr	0.1 min.
RUGBY TO DEVILS LAKE	55.6 miles	70 miles/hr	47.7 min.
DEVILS LAKE	0.2 miles	50 miles/hr	0.2 min.
	2.3 miles	40 miles/hr	3.5 min.
	0.2 miles	50 miles/hr	0.2 min.
DEVILS LAKE TO G.F.AIRPORT	80.5 miles	70 miles/hr	69.0 min.
G.F. AIRPORT TO GRAND FORKS	3.3 miles	55 miles/hr	3.6 min.
GRAND FORKS	2.4 miles	40 miles/hr	3.6 min.
	0.3 miles	35 miles/hr	0.5 min.
	1.0 miles	30 miles/hr	2.0 min.
TOTAL	353 miles	67* miles/hr	323 min. (= 5 hrs 23 min.)

* Average speed weighted by distance.

However, Table 6 does not include delays for traffic signals. The study found 17 traffic signal locations on the U.S. Highway route (Table 7). It is difficult to estimate precise travel time delay because it varies on truck weight, size, speed, timings and traffic conditions. The study assumed two minutes of the delay due to a traffic signal and fifty percent probability of receiving a red signal. Therefore, seventeen traffic signals are assumed to have a seventeen minute delay (=34 min.*0.5).

Table 7. Traffic Signal Locations on U.S. Highway 2 from Montana State Line to Grand Forks, ND.

City	**Location**	**Travel Time Delay due to Traffic Signal***
WILLISTON	US 2 (US 52, Dakota Parkway) & 18th St W	2 min.
	US 2 (US 52, Dakota Parkway) & 9th Ave NW	2 min.
MINOT	US 2 & US 83 Bypass	2 min.
DEVILS LAKE	US 2 & ND 19	2 min.
	US 2 & ND 20 (College Boulevard)	2 min.
	US 2 & 5th Ave S	2 min.
GRAND FORKS	US 2 & Airport Drive, West of town at airport entrance/exit	2 min.
	US 2 (Gateway Drive) & 47th St N	2 min.
	US 2 (Gateway Drive) & I-29 Western Ramps	2 min.
	US 2 (Gateway Drive) & I-29 Eastern Ramps	2 min.
	US 2 (Gateway Drive) & 42nd St N	2 min.
	US 2 (Gateway Drive) & Stanford Road	2 min.
	US 2 (Gateway Drive) & Columbia Road N	2 min.
	US 2 (Gateway Drive) & 20th St N	2 min.
	US 2 (Gateway Drive) & Bus 81 (Washington St N)	2 min.
	US 2 (Gateway Drive) & Mill Road / Bus 2 (5th St N)	2 min.
	US 2 (Gateway Drive) & 3rd St N / 11th Ave N	2 min.
TOTAL	**17 Traffic Signal Locations**	**34 min.**
	Expected Delay**	**17 min.**

* Although travel time delay varies based on truck weight and size, speed, traffic conditions, the study assumed two minutes of the travel time delay to decelerate, stop, wait, start, and accelerate, compared with a no traffic signal.

** The study assumed the probability of receiving a red signal is 50% and therefore the expected delay is 17 minutes.

Total travel time is calculated by summing the travel time based on the maximum speed limit (Table 6) and the time delays at traffic signals (Table 7). As the tables show, the travel time for U.S. Highway 2 was 5 hours and 23 minutes and the travel delay at 17 traffic signals was 17 minutes. Thus, the total travel time considering both the maximum speed limit and traffic signals is 5 hours and 40 minutes. This information can be compared to the travel times of other hypothetical travel scenarios.

Table 8 provides a comparison between the present travel time and hypothetical scenarios. The scenarios include 65 or 70 mile per hour maximum speed limits with or without traffic signals. The 70 mile per hour speed limit without any traffic signals scenario showed the lowest total travel time (5 hours and 3 minutes). This is an eleven percent decrease from the current travel time (5 hours and 40 minutes). The table implies that the maximum speed limits and traffic signal delays can directly affect travel time.

Table 8. Total Travel Time of Five Scenarios for U.S. Highway 2 from Montana State Line to Grand Forks, ND.

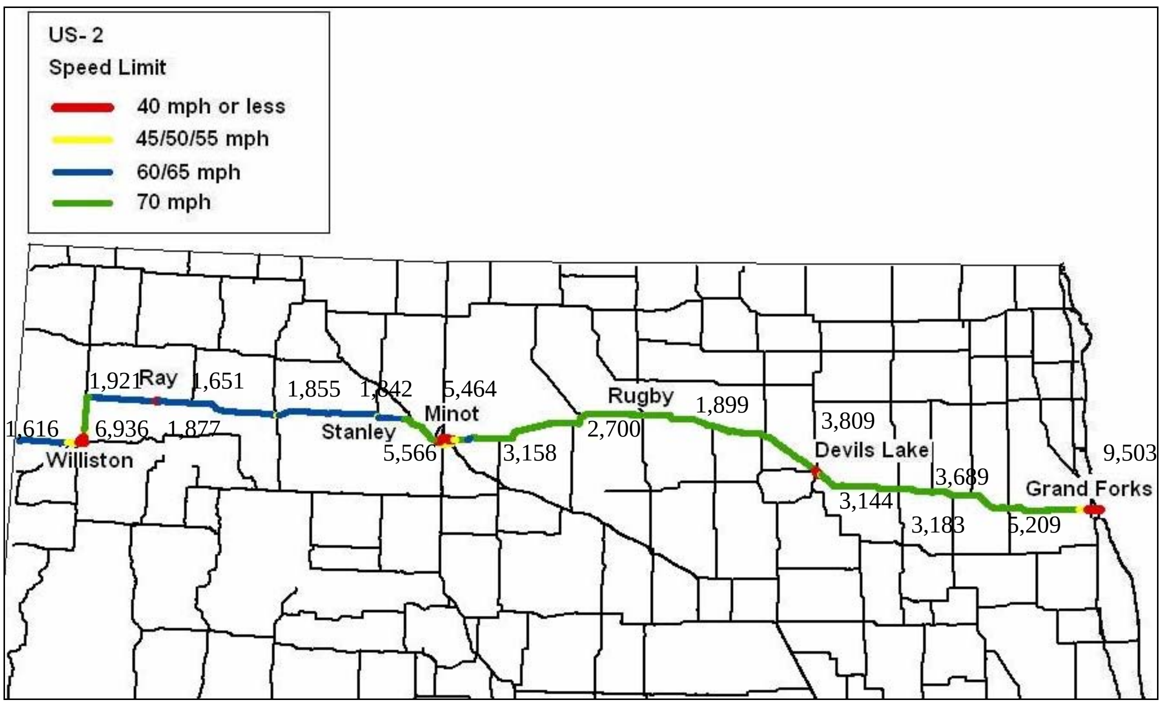
Scenario	**Speed Limit (Miles/hr)**	**Traffic Signal Location**	**Total Travel Time (Minutes)**
Current	Varies on highway segments (see Table 1)	17	5 hrs 40 min.
65 MPH & 17 signals	65 miles/hr	17	5 hrs 43 min.
65 MPH & no signals	65 miles/hr	0	5 hrs 26 min.
70 MPH & 17 signals	70 miles/hr	17	5 hrs 20 min.
70 MPH & no signals	70 miles/hr	0	5 hrs 3 min.

Costs associated with extended travel time can be viewed as an opportunity cost. For instance a trucking cost or rate may be used to evaluate costs associated with speed limit and signal delays. An estimated hourly cost for operating a 5 axle semi is a good proxy for rates. The Truck Costing Model[11] developed by UGPTI estimated the hourly rate of a commercial 5 axle semi at 86 dollars per hour. Examining the different truck counts inferences can be made about costs associated with delays. Truck traffic counts vary on the route segments, so it is difficult to estimate the exact impact of delays for the entire route. However, by using a weighted average calculation for distances and number of trucks on U.S. Highway 2, one can estimate the possible opportunity costs associated with delays on the highway segment. The weighted average number of trucks on U.S. Highway 2 is estimated at 495. If 495 trucks daily were delayed 17 minutes using the 86 dollars per hour operating cost, then the opportunity cost associated with delays would be estimated at over 12,000 dollars daily and over 4.4 million dollars per year. Other costs not included in this brief analysis could be inventory costs for businesses because of these delays.

[11] Berwick, M. and Farooq, M. *Truck Costing Model for Transportation Managers.* Mountain Plains Consortium No. 03-152. Upper Great Plains Transportation Institute, North Dakota State University, Fargo, August 2003.

Figure 7 shows average daily automobile traffic for U. S. Highway 2 from the Montana state line to Grand Forks, ND. Costs associated with extended travel time for automobiles can be calculated using the same methods as previously described for trucks. An average estimated hourly cost ($19.50) for operating an automobile is based calculations from data in the HERS Technical Report[12]. By using a weighted average calculation for distances and number of automobiles on U.S. Highway 2, costs associated with delays are calculated. The weighted average number of automobiles on U.S. Highway 2 is 3303. If 3303 automobiles were delayed 17 minutes using the $19.50 per hour operating cost, associated delay cost is estimated at 16,700 dollars per day and over 6.1 million dollars per year.

Figure 7. Average Daily Automobile Traffic for U.S. Highway 2 from Montana State Line to Grand Forks, ND (Source: NDDOT).

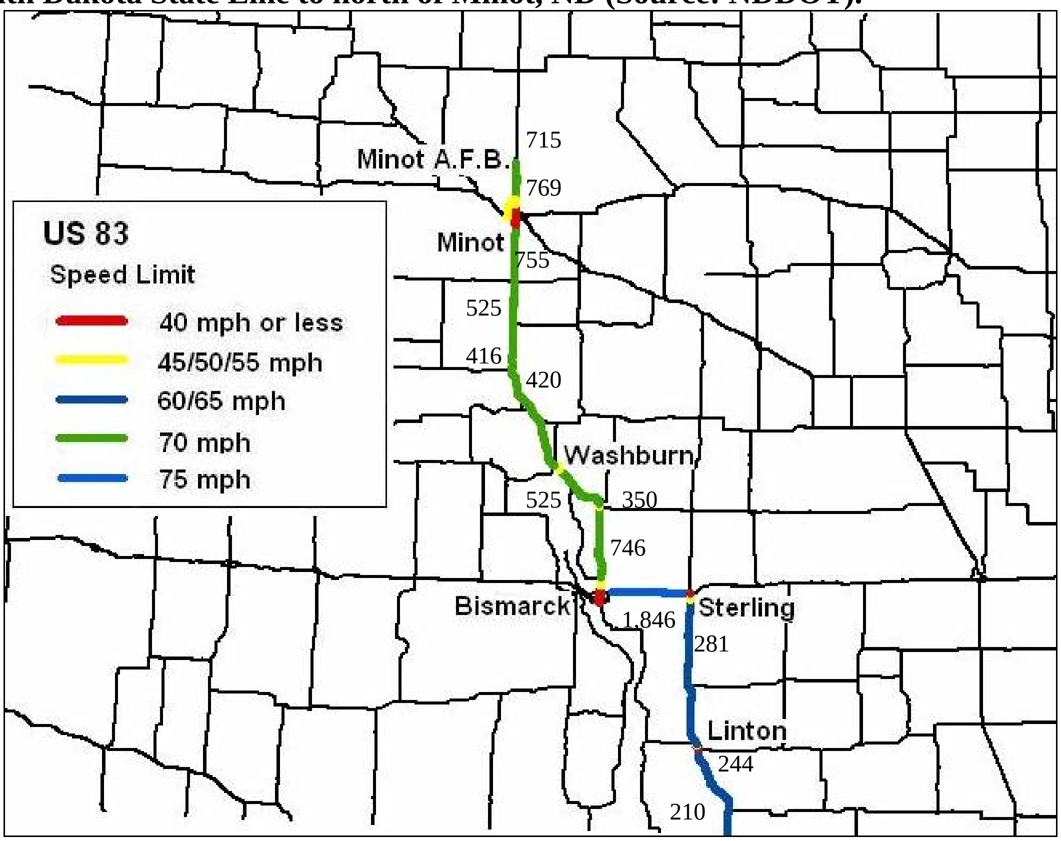


[12] U.S. Department of Transportation Federal Highway Administration, *HERS-ST Highway Economic Requirements System-State Version, Technical Report v3.54*, September 2002.

Case Study 2: North Dakota Speed Limit and Traffic Signal Impediments U.S. Highway 83

The second case study used U.S. Highway 83 from South Dakota state line to the Minot Air Force Base north of Minot. This route consists of two state highway performance classification systems: Interregional System (U.S. Highway 83) and Interstate System (Interstate 94). As shown in Figure 8, U.S. Highway 83 from the South Dakota state line to Sterling, ND has a 60 or 65 mile per hour maximum speed limit (blue line), Interstate 94 between Sterling, ND and Bismarck, ND has 75 mile per hour maximum speed limit (blue line) and U.S. Highway 83 from Bismarck to north of Minot has a 70 mile per hour maximum speed limit (green line). Bismarck, Minot, Linton, and Sterling, ND have speed limits of 40 miles per hour and less on intercity routes. The total distance for this scenario is 207 miles. Interstate 94 between Sterling and Bismarck has the largest average truck traffic at 1,846 trucks per day.

Figure 8. Average Daily Truck Traffic for U.S. Highway 83 and Interstate 94 from South Dakota State Line to north of Minot, ND (Source: NDDOT).



As previously shown in Case Study 1, estimates are calculated for travel time on the highway segments based on speed limits. Table 9 shows distances, speed limits, and travel times for highway segments from the South Dakota state line to the Minot Air Force Base north of Minot. The average speed weighted by distance is 66.8 miles per hour and the total travel time is 3 hours and 11 minutes.

Table 9. Distance, Speed Limit, and Travel Time for U.S. Highway 83 and Interstate 94 from South Dakota State Line to North Minot, ND (Source: NDDOT).

Route Segment	Distance (Miles)	Speed Limit (Miles/hr)	Travel Time (Minutes)
SOUTH DAKOTA LINE TO LINTON	24.7 miles	65 miles/hr	22.8 min.
LINTON	0.3 miles	45 miles/hr	0.4 min.
	0.9 miles	25 miles/hr	2.1 min.
	0.2 miles	45 miles/hr	0.3 min.
STERLING	38.0 miles	65 miles/hr	35.1 min.
	0.4 miles	45 miles/hr	0.6 min.
	1.2 miles	50 miles/hr	1.4 min.
E I-94 JCT STERLING	0.1 miles	40 miles/hr	0.2 min.
I-94	20.1 miles	75 miles/hr	16.1 min.
W I-94 JCT TO 43 RD AVE N	1.6 miles	40 miles/hr	2.4 min.
BISMARCK	2.3 miles	55 miles/hr	2.5 min.
BISMARCK TO WILTON	18.5 miles	70 miles/hr	15.9 min.
WILTON	0.8 miles	55 miles/hr	0.9 min.
WILTON TO WASHBURN	14.1 miles	70 miles/hr	12.1 min.
WASHBURN	0.1 miles	55 miles/hr	0.1 min.
	1.8 miles	45 miles/hr	2.3 min.
	0.2 miles	55 miles/hr	0.3 min.
WASHBURN-MAX	39.8 miles	70 miles/hr	34.1 min.
MAX	0.8 miles	50 miles/hr	1.0 min.
MAX TO MINOT	25.0 miles	70 miles/hr	21.4 min.
MINOT	0.2 miles	50 miles/hr	0.2 min.
	1.3 miles	40 miles/hr	2.0 min.
	1.3 miles	35 miles/hr	2.3 min.
	1.3 miles	30 miles/hr	2.6 min.
	1.2 miles	40 miles/hr	1.8 min.
NORTH MINOT	2.0 miles	55 miles/hr	2.2 min.
MINOT TO MINOT A.F.B.	8.9 miles	70 miles/hr	7.7 min.
TOTAL	207 miles	66.8 miles/hr	191 min. (= 3 hrs 11 min.)

* Average speed weighted by distance.

The route has 11 traffic signal locations (Table 10). Based on the assumption of two minutes of the delay due to a traffic signal and a 50 percent probability of a red traffic signal, the route has eleven minutes of delay (=22 min.*0.5).

Table 10. Traffic Signal Locations on U.S. Highway 83 and Interstate 94 from South Dakota State Line to North Minot, ND.

City	Location	Travel Time Delay due to Traffic Signal*
BISMARCK	US 83 (State St) & I-94 Northern Ramps	2 min.
	US 83 (State St) & Interstate Ave	2 min.
	US 83 (State St) & Century Ave	2 min.
	US 83 (State St) & Weiss Ave / Harvest Ave	2 min.
	US 83 (State St) & Calgary Ave	2 min.
	US 83 (State St) & 43rd Ave NE	2 min.
	US 83 & ND 1804 (71st Ave NE) north of town	2 min.
MINOT	US 83 (Broadway) & 31st Ave SW	2 min.
	US 83 (Broadway) & US 2 / US 52 Bypass southern exit ramp	2 min.
	US 83 Bypass & US 2 / US 52 Bypass	2 min.
	US 83 (Broadway) & US 83 Bypass	2 min.
TOTAL	**11 Traffic Signal Locations**	**22 min.**
	Expected Delay**	**11 min.**

* Although travel time delay varies based on truck weight and size, speed, and traffic conditions, the study assumed two minutes of the travel time delay to decelerate, stop, wait, start, and accelerate, compared with a no traffic signal.

** The study assumed that the probability of receiving a red signal is 50% and therefore the expected delay is 11 minutes.

Finally, the total travel time (Table 9) and time delay due to traffic signals (Table 10) are combined. As the tables show, the total travel time based on the maximum speed limits is 3 hours and 11 minutes and the travel delay due to 11 traffic signals is 11 minutes. Therefore, the total travel time is calculated as 3 hours and 22 minutes.

Table 11 compares the current total travel time to hypothetical travel scenarios. The scenarios include speed limit changes on all U.S. Highway 83 segments to 65 or 70 miles per hour. The scenario with a 70 mile per hour speed limit and no traffic signals showed the least total travel time (2 hours and 58 minutes). This is twenty four minutes (12 percent) less than the current travel time (3 hours and 22 minutes).

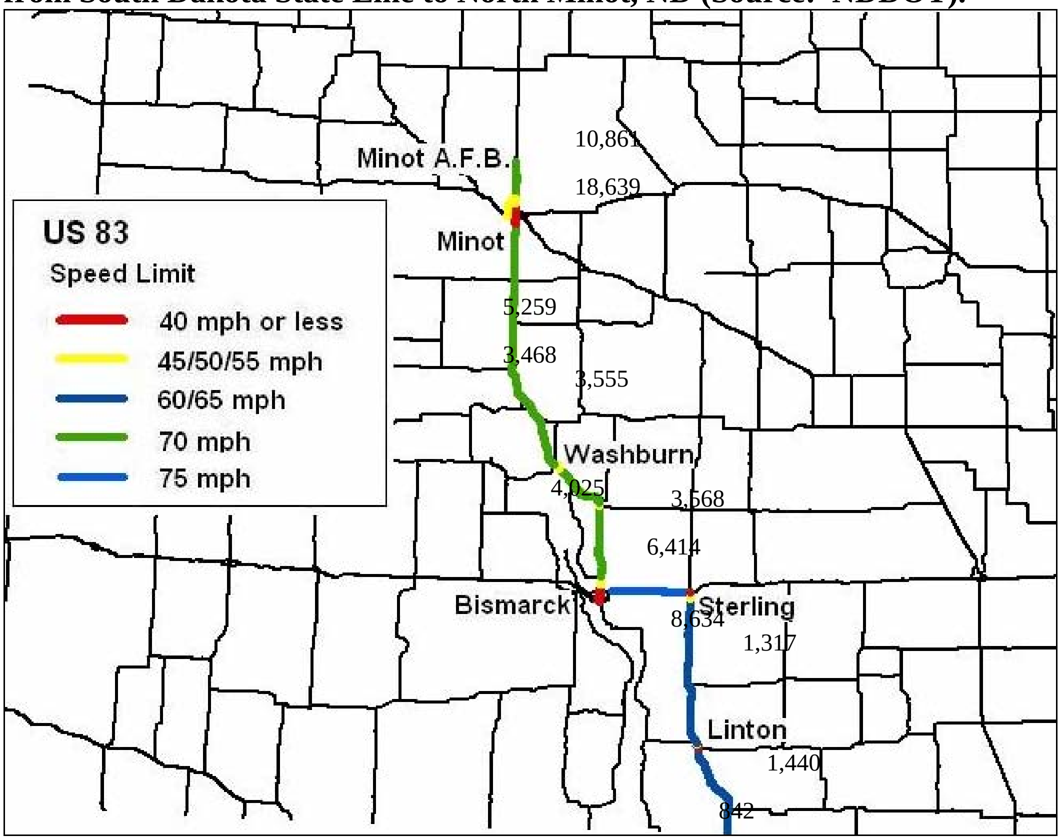
Table 11. Total Travel Time of Five Scenarios for U.S. Highway 83 from South Dakota State Line to North Minot, ND.

Scenario	Speed Limit on the US-83 (Miles/hr)	Traffic Signal Location	Total Travel Time (Minutes)
Current	Varies on highway segments (see Table 4)	11	3 hrs 22 min.
65 MPH on US-83 & 11 signals	65 miles/hr	11	3 hrs 21 min.
65 MPH on US-83 & no signals	65 miles/hr	0	3 hrs 10 min.
70 MPH on US-83 & 11 signals	70 miles/hr	11	3 hrs 9 min.
70 MPH on US-83 & no signals	70 miles/hr	0	2 hrs 58 min.

As stated previously in Case Study 1, costs associated with extended travel time can be viewed as an opportunity cost. Once again through the use of a weighted average calculation for distances and number of trucks one can estimate the possible opportunity costs associated with delays on the highway segment. The weighted average estimated number of trucks for Case Study 2 is 635. If 635 trucks daily were delayed 11 minutes using the 86 dollars per hour truck operating cost, then the opportunity cost associated with delays would be estimated at over 10,000 dollars daily and over 3.6 million dollars per year. As with the cost results from Case Study 1, other costs not included in this analysis could be inventory costs for businesses because of these delays.

Figure 9 shows average daily automobile traffic for U. S. Highway 83 and Interstate 94 from the South Dakota state line to North Minot, ND. Using the methods developed in Case 1, costs associated with extended travel time for automobiles can be calculated. The average estimated hourly cost of $19.50 is again used as a proxy. Using a weighted average calculation for distances and number of automobiles on U.S. Highway 83 and Interstate 94, costs associated with delays are calculated. The weighted average number of automobiles on U.S. Highway 83 and Interstate 94 is 4,646. If 4,646 automobiles were delayed 11 minutes using the $19.50 per hour operating cost, associated delay cost is estimated at 16,600 dollars per day and over 6 million dollars per year.

Figure 9. Average Daily Automobile Traffic for U.S. Highway 83 and Interstate 94 from South Dakota State Line to North Minot, ND (Source: NDDOT).



Conclusion

Highways selected for analysis were U.S. Highway 2 from the Montana state line to Grand Forks, ND and U.S. Highway 83 from the South Dakota state line to the Minot Air Force Base north of Minot, ND. Both case studies found the travel time of the current condition as longer than travel time of the scenario with a 70 mile per hour speed limit and no traffic signals. The travel time of the current condition is 11 and 12 percent longer than the 70 mile per hour speed limit and no traffic signal scenario for case one and two, respectively. The two case studies provide insight as to how speed limits and traffic signals influence travel time as well as costs associated with delays for trucks and automobiles. A reduced travel time can improve efficiency and reduce costs associated with freight and traffic flow and therefore, enhance the regional economy.

HIGHWAY DAMAGE IMPLICATIONS DURING SPRING THAW

This section of the report is to provide guidance for NDDOT's desire to increase the load capacity of the state highway system by 20%. This research focuses on spring load restrictions that are imposed on various highway corridors and segments[13].

North Dakota seasonal load restrictions are based on axle weights. The axle weights translate to total gross vehicle weights. From the total truck weights payloads may be estimated. Table 12 shows the least restrictive load restriction is the Class A and the most restrictive is the No. 2 restriction. Table 12 lists the load restrictions based on axle weights and the last row shows the gross vehicle weight allowed under the different level of restrictions.

Table 12. North Dakota Load Restrictions.

	Class A (8-ton) Load Restrictions	**No. 1 (7-ton) Load Restrictions**	**No. 2 (6-ton) Load Restrictions**
Single Axle	Not to exceed 18,000 lbs.	Not to exceed 15,000 lbs.	Not to exceed 12,000 lbs.
Tandem Axle	Not to exceed 16,000 lbs./axle	Not to exceed 15,000 lbs/.axle	Not to exceed 12,000 lbs./axle
3 Axles or More Group	14,000 lbs/axle on divisible loads the gross weight of the axle grouping may not exceed 42,000 lbs.	3 Axles or More Group: 12,000 lbs/axle on divisible loads the gross weight of the axle grouping may not exceed 36,000 lbs.	10,000 lbs/axle on divisible loads the gross weight of the axle grouping may not exceed 30,000 lbs.
Gross Weight	Not to exceed 105,500 lbs.	Not to exceed 80,000 lbs	Not to exceed 65,000 lbs.

Load Factor Equivalency of Various Axles & Restrictions

The 1986 AASHTO design procedures are based on designing for axle load equivalencies over a given period of time. The load equivalencies have been used by numerous derivative works that describe different methodologies for calculating damage equivalents for different axle groups and loadings. The following examples are based on

[13] Before any changes to existing procedures relative to spring restrictions are recommended engineering guidelines and impacts for any such changes should be evaluated. This paper discusses the load equivalency factors, the spring load damage factors for the different restriction levels, spring damage estimates, and scenarios of various damage estimates for two example highway segments.
The findings presented in this research are preliminary. More in-depth research is recommended to further refine the results. The preliminary results can be used to gain a better understanding of the performance of pavements during spring thaw and how the various load restriction levels impact long term performance of a highway segment.

the AASHTO 4th power rule for axle equivalencies. Damage equivalents were calculated for different axle groupings and axle load restrictions[14].

Table 13. Damage Equivalents for Seasonal Load Restrictions for Axle Configurations.

Axle Configuration	Seasonal Restriction	Basic Load (kips)[15]	Flexible Equivalency Factor (AASHTO 4th power rule)
Single	Class A (8-ton) (current legal)	18	1.00
	No. 1 (7-ton)	15	.48
	No. 2 (6-ton)	12	.20
Tandem	Current Legal	34	1.09
	Class A (8-ton)	32	.86
	No. 1 (7-ton)	30	.66
	No. 2 (6-ton)	24	.27
Tridem	Current Legal	48	1.03
	Class A (8-ton)	42	.76
	No. 1 (7-ton)	36	.33
	No. 2 (6-ton)	30	.20

[14] "NCHRP Web Doc 13 Developing Measure of Effectiveness for Truck Weight Enforcement Activities: Final Report (1988)".

[15] 1 kip = 1000 pounds

Spring Thaw Damage Estimates

Damage occurring during a week of spring thawing is estimated to be five times greater than an average week. This damage estimate is based on research conducted at MnRoad using the mechanistic-empirical pavement design software developed by the University of Minnesota. An estimated fatigue damage factor increases from 1 to 2.5 and the rutting increased from 1 to 4. The typical pavement damage would visually surface as alligator cracking and rutting (rutting of the base material that also causes the surface material to rut in asphalt pavements).

The MnRoad research presents two significant findings: 1) four times as much damage is done by a 10 ton axle as a 7 ton axle (Table 14) and, 2) the same load creates about seven times as much damage at the beginning of spring thaw compared to conditions towards the end of the thawing period (Figure 10). This is due to an excessively weak thawed layer sandwiched between the pavement and a frozen subsurface. This is the same time period that the potential for fatigue and rutting damage is the greatest.

Table 14. MNDot Comparison of Loadings and Restrictions.

Condition	Axle Loading	ESALs	AASHTO 4^{th} Power Rule
Unrestricted Condition	10 Ton Axle (20,000 pounds)	1.52	$e_{20}=1*(20/18)^4=$ 1.52
	9 Ton Axle	1.00	
Restricted Condition	7 Ton Axle	.37	$e_{14}=1*(14/18)^4=$ 0.37

The MnRoad research can be compared to the 1993 AASHTO Guide with very similar results. The "fourth power law" of damage results in the difference between the two axle tonnages of 4.11 times the damage. The 1993 AASHTO Guide estimates the damage due to a 50 percent reduction in the roadbed modulus would be about 5. The combined effect is therefore approximately 20 times the damage between the 7-ton and the 10-ton. Damage can be defined as accumulated 18 kip[16] axle loadings. For example, a 10 ton axle load during the spring thaw time will accumulate approximately 20 times the axle loadings as a 7 ton axle will accumulate. During summer months after the subgrade strength has recovered, the 10 ton axle accumulates approximately 4 times that done with a 7 ton axle.

The loss of support strength to a typical pavement section due to thawing conditions on North Dakota Highway 200 between mile points 320 and 325 is shown in Figure 8 in terms of loss of subgrade modulus. From the diagram, the subgrade strength shows a subgrade modulus approximately one-half the typical deflection found throughout the remainder of the year. This reduction in the modulus is similar to that found at the

[16] 1 kip = 1000 pounds

MnDOT MnRoad research facility. Further detailed information can be found in Case Studies of Annual Damage, Appendix 6.

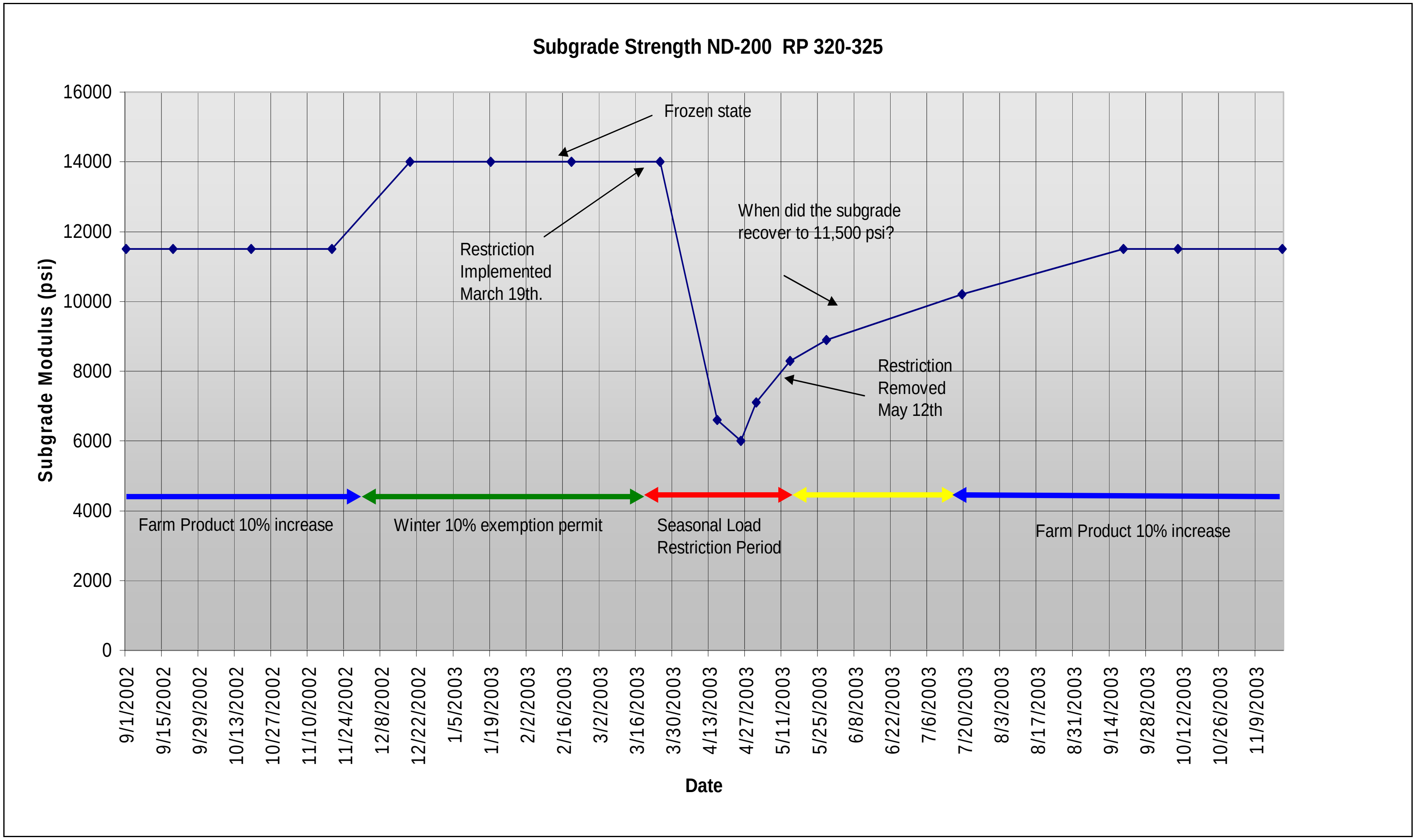


Figure 10 - Seasonal Variation of Subgrade Modulus Strength (Figure developed by John Thompson NDDOT District Engineer)

Conclusions

Load restrictions are a potential highway preservation strategy when looking at seasonal damage that occurs because of heavy axle loads on a thawing roadbed. The results of previous analysis may suggest that an alternative to strict restrictions may be to use axle restrictions to prevent damage while allowing higher GVW. Other conclusions may be to design key corridors to handle loads and reduce the time period of restrictions as most damage occurs during the maximum thaw period that is usually 30 days.

The economics for the shippers and the motor carrier industry would also lean towards higher GVWs especially for industries with perishable products, such as potatoes and sugar beets, and products must be moved to processing facilities before spoilage occurs. Some products can be transported after spring restrictions are removed, but perishable products may have to be transported while restrictions are in place to prevent spoilage and losses to producers or processors.

ECONOMIC IMPLICATIONS OF LOAD RESTRICTIONS FOR SHIPPERS AND MOTOR CARRIERS

The following section provides the economics from the motor carriers and shippers perspective. Seasonal restrictions are barriers to commerce and provide difficult decisions for some in particular industries about shipping and inventory levels.

Seasonal load restrictions limit axle and gross vehicle weight because of damage that may occur to the pavement during the spring thaw. Seasonal load restrictions are applied differently to the different classes of both roadways and vehicles. The economic impacts on shippers are variable and are difficult to quantify. Products that must move over restricted highways result in higher shipping costs.

North Dakota load restrictions are enforced at three different levels (Class A, No. 1, and No. 2 restrictions). The restrictions are placed on the highways based on the estimated damage that may occur during truck movements.

Load Restrictions

Payload weights can be estimated using the gross vehicle weight restrictions and different truck types. The following estimations are base on assumptions and/or averages of truck weights. Payloads vary based on different types of material and design of particular equipment. Table 15 illustrates differences in truck weights based on different seasonal load restrictions.

Table 15. Differences in Truck Weight (lbs.) Based on Different Seasonal Load Restrictions.

Truck Type	Restricted by Legal Weight	Class A (8-Ton) Load Restrictions	No. 1 (7-Ton) Load Restrictions	No. 2 (6-Ton) Load Restrictions
Single Axle	32,000	30,000	27,000	24,000
Tandem Axle	46,000	44,000	42,000	36,000
Tridem Axle	60,000	54,000	48,000	42,000
5 Axle Semi	80,000	76,000	72,000	60,000
RMD	105,500	105,500	80,000	65,000

Farm Truck Fleet
A survey conducted by UGPTI (Tolliver, 2002) revealed that the farm truck fleet is adding 5-axle semis. However the fleet is still dominated by single axle trucks. On many state highways the farm truck fleet is moving product in the spring when seasonal load restrictions are in place. Many farmers are also trying to move the previous year's crops and must meet seasonal load restrictions. The restrictions cause extra trips and costs. Table 16 shows the makeup of the farm fleet based on the 2002 survey.

Table 16. Farm Truck Fleet by Type.

Truck Type	Percentage (%)
Single	54.7%
Tandem	29.1%
Semi	12.1%
Tridem	4.1%

(Source: Tolliver, 2002)

Single axle trucks are still used by many farmers as their only method of transporting product to market. The study indicated that farmers are replacing smaller trucks with larger ones. Because of the relatively low annual use of smaller trucks, they have an extended useful life and will remain in the fleet. Tandems are the second most used trucks by farmers and the least used truck is the triple axle or tridem.

With the advent of shuttle elevator facilities, it is intuitive that grain will move longer distances to market. It is also reasonable to assume that larger trucks will participate in the farm to market movement because larger trucks are more efficient at longer distances.

Other factors that play a role in the trend toward larger trucks in the farm truck fleet are the relative costs of different truck types. In the last couple of years, there has been a large supply of used semi tractors resulting in lower prices. New single, tandems, and tridem straight farm trucks, in many cases, are more expensive than purchasing a used semi tractor and trailer. Either converting a used semi tractor to a tandem, or tridem farm truck, or purchasing a semi tractor and hopper bottom trailer is cheaper than purchasing a traditional farm truck new.

Truck Costing Model
An economic engineering truck costing model will be used to analyze trucking costs under different levels of gross vehicle weight restrictions. Different types of trucks will be used to demonstrate the impacts on all truck types. Comparisons can also be made among truck types to compare costs. Two case studies scenarios can be used to analyze costs. Farm truck costs will be used in the first scenario and commercial truck costs will be used in the second.

The main differences between farm and commercial truck costs are that the cost of equipment and usage are lower. Insurance rates, license fees and taxes are much lower for farm trucks.

To model trucking costs, assumptions are made about equipment costs, variable and fixed input costs, and travel characteristics for speed and fuel consumption. The model developed consists of decision variables which affect cost estimations. These variables include firm and/or operating characteristics and are classified as equipment characteristics, operational characteristics, and input prices associated with a particular movement.

Due to the cost differences between farm truck operations and commercial applications, models were adapted to fit both applications. The major difference between commercial applications and farm trucking costs are equipment use and costs, insurance costs, and the costs of license fees and taxes.

Many farmers purchase used equipment requiring less capital investment and considerably lower annual usage which extends the life of that equipment. Many commercial truckers use newer equipment, and because of considerably higher usage, maintenance and repair costs are also higher.

The first of the two case studies will estimate truck costs for farm commodities. The second case study will involve commercial trucking. Differences that exist between farm trucking characteristics and commercial trucking will be explained.

Case 1: Farm Truck Costs

The four truck types used to estimate farm truck costs are the single axle truck, tandem axle truck, triple axle truck, and the Rocky Mountain Double (RMD). Except for the RMD, these truck types are most commonly used by agricultural producers. The RMD is included because some farmers desire to reduce the number of trips necessary, especially when hauling longer distances to a grain shuttle facility.

Assumptions

The cost assumptions are for used trucks with low annual use and all trucks are owned. The cost estimates provide a comparison among the different truck types moving products to market. The goal of the case study is to show the economics of trucking under the different load restrictions and with different truck types.

Many of the assumptions (fuel price, speed, wage rates, and other variables) remain constant among the truck types. However, the differences in the size of the trucks change two very important variables that do not remain constant for a farm producer, and these are the equipment price and annual usage. This case has been designed to compare costs among farm truck types and then among different load restrictions. Because it is on a set amount of product, the annual usage will change based on truck size. This will have the effect of raising fixed costs for the larger trucks because they cost more to purchase, and will assume to have a lower utilization rate, resulting in increased equipment cost. The trip numbers for hauling 50,000 bushels intuitively will be less for the larger trucks. Table 17 shows the associated costs and trips using total trucking costs.

Equipment costs are based on a survey of farmers. The costs have been adjusted based on truck capacity. Costs for used equipment for farm use are not consistent. Therefore, the contention would be that the costs are relative and provide a reasonable estimate. Annual Miles provides a similar problem. As equipment size increases, it takes less miles to move the same amount of commodity. Equipment costs and annual miles are the major variables in raising fixed costs in the trucking industry. For commercial haulers the problem is less complex because it is reasonable to use new vehicle price and high annual miles. However, for the farm sector few trucks are purchased new, usage is usually seasonal and annual miles are only a fraction of the commercial trucker's annual miles.

Table 17. Truck Costs and Annual Miles for Farmer Hauling 50,000 Bushels 20 Miles (July, 2005).

Truck Type	Equipment Costs ($)	Annual Miles (miles)	Payload (lbs.)	Cost Per Ton-Mile ($)
Single	$15,000	5,320	22,500	$0.178
Tandem	$19,736	4,040	29,595	$0.180
Tridem	$28,200	2,824	42,500	$0.195
5 Axle	$37,250	2,120	56,600	$0.230
RMD	$42,250	1,652	72,600	$0.251

Table 18 shows the total costs of moving 50,000 bushels by the different truck types. It shows total costs and time needed to move grain. Costs are highest in the largest truck, but time needed to move the commodity is lowest with the largest truck.

Table 18. Costs and Time for Farmer to Haul 50,000 Bushels 20 Miles (July, 2005).

	Total Costs	Incremental Costs	Number of Trips	Time Factor (Hrs)	Days (10 Hr Days)
Single	$10,653	$2,916	133	319	32
Tandem	$10,790	$2,298	101	242	24
Triple	$11,696	$1,643	70	169	17
5 axle	$13,780	$1,430	53	127	13
RMD	$15,025	$1,220	41	98	10

Next are five tables that show characteristics of the different truck types as related to load restrictions. The single axle truck loses 8,000 pounds of payload from a restricted by legal weight scenario to the No. 2 restriction scenario, however, trip numbers increase by 55 percent. Costs increase proportionately (Table 19).

Table 19. Payloads and Time for Single Axle Truck Hauling 50,000 Bushels 20 Miles (July, 2005).

Single	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Payload (lbs.)	22,500	20,500	17,500	14,500
Bushels	375	342	292	242
Trips	133	146	171	207
Hours	319	350	410	494
Days	32	35	41	49
Ton-Mile Cost ($)	$0.178	$0.195	$0.228	$0.275

The payload and costs are similar for the tandem. From the restricted by legal weight to the No. 2 load restriction, payload decreases by 33 percent and costs increase just over 50 percent. The time factor increases by almost 13 days at the No. 2 restriction (Table 20).

Table 20. Payloads and Time for Tandem Axle Truck Hauling 50,000 Bushels 20 Miles (July, 2005).

Tandem	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Payload (lbs.)	29,595	27,595	25,595	19,595
Bushels	493	460	427	327
Trips	101	109	117	153
Hours	242	260	280	366
Days	24	26	28	37
Ton-Mile Cost ($)	$0.180	$0.193	$0.208	$0.272

A triple axle truck sacrifices 18,000 pounds of payload at an increased cost of over 14 cents per ton-mile, when going from a restricted by legal weight route to a No. 2 load restriction. Also, the time factor increases by an estimated 12 days of hauling (Table 21).

Table 21. Payloads and Time for Tridem Axle Truck Hauling 50,000 Bushels 20 miles (July, 2005).

Tridem	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Payload (lbs.)	42,500	36,500	30,500	24,500
Bushels	708	608	508	408
Trips	71	82	98	122
Hours	169	196	235	293
Days	17	20	23	29
Ton-Mile Cost ($)	$0.195	$0.227	$0.271	$0.336

The 5 axle semi-truck loses 20,000 pounds of payload going from a restricted by legal weight route to the No. 2 restriction. Costs increase over 50 percent comparing a non-restricted legal weight route and a No. 2 restricted route (Table 22).

Table 22. Payloads and Time for 5-Axle Truck Hauling 50,000 Bushels 20 Miles (July, 2005).

5-Axle Semi	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Payload (lbs.)	56,600	52,600	48,600	36,600
Bushels	943	877	810	610
Trips	53	57	62	82
Hours	127	136	147	196
Days	13	14	15	20
Ton-Mile Cost ($)	$0.230	$0.247	$0.267	$0.352

For the RMD, a Class A load restriction has no impact as the Gross Vehicle Weight (GVW) remains at 105,500 pounds. The No. 1 and No. 2 restrictions make it impractical to use a RMD in those situations. Unless a product's density characteristics require a large volume trailer, a RMD is not a viable option for No. 1 and No. 2 load restrictions (Table 23).

Table 23. Payloads and Time for RMD Truck Hauling 50,000 Bushels 20 Miles (July, 2005).

RMD	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Payload (lbs.)	72,600	72,600	47,600	32,600
Bushels	1210	1210	793	543
Trips	41	41	63	92
Hours	99	99	151	220
Days	10	10	15	22
Ton-Mile Cost ($)	$0.251	$0.251	$0.380	$0.552

Next is a comparison of the number of trips needed by the different truck types from non-restricted legal weight route to a No. 2 load restriction. Comparing the information among truck types again shows that the RMD configuration would only be used for the Class A restriction (Table 24).

Table 24. Number of Trips by Truck Type for 50,000 Bushels.

	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Single	133	146	171	207
Tandem	101	109	117	153
Tridem	71	82	98	122
5 axle	53	57	62	82
RMD	41	41	63	92

The economic costs associated with different load restrictions are demonstrated in Table 25. The costs listed in Table 25 include all costs, and the table shows that it is most economical to move product in a single axle truck under a restricted by legal weight scenario. However, the costs assigned to the different truck types, and low annual use, dictate higher fixed costs for larger truck types. This table does not take into account the time factor which is increased by several days, when altering from the larger to smaller trucks and from non-restricted legal weight to the different levels of restrictions.

Table 25. All Costs Per Ton-Mile by Truck Type and Load Restriction (July, 2005).

	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Single	$0.178	$0.195	$0.228	$0.275
Tandem	$0.180	$0.193	$0.208	$0.272
Tridem	$0.195	$0.227	$0.271	$0.336
5 axle	$0.230	$0.247	$0.267	$0.352
RMD	$0.251	$0.251	$0.380	$0.552

It can be argued that only incremental costs should be used in calculating the cost of imposing a load restriction. Table 26 shows the incremental costs of the different truck types across the different levels of load restrictions. The analysis shows that the smallest truck is the most costly to use and the 5-axle semi provides the least cost for producers for all levels of restrictions. Again, the RMD is least costly for non-restricted legal weight and Class A restriction.

Table 26. Incremental Trucking Costs with Different Levels of Restrictions (July, 2005).

	Restricted by Legal Weight	Class A (8-Ton) Restriction	No. 1 (7-Ton) Restriction	No. 2 (6-Ton) Restriction
Single	$0.097	$0.107	$0.125	$0.150
Tandem	$0.077	$0.082	$0.089	$0.115
Tridem	$0.055	$0.064	$0.076	$0.094
5 axle	$0.048	$0.051	$0.055	$0.071
RMD	$0.041	$0.041	$0.060	$0.086

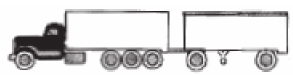
Case 2: Commercial Truck Costs

Many shippers and trucking companies struggle in the spring with the state, county, and city restrictions. The problem is that imposing load restrictions results in economic losses for business. And, a perfect example is trucking oil from the oilfields of western North Dakota.

Two cases were brought to the attention of the NDDOT during a 2002 conference held in Bismarck. Dave Wanah of Missouri Basin Well Service provided an example of hauling crude oil from wells to pipelines by truck during spring load restrictions. The trucks used to haul oil are specially designed for the oilfield. The same types of trucks haul the waste salt water to injection wells and also haul liquid material needed in the drilling process.

The truck types vary somewhat, but the configuration is usually a straight truck pulling a pup trailer that may either be a 4-axle or 2-axle trailer (Figure 11). The truck is usually a tridem axle truck and the third axle may be a tag axle which may be located in front of, or behind the drive axles.

Figure 11. Oil Truck Configuration.

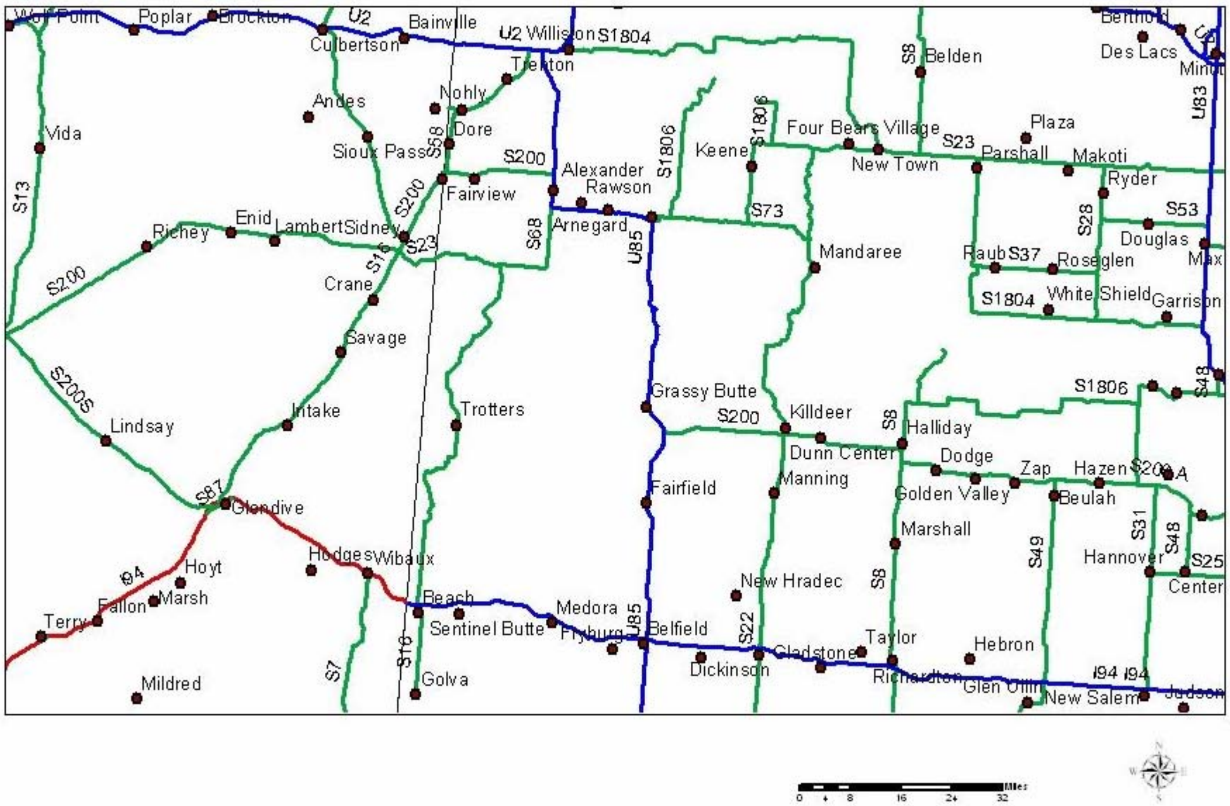

(Straight truck (a tridem axle) + pup trailer).

The truck is equipped with pumping equipment which adds weight limiting the payload. The configuration is used so that in the case of adverse weather events the truck can drop the pup and put chains on the drive axles. The roads to oil well sites are dirt, gravel, or scoria and lack maintenance or immediate snow removal. The truck type provides another alternative where the pup may be parked close to the main road and the truck makes two trips, one to fill the pup and the other to fill the truck. Without the pup the truck is much less likely to get stuck in the mud or snow and there is also less of a probability to slide off the roadway.

Mr. Wanah specifically discussed the oilfields directly north of Beach served by ND State Highway 16. Many wells exist within this region and in the spring of the year it is difficult for oil haulers and oil companies as the load restrictions dramatically increase transportation costs. Truckers avoid load restricted routes when they can. When seasonal restrictions can not be avoided the pup is parked on a non-seasonally restricted route and loaded. When both tanks are legally loaded, they are transported to the pipeline at either Alexander or Medora.

The other alternative is the No. 2 restriction. Some companies prefer to shut the wells down until load restrictions are removed. This limits annual production, reducing income for the producer, mineral owner, all service providers, and state and federal taxes that would have been collected. This case will provide cost examples for the truck delivering oil to the pipeline north of Alexander via loading to the No. 2 restriction, and also loading to the legal GVW using the extra trip method and routing the oil via Interstate 94 and Highway 85 (Figure 12).

Figure 12. Case Study Map (Oilfields in North of Beach, ND and Pipeline in North of Alexander. ND).



The following tables (Tables 27-30) show characteristics of the different truck types as related to load restrictions. Again, as shown in Case 1, costs increase as GVW decreases. In determining costs associated with different payloads both fixed and variable costs need to be included. It could be argued that only variable or incremental costs increase as extra trips are needed to haul smaller payloads based on restrictions for GVW. However, if a shipper is hiring transportation services, all costs are relative, and for most product movements all recognized costs are reflected in the rates.

Table 27. Truck Costs with Non-Restricted Legal Weight or Class A Restriction (July, 2005).

105,500 GVW	**Ton Mile Cost**	**Per Trip Cost at 60 Miles**	**Per Trip Cost at 190 Miles**
Fuel	$0.012	$21.90	$69.34
Labor	$0.011	$19.80	$62.70
Tires	$0.002	$4.14	$13.11
Maintenance	$0.005	$8.16	$25.85
Total Variable Costs	**$0.030**	**$54.00**	**$171.00**
Fixed Costs			
Equipment Cost	$0.012	$22.26	$70.49
License Fees and Taxes	$0.006	$11.46	$36.29
Insurance	$0.002	$4.31	$13.65
Management and Overhead	$0.004	$6.43	$20.37
Total Fixed Costs	**$0.024**	**$44.46**	**$140.80**
TOTAL COSTS	***$0.054***	***$98.46***	***$311.80***

Table 28. Truck Costs with No. 1 Restriction (July, 2005).

80,000 GVW	Ton Mile Cost	Per Trip Cost at 60 Miles	Per Trip Cost at 190 Miles
Fuel	$0.019	$19.49	$61.71
Labor	$0.019	$19.80	$62.70
Tires	$0.004	$3.93	$12.44
Maintenance	$0.007	$6.68	$21.15
Total Variable Costs	**$0.049**	**$49.90**	**$158.00**
Fixed Costs			
Equipment Cost	$0.022	$22.26	$70.49
License Fees and Taxes	$0.011	$11.46	$36.29
Insurance	$0.004	$4.31	$13.65
Management and Overhead	$0.006	$6.43	$20.37
Total Fixed Costs	**$0.043**	**$44.46**	**$140.80**
TOTAL COSTS	**$0.092**	**$94.36**	**$298.81**

Table 29. Truck Costs for No. 2 Restrictions (July, 2005).

65,000 GVW	Ton Mile Cost	Per Trip Cost at 60 Miles	Per Trip Cost at 190 Miles
Fuel	$0.032	$18.07	$57.22
Labor	$0.035	$19.80	$62.70
Tires	$0.007	$3.93	$12.44
Maintenance	$0.010	$5.81	$18.39
Total Variable Costs	**$0.084**	**$47.61**	**$150.75**
Fixed Costs			
Equipment Cost	$0.039	$22.26	$70.49
License Fees and Taxes	$0.020	$11.46	$36.29
Insurance	$0.008	$4.31	$13.65
Management and Overhead	$0.011	$6.43	$20.37
Total Fixed Costs	**$0.078**	**$44.46**	**$140.80**
TOTAL COSTS	**$0.162**	**$92.07**	**$291.55**

Table 30. Total Truck Cost Comparisons to Haul 300,000 Barrels at 190 Miles (July, 2005).

	Ton Mile Cost ($)	Maximum GVW (lbs.)	Payload (lbs.)	# of Trips to haul crude oil (300,000 barrels*)	Per Trip Cost at 190 Miles	Total Cost ($)
Class A Restrictions	$0.055	105,500	73,500	1,200	$311.80	**$374,160**
No.1 Restrictions	$0.093	80,000	48,000	1,838	$298.81	**$549,213**
No. 2 Restrictions	$0.162	65,000	33,000	2,673	$291.55	**$779,313**

* The study used crude oil weight conversion at 1 barrel = 294 pounds (weight of crude oil per barrel varies).

Conclusions

The section compared truck costs with and without load restrictions. Two case studies were conducted to show the economic impact of three levels of load restrictions in North Dakota. The results of case studies show the restrictions are directly associated with truck costs. For example, the second case study showed total truck costs to haul crude oil (300,000 barrels at 190 miles). The study found that a No. 2 restriction had $779,313 of total costs while a Class A restriction had $374,160 of total costs. This is approximately twice of truck costs with a Class A restriction. This provides evidence that load restrictions could significantly increase total transportation costs and reduce profitability of companies. Further, this could have negative effects on the efficiency of freight flows and competitiveness of our region.

KEY FINDINGS

Truck size and weight laws are continually evolving in the North Dakota and the reader should note that regulations are subject to change. The conclusions and recommendations that follow have been developed from the most current regulatory information available at the time of this report.

- Differences that exist in state and local motor carrier regulations and permitting processes impede the intrastate flow of goods.

- Uniform regulatory and permitting processes would enhance the seamless movement of freight within the state.

- Harmonizing state and local truck size and weight regulations and permitting processes would reduce confusion, promote regulatory compliance and most importantly improve commerce.

- State leadership may be necessary to promote local uniform truck size and weight regulations and permitting.

- Maintaining the efficient movement of freight and traffic through the minimal use of speed restrictions and traffic signals can enhance the local and regional economy.

- Costs associated with extended travel time can be viewed as an opportunity cost. For instance a trucking cost or rate may be used to evaluate costs associated with speed limit and signal delays. An estimated hourly cost for operating a 5 axle semi is a good proxy for rates. The Truck Costing Model developed by UGPTI in 2002[17] estimated the hourly rate of a commercial 5 axle semi at 86 dollars per hour.

- Examining the different truck counts, inferences can be made about costs associated with delays. Truck traffic counts vary on the route segments, so it is difficult to estimate the impact of delay for the entire route. However, case studies examined in this report found opportunity costs associated with delays from 10,000 dollars to 12,000 dollars daily and 3.6 million dollars to 4.4 million dollars per year. Other costs not included in the brief analysis could be increased inventory costs for businesses because of these delays.

- Seasonal load restrictions are an impediment to traffic flow. These restrictions are put in place to preserve the highway during spring thaw when the road infrastructure is most susceptible to damage by heavy trucks.

- Load restrictions are a highway preservation strategy used to reduce seasonal damage that occurs because of heavy axle loads on a thawing road infrastructure.

- The results of previous analysis suggest that an alternative to gross vehicle weight (GVW) restrictions may be restricting axle loads. Other conclusions may be to design key corridors to handle heavier loads and reduce the time period of restrictions as most damage occurs during the maximum thaw period that is approximately 30 days.

- The economics for shippers and the motor carrier industry lean toward higher GVWs, especially for perishable products such as potatoes and sugar beets. Some products can be transported after spring restrictions are removed, but other perishable products have to be transported while restrictions are in place to prevent spoilage.

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[17] (Software Model) Berwick, M. and Farooq, M. *Truck Costing Model for Transportation Managers, 2002-03.* Mountain Plains Consortium No. 03-152. Upper Great Plains Transportation Institute, North Dakota State University, Fargo, August 2003.

- Results of case studies show that load restrictions increase truck costs. The case studies show that truck costs more than double with a No. 2 restriction versus a Class A restriction.

- Higher load limits could significantly reduce total transportation costs and increase profitability of companies. This could have positive effects on the efficiency of freight flows and competitiveness of our region.

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www.state.nd.us/dot/divisions/planning/hwyclassification.html

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APPENDIX 1
NORTH DAKOTA VEHICLE SIZE AND WEIGHT GUIDE

A. Legal Width

1. 8 feet 6 inches on all highways.

2. Exceptions.

   a. Construction and building contractors' equipment and vehicles used to move such equipment which does not exceed ten feet in width when being moved by contractors or resident carriers. Nighttime travel is allowed provided moving equipment is properly lighted.

   b. Implements of husbandry being moved by resident farmers, ranchers, dealers, or manufacturers or government entities between sunrise and sunset. Nighttime travel is allowed provided the implements are properly lighted and not being moved on the interstate highway system.

   c. Hay in the stack being moved along the extreme right edge of a roadway between sunrise and sunset by someone other than a commercial mover. Commercial haystack movers, overwidth self-propelled fertilizer spreaders, overwidth self-propelled agricultural chemical applicators, hay grinders, grain cleaners, and forage harvesters if the owners have seasonal permits.

   d. All vehicles exempt from width limitations are subject to safety rules adopted by the Highway Patrol.

B. Legal Height

1. 14 feet whether loaded or unloaded, unless routes of travel include structures such as bridges and underpasses that are not 14 feet in height.

2. Exception.

   a. Implements of husbandry may not exceed 15 feet 6 inches in height when being moved by resident farmers, ranchers, dealers, or manufacturers between sunrise and sunset. The distance traveled cannot exceed 60 miles and travel on the interstate system is not allowed.

C. Legal Length

1. A single unit vehicle with two or more axles including the load thereon shall not exceed a length of 50 feet.

2. A combination of two, three, or four units including the load thereon shall not

exceed a length of 75 feet on non-designated highways. Three and four unit combinations are subject to safety rules adopted by the NDDOT Director.

3. A combination of two, three, or four units including the load thereon may exceed 75 feet in length but shall not exceed 95 feet or 110 feet in length when traveling on four-lane divided highways and those highways designated by the NDDOT Director and local authorities as to the highways under their respective jurisdictions. The NDDOT designated highway map identifies those designated state highways. All such combinations are subject to safety rules adopted by the NDDOT Director.

4. The length of a trailer or semitrailer including the load thereon may not exceed 53 feet; however, trailers and semitrailers titled and registered in North Dakota prior to July 1, 1987, and towed vehicles may not exceed a length of 60 feet.
5. Exceptions to length limitations.

    a. Building moving equipment.
    b. Emergency tow trucks towing disabled lawful combinations of vehicles to a nearby repair facility.
    c. Vehicles and equipment owned and operated by the armed forces of the United States or the national guard of this state.
    d. Structural material of telephone, power, and telegraph companies.
    e. Truck-mounted haystack moving equipment, provided such equipment does not exceed a length of 56 feet.
    f. A truck-tractor and semitrailer or truck-tractor, semitrailer and trailer when operated on interstate highway systems or parts of the federal aid primary system designated by the NDDOT Director.

6. Towing converter dollies.

    a. Converter dollies that are used to convert semitrailers to trailers are considered trailers if they meet all lighting requirements and are equipped with brakes and safety chains.

    b. No more than one converter dolly can be towed behind a truck-tractor, semitrailer, and trailer; and no more than two converter dollies can be towed behind a truck-tractor and semitrailer.

D. Mobile Homes

1. A mobile home permit is needed when the mobile home itself exceeds 8 feet 6 inches in width, 14 feet in height, or 75 feet in overall length including the towing vehicle.

E. Legal Weight Limitations

1. Gross vehicle weight on interstate system.

   a. The gross vehicle weight of any vehicle or combination of vehicles is determined by the following weight formula of:

$$W = 500 \left(\frac{LN}{N-1} + 12N + 36 \right)$$

   where W equals maximum weight in pounds carried on any group of two or more axles; L equals distance in feet between the extremes of any group of two or more consecutive axles; and N equals number of axles in the group under consideration except that two consecutive sets of tandem axles may carry a gross load of 34,000 pounds each, providing the overall distance between the first and last axles of the consecutive sets of tandem axles is at least 36 feet.

   b. The maximum gross vehicle weight on the interstate highway system is 80,000 pounds.

2. Gross vehicle weight **on highways other than the interstate system**.

   a. The gross vehicle weight of any vehicle or combination of vehicles is determined by the following weight formula of:

$$W = 500 \left(\frac{LN}{N-1} + 12N + 36 \right)$$

   where W equals the maximum gross weight in pounds on any vehicle or combination of vehicles; L equals distance in feet between the two extreme axles of any vehicle or combination of vehicles; and N equals the number of axles of any vehicle or combination of vehicles under consideration.

   b. The maximum gross vehicle weight on state highways is 105,500 pounds unless otherwise posted. On all other highways the maximum gross vehicle weight is 80,000 pounds unless designated for more, not to exceed 105,500 pounds.

3. Axle weight.

   a. No single axle shall carry a gross weight in excess of 20,000 pounds. Axles spaced 40 inches or less apart are considered one axle. Axles spaced 8 feet apart or over are considered as individual axles. (The gross weight of two individual axles may not exceed 40,000 pounds on highways other than the interstate system.) On the interstate system the gross weight of two individual axles **may** be restricted by the weight formula. Spacing between axles shall be measured from axle center to axle center.

b. Axles spaced over 40 inches apart and less than 8 feet apart shall not carry a gross weight in excess of 19,000 pounds per axle. The gross weight of a tandem axle may not exceed 34,000 pounds. The gross weight of three or more axles in a grouping may not exceed 48,000 pounds on highways other than the interstate system. On the interstate system the gross weight of three or more axles **is** restricted by the weight formula.

   1) Axles that can be raised or lowered by air, hydraulic, or other pressure cannot be raised if it will cause any other axle to exceed legal limits when being operated on a public highway.

c. During the spring breakup season or on otherwise posted highways, reductions in the above axle weights may be specified. Axle weights may also be reduced by the bridge load limitations map.

4. Wheel weight.

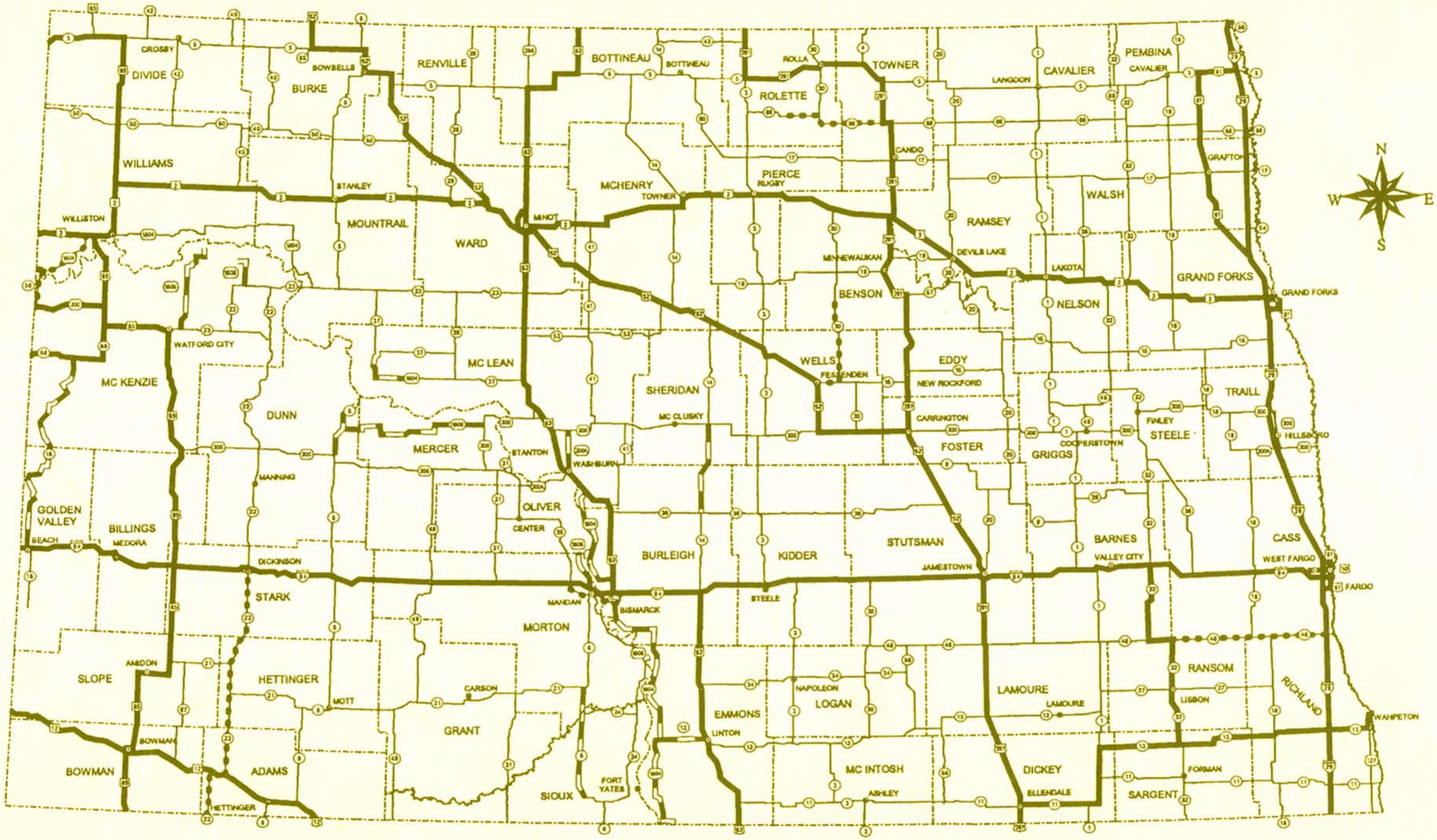
   a. The weight in pounds on any one wheel shall not exceed one-half the allowable axle weight. Dual tires are considered one wheel.

5. Tire weight.

   a. The weight per inch width of tire shall not exceed 550 pounds. The width of tire for solid tires shall be the rim width; for pneumatic tires, the manufacturer's width. Metric tire sizes are converted to inches by dividing millimeters by 25.4.

Permits for oversize and overweight vehicles and loads and other size and weight information can be obtained by calling 701-328-2621 or writing to: North Dakota Highway Patrol, Motor Carrier Division, 600 E Boulevard Avenue Dept. 504, Bismarck ND 58505-0240.

DESIGNATED NORTH DAKOTA STATE HIGHWAYS FOR VEHICLE COMBINATIONS EXCEEDING 75 FEET IN OVERALL LENGTH



Indicates highways posted where vehicle combinations may not exceed 75 ft. in overall length.

Indicates designated highways where vehicle combinations as provided for in Chapter 37-06-04, NDAC, may exceed 75 ft. but not exceed 95 ft. in overall length.

or ● ● ● ● Indudes designated highways where vehicle combinations as provided for in Chapter 37-06-04, NDAC, may exceed 75 ft. but not exceed 110 ft. in overal length.

Indicates the "national network" where the following vehicle combinations are exempt from overall length limitations as provided for in the Surface Transportation and Assistance Act of 1982: 1. A truck-tractor and semitrailer. 2. Truck-tractor, semitrailer and trailer, or semitrailer converted to a trailer by use of a converter dolly and fifth wheel.

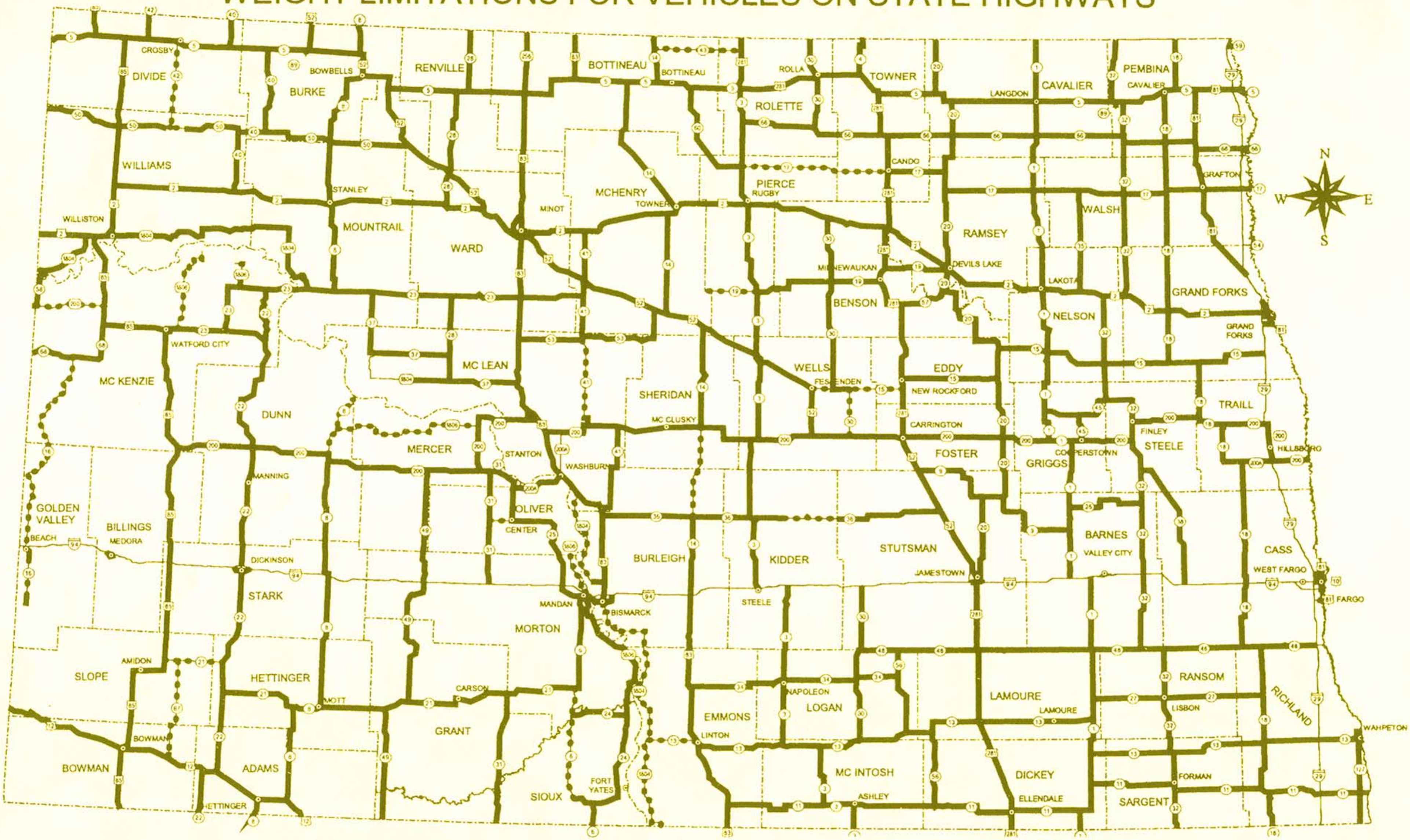
Vehicle combinations authorized to exceed 75 ft. in overall length may travel a distance of 10 miles on state highways off the designated routes

APPROVED:

Keith C. Magnuson   10 Oct 02

On behalf of NDDOT DIRECTOR   DATE

NORTH DAKOTA STATE HIGHWAY SYSTEM
WEIGHT LIMITATIONS FOR VEHICLES ON STATE HIGHWAYS



A- ROUTES WITH GROSS WEIGHT NOT TO EXCEED 105,500 LBS.

B- POSTED ROUTES WITH GROSS VEHICLE WEIGHT NOT TO EXCEED 80,000 LBS.

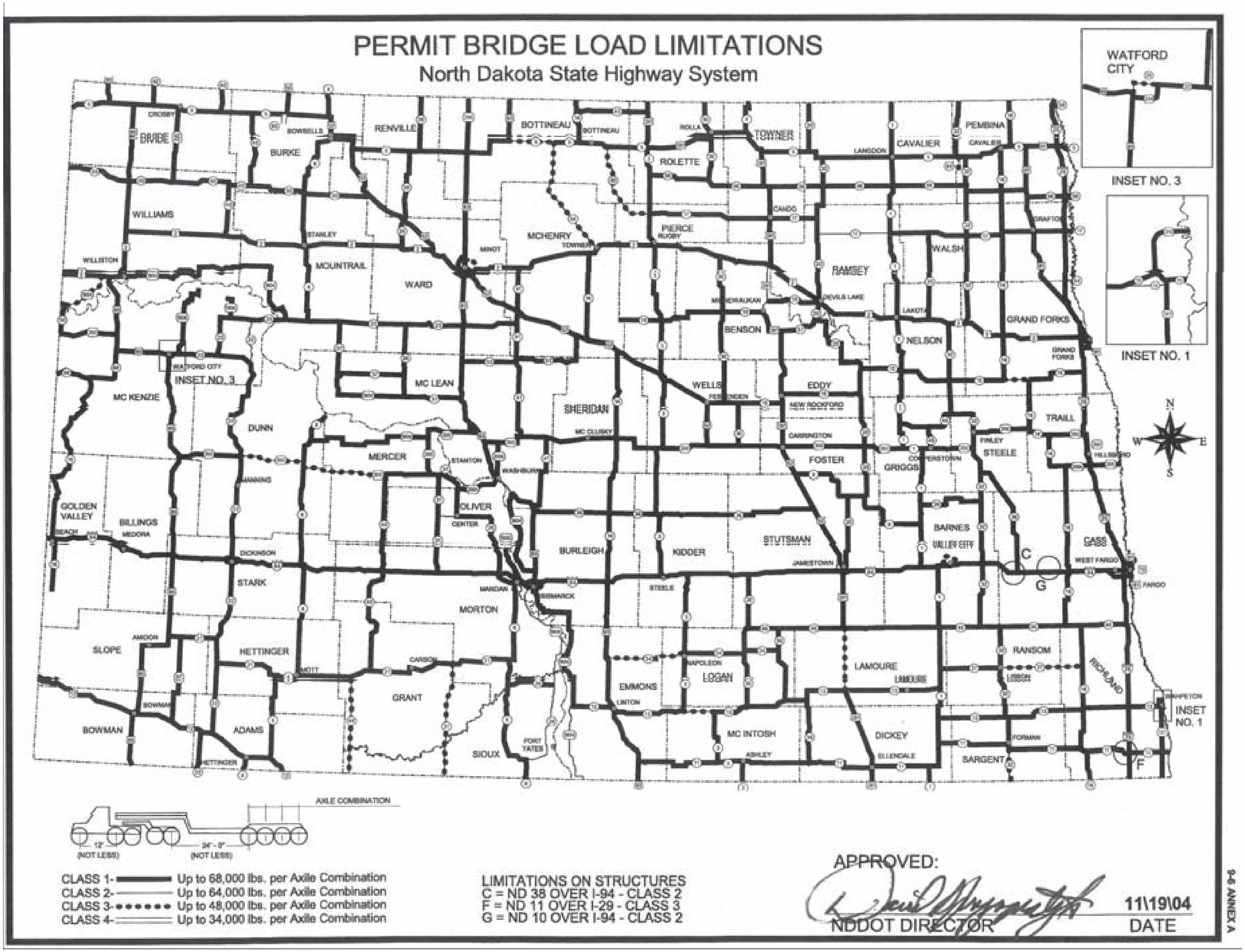
C- INTERSTATE ROUTES WITH GROSS VEHICLE WEIGHT NOT TO EXCEED 80,000 LBS.

The gross Vehicle Weight for all vehicles and vehicle combinations is determined by the WEIGHT LIMITATION CHART, N.D.H.P. FORM 921

APPROVED: [signature] 11/19/04

NDDOT DIRECTOR DATE

9-1 ANNEX D



PERMIT BRIDGE LOAD LIMITATIONS
North Dakota State Highway System
WATFORD CITY
INSET NO. 3
INSET NO. 1
DIVIDE
BURKE
RENVILLE
BOTTINEAU
ROLETTE
TOWNER
CAVALIER
PEMBINA
WILLIAMS
MOUNTRAIL
WARD
MCHENRY
PIERCE
RAMSEY
WALSH
BENSON
NELSON
GRAND FORKS
MC KENZIE
MC LEAN
SHERIDAN
WELLS
EDDY
TRAILL
DUNN
MERCER
FOSTER
GRIGGS
STEELE
GOLDEN VALLEY
BILLINGS
OLIVER
BURLEIGH
KIDDER
STUTSMAN
BARNES
CASS
STARK
MORTON
SLOPE
HETTINGER
GRANT
EMMONS
LOGAN
LAMOURE
RANSOM
RICHLAND
BOWMAN
ADAMS
SIOUX
MC INTOSH
DICKEY
SARGENT
INSET NO. 1
AXLE COMBINATION
12' (NOT LESS)
24' - 0" (NOT LESS)
CLASS 1- Up to 68,000 lbs. per Axile Combination
CLASS 2- Up to 64,000 lbs. per Axile Combination
CLASS 3- Up to 48,000 lbs. per Axile Combination
CLASS 4- Up to 34,000 lbs. per Axile Combination
LIMITATIONS ON STRUCTURES
C = ND 38 OVER I-94 - CLASS 2
F = ND 11 OVER I-29 - CLASS 3
G = ND 10 OVER I-94 - CLASS 2
APPROVED:
NDDOT DIRECTOR
11\19\04
DATE
9-6 ANNEX A

APPENDIX 2
PERMITS

A. Oversize and/or Overweight Vehicles or Load Movements

Travel Restrictions and Safety Requirements

All over-dimensional and overweight permits have specific conditions that apply to all types of loads. **All** over-dimensional vehicles and loads shall have minimum 12”x12” red or bright orange flags displayed on the traffic side, front and rear. When the overall length of an over-dimensional movement exceeds 75 feet, there shall be at least an 18”x84” OVERSIZE LOAD sign on the rear. All over-dimensional loads are restricted to traveling during daylight hours. There are also weekend and holiday travel restrictions when the overall width of a load or vehicle exceeds 16 feet.

Manufactured housing units may not move when wind velocity exceeds 25 miles per hour. Overall width shall not exceed 18 feet. Oversize Load (18” X 84”) signs are required on the front end of the towing vehicle and on the backside of the manufactured housing unit for all movements. Proof of insurance must be on file with the NDHP in order to obtain a permit.

Overweight vehicles or loads shall not move on flexible pavements when atmospheric temperature is 85 degrees F or above. The speed shall not exceed 40 miles per hour if GVW is more than 120,000 pounds or more than 5,000 pounds over legal axle weight limits. Overweight permits will be issued for hauling ONLY single piece loads.

Pilot car(s) are required for all movements exceeding 14 feet 6 inches in width, 18 feet in height, and 120 feet in overall length. In lieu of the pilot car, **overwidth** movements exceeding 14 feet 6 inches but not 16 feet may be equipped with lighted rotating or flashing amber light(s) that are visible from the front and rear at 500 feet. Load movements exceeding 18 feet in overall width are subject to an North Dakota Highway Patrol escort. Excessive overweight load movements are also subject to pilot cars and/or an official escort.

Axle Weight Limitations

1. Axle weight limitations for vehicles and vehicle combinations (with permit).

   a. Vehicles or vehicle combinations hauling non-divisible overweight loads cannot exceed the following maximum permittable axle weights. (Single and tandem axle weights may not exceed 600 pounds per inch width of tire; groupings with three axles or more may not exceed 550 pounds per inch width of tire.) Metric tire sizes are converted to inches by dividing millimeters by 25.4.

Table 31. Maximum Permittable Axle Weights (Vehicles or Vehicle Combinations Hauling Non-divisible Overweight Loads)

Tire Size	Single Axle 2 Tires	Single Axle 4 Tires	Tandem Axle 4 Tires	Tandem Axle 8 Tires	Triple Axle 12 Tires	Four Axles 16 Tires
8:25	9,900 lbs	19,800 lbs	19,800 lbs	39,600 lbs	54,450 lbs	*68,000 lbs
9:00	10,800 lbs	21,600 lbs	21,600 lbs	43,200 lbs	59,400 lbs	*68,000 lbs
10:00	12,000 lbs	*24,000 lbs	24,000 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
11:00	13,200 lbs	*24,000 lbs	26,400 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
12:00	14,400 lbs	*24,000 lbs	28,800 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
13:00	15,600 lbs	*24,000 lbs	31,200 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
14:00	16,800 lbs	*24,000 lbs	33,600 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
15:00	18,000 lbs	*24,000 lbs	36,000 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
16:50	19,800 lbs	*24,000 lbs	39,600 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs
18:00	21,600 lbs	*24,000 lbs	43,200 lbs	*45,000 lbs	*60,000 lbs	*68,000 lbs

* Maximums include all tolerances

2. Axle weight limitations for fixed load equipment mounted on truck-type chassis.

a. The following are the maximum permittable axle weights for fixed load equipment mounted on trucktype chassis such as truck cranes and workover rigs. (Single and tandem axle weights may not exceed 650 pounds per inch width of tire; groupings with three or more axles may not exceed 550 pounds per inch width of tire.) Metric tire sizes are converted to inches by dividing millimeters by 25.4.

Table 32. Maximum Permittable Axle Weights (Fixed Load Equipment)

Tire Size	Single Axle 2 Tires	Single Axle 4 Tires	Tandem Axle 4 Tires	Tandem Axle 8 Tires	Triple Axle 6 Tires	Triple Axle 12 Tires	Four Axle 16 Tires
8:25	10,725 lbs	21,450 lbs	21,450 lbs	42,900 lbs	27,225 lbs	54,450 lbs	*68,000 lbs
9:00	11,700 lbs	23,400 lbs	23,400 lbs	46,800 lbs	29,700 lbs	59,400 lbs	*68,000 lbs
10:00	13,000 lbs	26,000 lbs	26,000 lbs	*50,000 lbs	33,000 lbs	*60,000 lbs	*68,000 lbs
11:00	14,300 lbs	28,600 lbs	28,600 lbs	*50,000 lbs	36,300 lbs	*60,000 lbs	*68,000 lbs
12:00	15,600 lbs	*30,000 lbs	31,200 lbs	*50,000 lbs	39,600 lbs	*60,000 lbs	*68,000 lbs
13:00	16,900 lbs	30,000 lbs	33,800 lbs	*50,000 lbs	42,900 lbs	*60,000 lbs	*68,000 lbs
14:00	18,200 lbs	*30,000 lbs	36,400 lbs	*50,000 lbs	46,200 lbs	*60,000 lbs	*68,000 lbs
15:00	19,500 lbs	*30,000 lbs	39,000 lbs	*50,000 lbs	49,500 lbs	*60,000 lbs	*68,000 lbs
16:50	21,450 lbs	*30,000 lbs	42,900 lbs	*50,000 lbs	54,450 lbs	*60,000 lbs	*68,000 lbs
18:00	23,400 lbs	*30,000 lbs	*46,800 lbs	*50,000 lbs	59,400 lbs	*60,000 lbs	*68,000 lbs

* Maximums include all tolerances

b. The rear axles of a truck crane and the dollies **mounted** behind the truck crane are considered one combination. If a boom trailer or boom dolly is towed behind a truck crane, the towed trailer is considered a separate combination **if the axle spacing is 8 feet or more** behind the truck crane. The gross weight of axles or axle groupings on trailers or dollies pulled behind truck cranes or other fixed load vehicles cannot exceed axle weight limitations as authorized for vehicle combinations in section 1.a.

3. Routing is restricted by the Permit Bridge Load Limitations Map (page 40) and the Weight Limitations Map (page 31). The Weight Limitations Map shows those highways posted for 80,000 lbs. G.V.W.
   a. Road construction may also restrict requested routes of travel. Contact the permit section to obtain width restrictions, or visit the NDDOT Road Construction Report website at www.state.nd.us/dot/road.html.

4. Permits must be in possession prior to starting any oversize/overweight load movement. The permits may be obtained from the Highway Patrol permit section, weigh/inspection stations, or highway patrol troopers. To obtain a permit via fax, contact the permit section at 701-328-2621.

5. You will need to have the following information available to complete the application procedure:

   a. Company name and address.
   b. Description of power unit: year, make, capacity, serial number, license number and state, tire sizes, and number of axles.
   c. Description of towed unit: type of unit, make, tire sizes, and number of axles.
   d. Overall dimensions of vehicle and load.
   e. Axle weights and gross weight of vehicles and load if overweight is requested.
   f. Dates of travel, point of origin and destination, and desired route to be traveled.
   g. Axle spacings are required on a vehicle combination when the GVW exceeds 150,000 pounds, and on special mobile equipment with a GVW in excess of 114,800 pounds. A bridge analysis shall be completed.

Permit Fees

1. $20 for each single trip permit (SFN 3507, Official Receipt/Permit) except for loads in excess of 150,000 pounds GVW self-propelled special mobile equipment.

2. Graduated fee for each single trip permit (SFN 3507, Official Receipt/Permit) exceeding 150,000 pounds gross vehicle weight:
   Gross Vehicle Weight Permit Fee
   150,001-160,000 lbs. $30
   160,001-170,000 lbs. $40
   170,001-180,000 lbs. $50
   180,001-190,000 lbs. $60
   190,001 and over $70

3. $25 for each single trip permit for overweight self-propelled special mobile equipment.

4. $10 for each Identification Supplement, SFN 3317 (SFN 3318 for manufactured housing).

5. $20 for each Single Trip Movement form, SFN 3540 (SFN 14242 for manufactured housing).

6. $25 for each Special Mobile Equipment Single Trip Movement Approval form (SFN 16320) that must be used to validate the special mobile equipment identification supplements.

7. $25 engineering fee for those movements that require approval by DOT engineers.

8. $.05 per ton per mile is assessed upon the portion of G.V.W. exceeding 200,000 pounds.

9. Escort services provided by the NDHP are $30 per hour and $.30 per mile.

10. Official or publicly owned vehicles shall not be required to pay charges for permits. (No fee to commercial hauler doing charity hauling.)

B. Interstate Permit Policy

Single trip permits are required for legal size divisible load vehicles exceeding the federal gross vehicle weight cap of 80,000 pounds for movement on the interstate highway system. All weights are restricted by the North Dakota Weight Limitations Chart and the North Dakota Axle Weight Limitations Chart.

The interstate permit must be in possession prior to traveling on the interstate system in North Dakota. The fee for a receipt issued "Interstate Only" permit is $10. It can be purchased online at www.discovernd.com/ndhp/ or obtained from the Highway Patrol permit section, weigh/inspection stations, district offices, or highway patrol officers. The fee for a self-issue "Interstate Only" permit is $5. It can also be purchased online at www.discovernd.com/ndhp/ or obtained from the Highway Patrol permit section.

C. Seasonal Permit Policy

Seasonal permits will be issued in lieu of single trip permits for commercial movement of overwidth haystacks, hay bales, forage harvesters, grain cleaners, hay grinders, fertilizer spreaders and chemical applicators transported by another vehicle, and for commercial movement of overwidth and overweight selfpropelled fertilizer spreaders and self-propelled agricultural chemical applicators. The seasonal permits are regulated under authority of section 39-12-04 and 39-12-05.3 of the North Dakota Century Code. The permits can be purchased online at www.discovernd.com/ndhp/ or obtained from the Highway Patrol permit section, weigh/inspection stations, or highway patrol troopers. The following information is needed to complete the application procedure:

1. Applicant's name, address, and telephone number.

2. Indicate whether application is new or renewal. If it is a renewal and there are no changes from the previous year, the application does not have to be filled out (write the previous year's number on the receipt).

3. Check the type of power unit.

4. Description of power unit: unit number, year, make, license number and state (when applicable), and serial number (VIN).

5. Check the type of towed unit.

6. Description of towed unit: make and serial number (VIN).

7. Type of load.

8. Overall dimensions of vehicle or vehicle combination.

9. Number of axles.

10. The axle spacings' dimensions, tire sizes, and number of tires per axle.

11. The permit fee is $50 per year.

12. An insurance certificate showing a minimum $300,000 liability and property damage insurance **must be submitted** with the application.

D. Electronic Permits

The following permits may be purchased online at www.discovernd.com/ndhp/:

- Trip
- Fuel
- Interstate
- LCV
- Seasonal
- 10% Weight Exemption
- Combine
- Self-issue Interstate

APPENDIX 3
NORTH DAKOTA SEASONAL PERMIT POLICIES

Purpose of North Dakota Seasonal Permit Policy
To establish guidelines when seasonal permits will be issued for commercial haystack and hay bale movers, overwidth and/or overweight self-propelled fertilizer spreaders, overwidth and/or overweight self-propelled agricultural chemical applicators, overwidth hay grinders, overwidth grain cleaners, and overwidth forage harvesters that are exempt from width limitations so they can be moved upon the highways of the state of North Dakota.

Policy statement
As authorized by sections 39-12-04 and 39-12-05.3 NDCC, the NDHP will issue seasonal permits in lieu of single trip permits for overwidth movements of hay in the stack, hay bales, hay grinders, grain cleaners, forage harvesters, fertilizer spreaders and agricultural chemical applicators being transported by another vehicle, and for overwidth and overweight movements of self-propelled fertilizer spreaders and self-propelled agricultural chemical applicators operating under their own power.

Procedure
A. Travel Restrictions
1. Seasonal permits shall not authorize movements between sunset and sunrise, except self-propelled fertilizer spreaders and self-propelled agricultural chemical applicators operating under their own power.

2. Movement is not authorized when inclement weather prevails, highways are slippery, or when visibility is poor.

3. Haystacks and hay bales must be moved along the extreme right edge of roadway.

4. Seasonal permits do not authorize movement of haystacks and hay bales on I-29 and I-94 when using haystack moving equipment. If no alternate routes are available, a $20 single trip permit may be issued provided a pilot car follows the movement.

B. Size Limitations
1. The seasonal permits issued for stackmovers will show "**EXEMPT**" on the width. All other types of vehicles used for hauling hay bales will be restricted to 12 feet in overall width, except trailers designed specifically for hauling hay bales shall not exceed 12 feet 10 inches wide including the loading arm (trailer extensions must be retracted when unladen).

2. The seasonal permits issued for haystack moving equipment will show 17 feet 6 inches in height. All other types of vehicles or vehicle combinations hauling hay will be restricted to 15 feet in overall height.

3. Legal length for **truck-mounted** haystack moving equipment is 56 feet.

4. Vehicle combinations exceeding 75 feet in overall length must travel on highways that are designated state and US highways, to include the interstate system.

C. Axle weight limitations on self-propelled fertilizer spreaders and self-propelled chemical applicators operating under their own power.

1. The maximum permittable weight on a single axle shall not exceed 22,000 pounds gross weight, whether empty or loaded.
    a. The weight per inch width of tire shall not exceed 550 pounds.
    b. No travel allowed on the interstate system.

D. Flagging requirements for self-propelled fertilizer spreaders and self-propelled agricultural chemical applicators whether being operated under their own power or being transported by another vehicle, hay grinders, grain cleaners, forage harvesters, and vehicles or combinations of vehicles hauling hay bales if they do not exceed 14 feet 6 inches in overall width.

1. Red or bright orange flags shall be mounted on the most practical outside dimension on the traffic side of the overwidth vehicle or load, front and rear. If one flag is visible from both the front and rear, only one flag would be required. All flags shall be made of red or bright orange cloth or other suitable material and shall be at least 12 inches by 12 inches in size, **or**

2. The overwidth movement may be followed by a pilot car equipped with a lighted rotating or flashing amber light(s) that is visible from the rear for a minimum 500 feet, **or**

3. The overwidth vehicle itself, or vehicle towing or hauling an overwidth load, may be equipped with a lighted rotating or flashing amber light(s) that is visible from the rear for a minimum 500 feet.

E. Flagging requirements for haystack moving equipment or any other vehicle or load exempt from width limitations that ***exceeds*** *14 feet 6 inches in overall width.*

1. Red or bright orange flag that is at least 12 inches by 12 inches in size shall be mounted on a pole showing the extreme outside width and height on the traffic side of the load. If one flag is not clearly visible from the front and rear, then flags must be mounted on both the front and rear of the vehicle; or

2. The overwidth movement shall be preceded and followed by pilot cars equipped with a lighted rotating or flashing amber light(s) mounted on top of the highest part of the vehicle that is visible for a minimum 500 feet; or

3. The vehicle, or vehicle towing or hauling the load, shall be equipped with a lighted rotating or flashing amber light(s) that is visible from the front and rear for a minimum 500 feet.

F. Sign Requirements

1. When the overall length of a vehicle combination exceeds 75 feet in length, there must be a minimum 18” X 84” **OVERSIZE LOAD** sign on the rear. The lettering must be black on yellow background. Letters must be at least 10 inches high with 1 5/8 inch brush stroke (trailer and load length cannot exceed 53 feet).

G. Vehicle hazard warning signal lamp requirements for self-propelled fertilizer spreaders and self-propelled agricultural chemical applicators traveling between sunset and sunrise.

1. Vehicular hazard warning signal lamps used to display warning to the front must be mounted at the same level and as widely spaced laterally as practicable, and must display simultaneously flashing white or amber lights, or any shade of color between white and amber. The lamps used to display warning to the rear must be mounted at the same level and as widely spaced laterally as practicable and must show simultaneously flashing amber or red lights, or any shade of color between amber and red. These warning lights must be visible from a distance of not less than 500 feet in normal sunlight.

H. Commercial haystack movers who have a seasonal permit in possession may also haul hay bales.

I. A North Dakota farmer or rancher moving his/her own hay (bales or haystacks) is not required to have a seasonal permit or single trip permit, regardless of what type of equipment is used. A farm truck with mounted haystack moving equipment is considered an implement of husbandry and exempt from registration.

J. Towing vehicle must have two mirrors to reflect a rear view of 200 feet to the driver.

K. All commercial oversize vehicles must be equipped in accordance with the requirements and specifications of Parts 393 and 396 of 49CFR.

L. A seasonal permit shall be in lieu of registration requirements during the period covered by such permit. This exemption does not include trucks pulling trailers or truck-tractor semitrailer combinations. It does not exempt a nonresident commercial mover from trip permits. A seasonal permit does not exempt trucks pulling trailers or truck-tractor semitrailer combinations from the interstate permit when exceeding 80,000 lbs. gross vehicle weight and traveling on I-29 or I-94.

M. Application Procedure

1. Seasonal permits can be purchased online at www.discovernd.com/ndhp/ or obtained from the Highway Patrol permit section. Applications can be made in person, by mail, to any highway patrol officer, or at any weigh/inspection station.

a. SFN 3527, Application for North Dakota Seasonal Permit, must be completed as follows:

1) Applicant's name, address, and telephone number.

2) Indicate whether application is new or renewal. If it is a renewal and there are no changes from the previous year, the application does not have to be filled out. Write the previous year's number on the receipt.

3) Check the type of power unit.

4) Description of power unit: unit number, year, make, license number and state, and serial number (VIN).

5) Check the type of towed unit.

6) Description of towed unit: make and serial number (VIN).

7) Type of load.

8) Overall dimensions of vehicle or vehicle combination.

9) Circle the number of axles.

10) Indicate the axle spacings, tire sizes, and number of tires per axle.

b. Seasonal permits for hauling hay can be issued to truck-mounted stack movers, towed stack movers, towed bale handlers, trucks, or other legal vehicle combinations.

c. An insurance certificate **must** be submitted showing proof of liability and property damage coverage of not less than $300,000.

d. Seasonal permits expire December 31 but are considered valid through January 31 of the following year.

e. If an application for a seasonal permit is made to a highway patrol officer or at a weigh/inspection station, upon payment of the $50 fee, Official Receipt/Permit (SFN 3507) can be used as a temporary seasonal permit for 30 days.

2. The permit fee for each seasonal permit issued is $50.

3. Applications for seasonal permits can be obtained from the North Dakota Highway Patrol, Motor Carrier Division, 600 E Boulevard Avenue Dept. 504, Bismarck ND 58505-0240. The telephone number is 701/328-2621.

APPENDIX 4.
BRIDGE CONDITION CODES FOR STRUCTURALLY DEFICIENT AND FUNCTIONALLY OBSOLETE BRIDGES

Table 33. Bridge Condition Codes.

Code	Description
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION - no problems noted.
7	GOOD CONDITION - some minor problems.
6	SATISFACTORY CONDITION - structural elements show some minor deterioration.
5	FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	POOR CONDITION - advanced section loss, deterioration,
3	SERIOUS CONDITION - loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	FAILED CONDITION – out of service - beyond corrective action.
N	NOT APPLICABLE

(Source: 2005 bridge data, ND DOT).

APPENDIX 5.
GENERAL GUIDELINES FOR STRUCTURE DESIGN (NDDOT)

IV-01.01 Guidelines

This chapter contains guidelines for the design of structures on the North Dakota State Highway System. The bases for these guidelines are found in the current editions of the following publications:

1. STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES - - AASHTO
2. STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, VOL 1, NDDOT
3. APPLICABLE SECTIONS OF THE FEDERAL AID POLICY GUIDE, 23CFR650
4. NORTH DAKOTA PRESTRESS GIRDER DESIGN AND CHECKING GUIDE, 1990

Prior to the beginning of a design, Bridge Division records will be researched, namely, the correspondence file, the bridge inspection file, the central file, the bridge unique features file (BUFF), the historical bridge candidate list, the hydraulic report (if applicable),and the plans of the existing structure. The Environmental Impact Statement (EIS) or the project concept report (PCR) must also be reviewed. Other items that should be considered are the need for agreements or permits. Once all of these have been studied, the design Section Leader should schedule a pre-design meeting with the Bridge Engineer.

All bridges are identified by their bridge number. The bridge numbers for bridges on the State Highway System are determined by the highway the bridge is on, and the location of the bridge on that highway as indicated by the Reference Point of the center of the bridge. For example: Bridge Number 2-146.366 means that the bridge is located on US Highway 2 at reference point 146.366. The Planning and Programming Division is responsible for the establishment and maintenance of the reference point system. All reference point designations are extended to three decimal places. The bridge number is permanent and does not change due to replacement, regrading, or other factors which might cause minor changes in the bridge location reference point. All structural plans should contain the bridge number, as well as all design records and any other records pertaining to each individual structure.

The primary design method for structures should be Load Factor Design (LFD). Details on the LFD design method can be found in reference 1. above. Working Stress Design (WSD) should be used for designing piling and may be used for designing certain secondary members of structures, or when the design engineer determines that LFD is inappropriate. An HS25 truck should be used for the live load when designing new structures and when practical in rehabilitating existing structures, otherwise an HS20 truck should be used.

The National Bridge Inspection Program requires that every bridge in the state be rated for Inventory and Operating loadings. The ratings should be according to the AASHTO "Manual for Maintenance Inspection of Bridges" using an HS truck and WSD method except for NHS routes, new structures, and rehabilitated bridges, which should be rated with the LFD method. The Preliminary Engineering and Structural Management Section (Bridge) will rate the bridges.

Bridge Concerns

The 2005 North Dakota Department of Transportation bridge data identifies bridges, their locations, and conditional factors. Bridges are classified into three conditions: non-deficient, structurally deficient, and functionally obsolete. A non-deficient bridge is one that meets standards[18]. A structurally deficient bridge is one that fails to meet bridge deck, pavement, or supporting structure standards. A functionally obsolete bridge is one that has inadequate width or vertical clearance.

Table 34 identified how many bridges are non-deficient, structurally deficient, and functionally obsolete. The table shows bridges with a span of 20 feet and greater. This is consistent with the National Bridge Inventory data. As the table shows, ND state structures have 28 structurally deficient bridges and 38 functionally obsolete bridges, respectively (also see Figure 13). ND state structures include all bridges on Interstate System, U.S. and State highways and 1,702 ND state structures are in service.

Table 34. North Dakota Bridges* in Service (2005).

	ND State Structure (Bridges on Interstate System, U.S. and State Highways)
Non-Deficient	1,636
Structurally Deficient	28
Functionally Obsolete	38
Total	1,702

(Source: 2005 bridge data, ND DOT)
* Bridges with a span of 20 feet and greater.

[18] The design of bridge structures on the ND State Highway System is based on 1) Standard Specifications for Highway Bridges (AASHTO), 2) Standard Specifications for Road and Bridge Construction (NDDOT), 3) Applicable Sections of the Federal Aid Policy Guide (23 CFR650), and 4) North Dakota Prestress Girder Design and Checking Guide (see APPENDIX 5. General Guidelines for Structure Design)

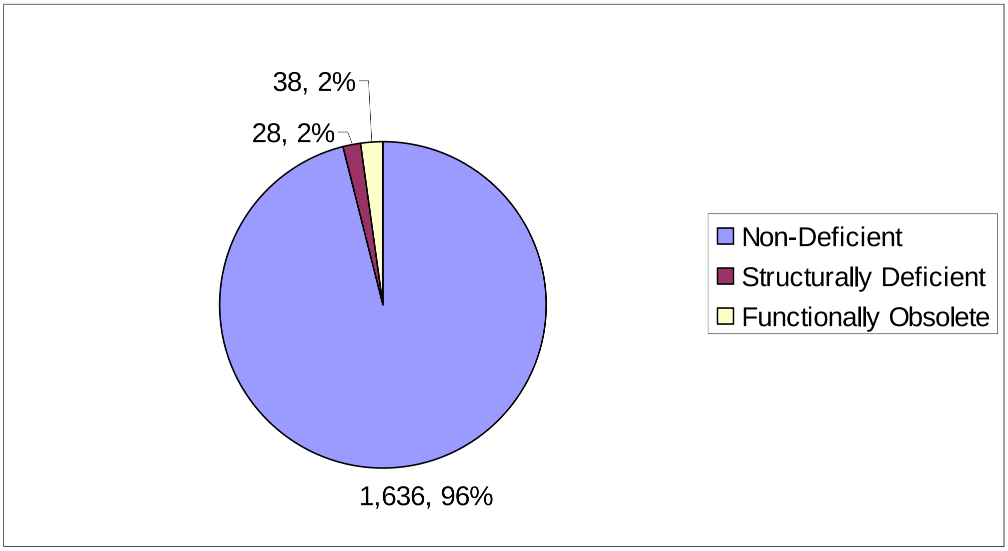


Figure 13. Bridges on Interstate System, U.S. and State Highways in North Dakota (2005) (Source: 2005 bridge data, NDDOT).

Structurally deficient and functionally obsolete bridges are categorized by highway class. Table 35 shows structurally deficient and functionally obsolete ND state structures by Interstate System, U.S. and State highways. The data shows that there are fourteen structurally deficient bridges on Interstate System. Two bridges are structurally deficient on U.S. highways and twelve bridges are structurally deficient on State highways. For functionally obsolete bridges, twenty-eight bridges are on Interstate System. Seven bridges are on U.S. highways and three bridges are on State highways, respectively.

Table 35. Structurally Deficient and Functionally Obsolete ND State Structures by Highway Class (2005).

ND State Structure (Bridges on Interstate System, U.S. and State Highways)	Structurally Deficient	Functionally Obsolete
Interstate System	14	28
U.S. Highway	2	7
State Highway	12	3
Total	28	38

(Source: 2005 bridge data, ND DOT).

Table 36 shows structurally deficient and functionally obsolete ND state structures by state highway performance classification system. As shown in the previous table, there are 14 structurally deficient and 28 functionally obsolete bridges on Interstate System. The table also shows four structurally deficient and seven functionally obsolete bridges on Interregional System. These bridges could directly affect freight movement because Interstate and Interregional Systems generally have high truck volume and density.

Table 36. Structurally Deficient and Functionally Obsolete ND State Structures by State Highway Performance Classification System (2005).

ND State Structure (Bridges on Interstate System, U.S. and State Highways)	Structurally Deficient	Functionally Obsolete
Interstate System	14	28
Interregional System	4	7
State Corridor	3	2
District Corridor	3	1
District Collector	4	0
Total	28	38

(Source: 2005 bridge data, ND DOT).

Table 37 shows these bridge condition factors for functionally obsolete ND state structures on Interstate and Interregional Systems. A bridge structure is considered functionally obsolete; 1) when the rating is three[19] or less for deck geometry, underclearances, or approach roadway alignment or 2) when the rating is three or less for structural condition or waterway adequacy. The deck geometry column in the Table 4 shows an overall rating value for deck geometry, taking into account; 1) the curb-to-curb or face-to-face of the rail bridge width or 2) the minimum vertical clearance over the bridge roadway. Also, the approach roadway alignment column shows a rating based on the adequacy of the approach roadway, as determined using a 50 to 55 mph speed limit. The structure condition is based on the overall condition of the structure, accounting for deficiencies noted in the superstructure, substructure, and inventory rating, which in turn is interpreted against the Average Daily Traffic (ADT). Finally, the waterway adequacy column represents an appraisal of the waterway opening with respect to the passage of water through the bridge structure.

The numbers with an asterisk are used to identify a rating of three or less. The table also provides the highway number and location of the bridge. As the table shows, 26 functionally obsolete bridges have a rating of 3 in the vertical and horizontal underclearances column. Seven bridges have low ratings (2-3) in the deck geometry and two bridges have the rating of 3 in approach roadway alignment.

[19] The rating of 3 represents serious condition (see Appendix 4. Bridge Condition Codes)

Table 37. Functionally Obsolete Bridges on Interstate and Interregional Systems in North Dakota (2005).

Class	Highway #	Location	Deck Geometry	Vertical and Horizontal Underclearances	Approach Roadway Alignment	Structure Condition	Waterway Adequacy
Interstate	29	1 SOUTH OF I 94	2*	N	6	6	N
Interstate	29	3 NORTH OF NO 17	3*	N	8	7	8
Interstate	29	4 NORTH OF ND 66	5	3*	7	6	N
Interstate	29	6 NORTH OF ND 66	6	3*	7	6	N
Interstate	29	7 SOUTH OF ND 5	5	3*	8	7	N
Interstate	29	3 SOUTH OF ND 5	6	3*	7	7	N
Interstate	29	3 NORTH OF ND 5	6	3	7	7	N
Interstate	29	5 NORTH OF ND 5	5	3*	7	4	N
Interstate	29	3 SOUTH OF ND 59	7	3*	7	7	N
Interstate	29	JCT ND 59	8	3*	7	7	N
Interstate	94	17 EAST OF JCT. ND 16	5	3*	7	5	N
Interstate	94	17 EAST OF JCT. ND 16	5	3*	7	5	N
Interstate	94	18 WEST OF JCT. US 85	4	3*	7	5	8
Interstate	94	18 WEST OF JCT. US 85	4	3*	7	5	8
Interstate	94	5 EAST OF ND 25	5	3*	8	7	N
Interstate	94	5 EAST OF ND 25	5	3*	8	5	N
Interstate	94	8 EAST OF ND 3 SOUTH	6	3*	6	7	N
Interstate	94	7 WEST OF ND 30	5	3*	6	7	N
Interstate	94	1 WEST OF US 281	3*	4	7	5	N
Interstate	94	JCT US 281 & I-94	9	3*	7	7	N
Interstate	94	11 WEST OF ND 1 NORTH	5	3*	6	5	N
Interstate	94	9 WEST OF ND 1 NORTH	5	3*	6	7	N
Interstate	94	JCT I 94 & ND 1 NORTH	7	3*	7	7	N
Interstate	94	JCT I 94 & ND 1 NORTH	7	3*	7	8	N
Interstate	94	8 WEST OF ND 18	6	3*	5	5	N
Interstate	94	3 WEST OF I-29	4	3*	8	7	N
Interstate	94	BETWEEN BISMARCK & MANDAN	3*	N	8	5	8
Interstate	94	WEST MAIN & WASHINGTON ST	5	3*	8	9	N
Interregional	2	4 EAST OF US 85 SOUTH	4	N	3*	7	8
Interregional	2	4 EAST OF US 85 SOUTH	4	N	3*	7	9
Interregional	2	EAST OF US 81	5	3*	7	7	8
Interregional	2	GRAND FORKS	3*	N	7	7	6
Interregional	10	IN WEST FARGO	3*	N	7	8	8
Interregional	10	MAIN AVE & 10TH ST-FARGO	5	3*	8	5	N
Interregional	10	MAIN AVE. IN FARGO	2*	N	8	6	8

* A rating of three or less.
(Source: 2005 bridge data, ND DOT).

A structure is considered structurally deficient; 1) if the rating is four[20] or less for deck, superstructure, substructure, or culvert and retaining walls, or 2) if the rating is two or less for structural condition, or waterway adequacy. Similar to the Table 37, Table 38 shows conditional factors for structurally deficient state structures on the Interstate and Interregional Systems. The deck column shows the condition rating for the structure's deck and the superstructure column shows the condition rating for the bridge's structural members. The substructure column represents the condition rating for the bridge's piers, abutments, piles, fenders, footings, and other components. The culvert and retaining walls column is based on an evaluation of alignment, settlement, joints, structural condition, scour, and other items associated with culverts.

The numbers with an asterisk are used to identify the rating of four or less for deck, superstructure, substructure, and culvert and retaining walls. Among these condition factors, nine bridges have low ratings (three or four) in the deck column. Eight bridges have low ratings in the substructure column. Only two structures have the rating of four in the superstructure column and one structure has the rating of four in the culvert and retaining walls column. No bridge has the rating of two or less for structural condition or waterway adequacy.

[20] The rating of 4 represents poor condition (see Appendix 4. Bridge Condition Codes)

Table 38. Structurally Deficient Bridges on Interstate and Interregional Systems in North Dakota (2005).

Class	High way #	Location	Deck	Superstructure	Sub-structure	Culvert and Retaining Walls	Structural Condition	Waterway Adequacy
Interstate	29	6 NORTH OF ND 46	***4****	7	5	N	5	6
Interstate	29	6 NORTH OF ND 46	5	7	***4****	N	4	6
Interstate	29	6 NORTH OF ND 46	***4****	7	6	N	6	N
Interstate	29	7 SOUTH OF I-94	***4****	7	7	N	7	N
Interstate	29	2 NORTH OF US 10	***4****	6	7	N	6	N
Interstate	29	8 SOUTH OF ND 200	***4****	7	6	N	6	N
Interstate	29	5 SOUTH OF ND 5	7	7	***3****	N	3	N
Interstate	29	JCT US 81 AND ND 5	8	8	***4****	N	4	N
Interstate	94	8 EAST OF JCT. 22	8	7	***3****	N	3	N
Interstate	94	12 WEST OF ND 8	7	7	***4****	N	4	N
Interstate	94	9 WEST OF JCT. ND 8	7	7	***4****	N	4	N
Interstate	94	6 EAST OF ND 38	***4****	5	6	N	5	N
Interstate	94	JUNCTION OF ND 18	7	7	***4****	N	4	N
Interstate	94	1 EAST I-29	5	***4****	5	N	4	N
Interregional	2	2 WEST OF HWY 83	***3****	6	6	N	5	N
Interregional	13	2 WEST OF ND HIGHWAY 18	N	N	N	***4****	4	7
Interregional	13	CITY OF WAHPETON	***4****	***4****	***4****	N	4	6
Interregional	281	3 NORTH OF ND 13	***4****	6	5	N	5	6

* A rating of four or less for deck, superstructure, substructure, and culvert and retaining walls. (Source: 2005 bridge data, ND DOT)

Figure 14 shows functionally obsolete and structurally deficient bridges identified in the Tables 37 and 38. Most of the impaired bridges are located on or near interstates. This implies that these bridges could directly or indirectly limit the efficiency of truck movement.

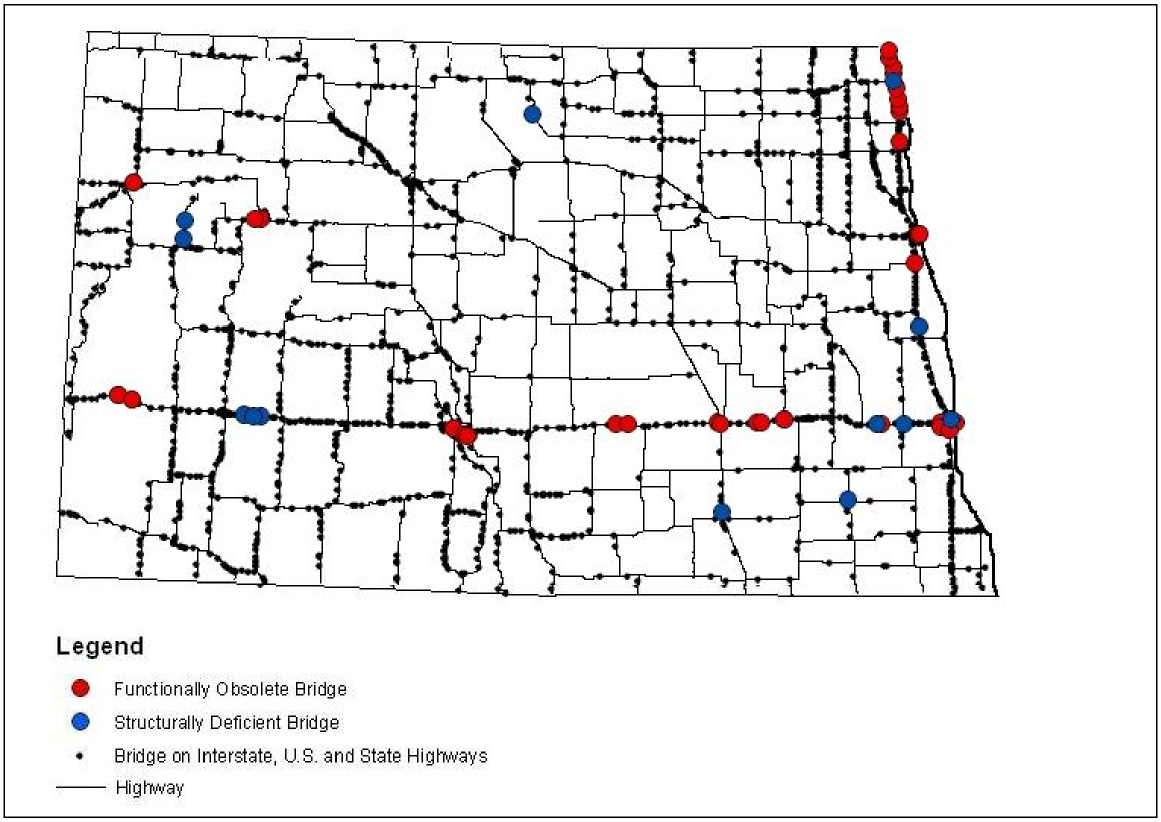


Figure 14. Structurally Deficient and Functionally Obsolete Bridges on Interstate System, U.S. and State Highways in North Dakota (2005) (Source: ND DOT) (Source: 2005 bridge data & ArcGIS data, ND DOT).

APPENDIX 6
CASE STUDIES OF ANNUAL DAMAGE

The following cases use research methods from MnRoad (Minnesota Road Research Facility) and apply them generally to two North Dakota highway segments. The two highway segments chosen included one on Highway 200 where Falling Weight Deflectometer data was available and the segments of Highway 26 where the restrictions are placed for the purpose of trying to lower axle weights during the spring thaw period. These road segments were chosen because of similarities in the pavement sections that MnRoad used in their research.

North Dakota Highway 200

The following example is for North Dakota Highway 200 milepost 320 to 325 allowing the Truck Annual Daily Traffic to travel at legal weights except for when the seasonal Class A Restriction is imposed[21]. Spring damage including rutting and fatigue would be estimated at four times the normal or typical damage or 3.16 ESALs for the min thaw[22] damage while the max thaw[23] damage accounts for 15.8 ESALS or 5 times the min thaw accounting for 74,892 annual ESALs (Table 39).

Table 39. Class A Distribution of Annual Damage Units.

Time Period	**Number of Days (Annual)**	**Class A Restriction** **ESALs (Damage Units)**	**No. 1 Restriction** **ESALs (Damage Units)**	**No. 2 Restriction** **ESALs (Damage Units)**
Normal	304	48,032	48,032	48,032
Max Thaw Period	30	74,892	45,504	18,960
Min Thaw Period	31	15,478	9,404	3,916
Total	*365*	*138,402*	*102,940*	*70,910*

Note: The 2 month period Spring thaw period accounts for 65% of the annual damage. All ESALs are two-way. Damage units are defined as equivalent single axle loadings.

For the No. 1 Load restriction, seasonal damage including rutting and fatigue would be estimated at four times the normal or typical damage or 1.92 ESALs for the min thaw damage while the max thaw damage accounts for 10 ESALs or 5 times the min thaw accounting for 45,504 annual ESALs (Table 39).

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[21] Assumes a majority of the trucks are 5 axle semi's or smaller which is the most predominant configuration visually observed operating at the 80,000 GVW which is the GVW of a Class A Restriction – therefore the highway segment is running as desired for most truck classes utilizing it. The ESAL factor used for the mix of traffic was .79 as indicated in the North Dakota Pavement Management System (NDPMS) data file.)

[22] Min thaw is the second half of thawing period where a uniformly wider area of breakup in pavement occurs.

[23] Max thaw is the first half of the thawing period where the maximum damage to the pavement occurs (violent pavement conditions occur such as potholes and rutting).

Under the No. 2 restriction, spring damage including rutting and fatigue would be estimated at four times the normal or typical damage or .8 ESALs for the min thaw damage while the max thaw damage accounts for 4 ESALs or 5 times the min thaw accounting for 18,960 annual ESALs.

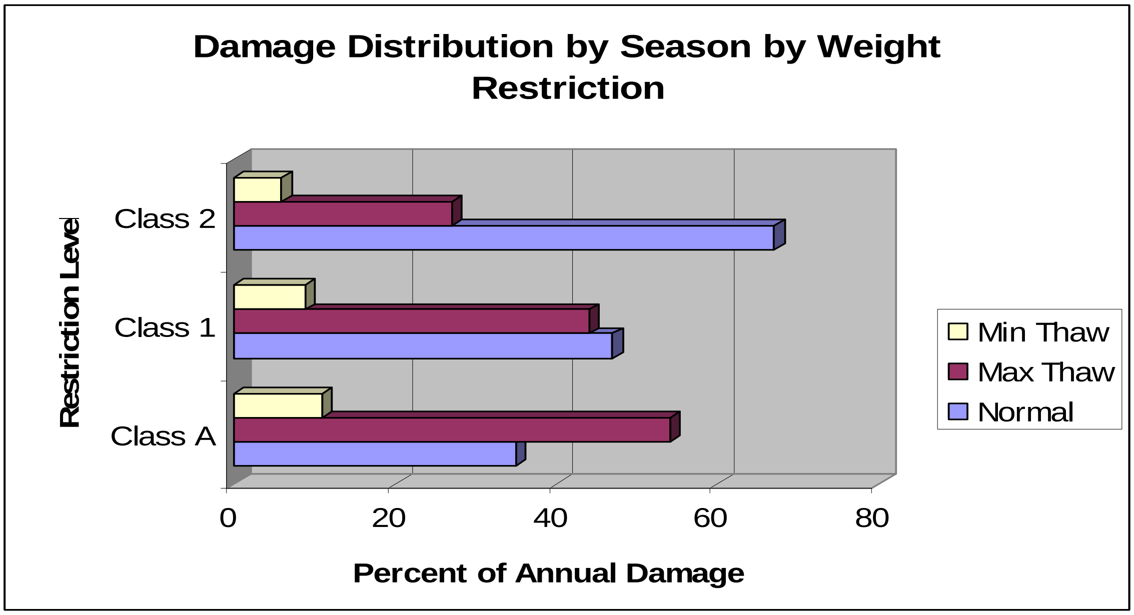

Figure 15 - Seasonal Damage by Load Restriction Level

Figure 15 is specific to the ND 200 segment but some general indications can be concluded by the results. The key finding is that the use of load restrictions can impact a shift in damage by the season in which the damage occurs. The “Max Thaw” time period is approximately a four week time period beginning with the initial thaw. Research from MnRoad found that up to 28 times normal ESAL damage occurs during the “Max Thaw” time period and seven times more damage than the “Min Thaw” time period. Under the Class A load restriction scenario, a little over 50% of the annual accumulated damage occurs during the “Max Thaw” period.

Damage accumulated during the “Min Thaw” time period is substantially less than the “Max Thaw” time period (Figure 11). The other finding is the difference between the accumulated damage and the various restriction levels, most notably the difference is significantly less than the “Max Thaw” time frame. It is also important to note that the total accumulated damage for all seasons is the least for the Class 2 restriction. Figure 15 shows the percent of annual damage not the total damage accumulated. The total annual Class A damage is approximately 138,000 ESALs per year compared to approximately 71,000 ESALs per year for the Class 2 restriction. With the use of annual growth factors for the ESALs, the Class 2 restricted roadway would last substantially longer than one less restricted all other conditions being held equal (thickness, truck volumes, etc.).

Highway 26
The following example is for North Dakota Highway 26 milepost 0 to 21.43 allowing the Truck Annual Daily Traffic to travel at legal weights except for when the seasonal No. 2 restriction is imposed (Table 40).

Table 40. Condition of Highway 26.

Highway 26	Milepost 0 to 7.62	Milepost 7.62 to 14.26	Milepost 14.26 to 21.43	Average
Daily ESALS	71	71	64	68.7
ESAL Fact.	0.75	0.75	0.75	
Segment Length	7.62	6.98	7.17	
Last Work	1996	1996	1996	
Pvt. Depth	6	6	5.5	
Ride	3.97	3.97	3.79	
Distress	94			
Structural Number	2.96	2.96	2.86	
Total Average Daily Traffic	95	94	96	95
Aggregate Base	6	6	6	
Rutting=.05, Transverse cracks are the majority of distress recorded				

Spring damage including rutting and fatigue would be estimated at four times the normal or typical damage or .8 ESALs for the min thaw damage while the max thaw damage accounts for 4 ESALs or 5 times the min thaw accounting for 30,967 annual ESALs (Table 41).

Table 41. ND 26 Restriction Example. (No 2. Current Restriction Level).

Time Period	**Number of Days (Annual)**	**Class A (8-Ton) Restriction** ESALs (Damage Units)	**No. 1 (7-Ton) Restriction** ESALs (Damage Units)	**No. 2 (6-Ton) Restriction** ESALs (Damage Units)
Normal	304	20,976	20,976	20,976
Max Thaw Period	30	31,050	19,872	8280
Min Thaw Period	31	6,417	4,107	1,711
Total	*365*	*58,443*	*44,955*	*30,967*

Note: All ESALs are two way.

For the No. 1 restriction, seasonal damage including rutting and fatigue would be estimated at four times the normal or typical damage or 1.92 ESALs for the min thaw damage while the max thaw damage accounts for 10 ESALs or 5 times the min thaw accounting for 44,955 annual ESALs (Table 41).

For the Class A example spring damage including rutting and fatigue would be estimated at four times the normal or typical damage or 3 ESALs for the min thaw damage while the max thaw damage accounts for 15 ESALs or 5 times the min thaw accounting for 58,433 annual ESALs (Table 41).

The pavement structure during initial thawing is weakest when the base is starting to thaw and the subgrade is still frozen. This time period is also when the flexible pavement is most susceptible to fatigue and rutting damage because of the weak base and subgrade modulus. Rutting damage is primarily reflected by rutting of the base layer(s). Due to the still frozen condition of the subgrade and the weakened condition of the base, the susceptibility for rutting will in most cases result in fatigue damage to the pavement in the form of alligator cracking. The support modulus of the thawed layers during thaw is approximately one-half the recovered unthawed modulus. The physical damage to the pavement as a result of the thawing phenomenon is permanent and can only be repaired by a more costly structural repair of the pavement section

Annual Accumulated ESALs Impact on Design Life

The prior sections presented a general methodology that could be expanded to a system wide approach to identify annual accumulated ESAL damage due to spring thaw conditions under various load restriction levels. Once an understanding of annual damage is determined, it is then possible to measure the impact on the projected design life of a pavement section as well as estimating the economic impact of various restriction levels imposed on a highway corridor. The highway is typically designed for the estimated annual damage that would accumulate over the 20 year period.

Highways 200 and 26, both have similar pavement sections. North Dakota 200 is restricted at a Class A level while ND 26 is restricted at a Class 2 level. ND 200 generally is adjacent to a flat terrain of good quality farm land of a heavier clay-silt mix, and ND 26 generally is adjacent to a rolling terrain of a lighter soil quality. Both road segments are similar to the sections of MnRoad examples where the methodology for this research originated (Table 42).

Table 42. Highway 200 Pavement Section Example.

Highway 200 MP 320 to 325		(Annual)	(Class A damage)
Daily ESALs (2002 NDDOT)	158	57,670	138,402
ESAL Factor	0.79		
Last Work	1994	11 years old	
Pavement Depth (inches)	6		
International Roughness Index[24]	68.71		
Ride Index (0 to 5) (5 is Best)	3.83		
Distress	88	(alligator cracks, longitudinal cracks and transverse cracks)	
Rutting (inches)	.07		
Structural Number[25]	3.17		
Total Average Daily Traffic	195		
Base1	5	Aggregate Base	
Base 2	2	Stabilized Base	

Example of Varying Design Life for ND 200 Milepost 320 to 325

The following examples show varying design life for a highway segment and the annual worth or costs associated with the two different designs. The differences would be in design and time period. Working through the different examples shows that it costs less annually to design the roadway for a 20 year time frame.

Designed for 20 years at current daily EASLs
1.2% annual growth (NDDOT Planning Division, 2004).
Structural Number = 3.17
Daily ESALs = 158
Design ESALs = 3,107,125 with Class A restriction damage assessment

Accounting for the 1.2 percent growth over the twenty-year design life:
Design Traffic = 138,402(current annual ESALs) * $\{[(1+0.012)^{20}-1]/0.012\}$
138,402 * 22.45 = 3,107,125 ESALs @ a Class A restriction level
(The 138,402 is the annual damage accumulated seasonally from the prior section for a Class A restriction.)
Design ESAL's (20 years) = 3,107,125 (two-way accounting for damage)
1,553,560 (one-way accounting for damage)

Annual Worth Determination

The conversion of a present worth (PW) to an annual worth (AW) is computed as:

[24] The International Roughness Index (IRI) summarizes the roughness qualities that impact vehicle response, and is most appropriate when a roughness measure is desired that relates to: overall vehicle operating cost, overall ride quality, dynamic wheel loads (damage to the pavement from tire loads, braking and cornering safety), and overall surface condition.

[25] Flexible pavement structural number is a measure of pavement strength determined from materials, thickness and drainage characteristics of the pavement subbase, base and surface layers.

AW[26] = PW* [i * (1 + i) ^ n] / [(1 + i) ^ n - 1].
AW represents an estimate of the annual cost over a period of time (pavement design life).

Assumptions: Interest = 4%
Construction cost:
NDDOT Project Master File for the segment = $1.5 million
Life expectancy = 20 years
AW= $110,372

Assumptions: Interest = 4%
Construction cost:
5 miles @ $300,000/mi. = $1.5 million
Life expectancy: 15 years
AW= $134,911

Difference between the costs associated with the two time frames, 15 year versus 20 year life expectancy, is 22 percent annually. The difference in costs for the two life cycle of the roadway can be calculated as:

(1,500,000*.22) = $330,000.

Example of Design for No. 1 or 2 Seasonal Restrictions – 20 year design
Total Design ESALs = 138,402*22.45 = 3,107,125
(This is the estimate of design ESALs if the roadway segment was restricted only by the legal limits.)

[26] Denotes what uniform annual cash flow must be received to recover the equivalent power of a present sum of money.

The potential life extension by imposing No. 1 restrictions can be estimated by dividing the design ESALs of the legally restricted loadings (3,107,125) by the annual accumulated damage under a No. 1 restriction (102,940). The potential design life is lengthened significantly by using restrictions. This reflects only damage done by traffic. There will be damage accumulated by environmental factors in addition to traffic.

No. 1 Seasonal Restriction:

Accounting for the 1.2 percent growth over the twenty-year design life:
Design Traffic = 102,940 (from prior analysis) * $\{[(1+0.012)^{20}-1]/0.012\}$

102,940*22.45 = 2,311,000 Total Design ESALs
3,107,125/102,940 = 30.18 years

The potential life extension by imposing No. 2 restrictions can be estimated by dividing the design ESALs of the legally restricted loadings (3,107,125) by the annual accumulated damage under a No. 2 restriction (90,710). The potential design life is extended to 43.82 years. However this does not account for environmental factors.

No. 2 Seasonal Restriction:

Accounting for the 1.2 percent growth over the twenty-year design life:
Design Traffic = 90,170 (from prior analysis) * $\{[(1+0.012)^{20}-1]/0.012\}$

90,710*22.45 = 2,036,439 ESALs
3,107,125/70,910 = 43.82 years