Impacts of Transportation Infrastructure on the Economy of North Dakota

A Report to the North Dakota Legislative Council
by the Upper Great Plains Transportation Institute

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Executive Summary

The primary objective of this study is to describe how improvements to the state's transportation infrastructure might "enhance the business climate and the state's competitive position in economic development, with a focus on the potential to expand the sale of goods to markets outside the state by strengthening the state's transportation infrastructure." Specifically, the study calls for an analysis of the benefits and costs of potential enhancements to the state's highways to allow load limits to be raised to more efficiently move goods to market

An integration of three key software models was used to perform this analysis. HERS-ST, REMI, and Cube were used separately and in conjunction to provide a broad picture of the impacts of North Dakota's transportation system. Various components of the study were coordinated with the North Dakota Department of Transportation (NDDOT) and the North Dakota Aeronautics Commission to ensure that the results were realistic and applicable to the state transportation planning process.

Highway Infrastructure Analysis. The HERS-ST software was used in conjunction with NDDOT's Highway Performance Monitoring System to simulate pavement condition, capacity, deterioration, and rehabilitation over a 20-year analysis period. The analysis required calibration of the HERS-ST model to reflect NDDOT highway rehabilitation practices, design standards, improvement costs, and expected deterioration rates. The HERS-ST analysis simulated the improvement of 16,263 lane-miles of highway over 20 years with a total improvement cost of $3.145 billion during the analysis period. The average benefit-cost ratio of all improvements was 4.9. HERS-ST estimated that user costs will remain virtually unchanged over the 20-year period if these improvements are made, despite an annualized growth in vehicle-miles of travel (VMT) of 2.2%.

The Direct Effects of Highway Infrastructure Funding. Three budget-constrained analyses were performed with HERS-ST. The funding level mentioned above was reduced by 25%, 50%, and 75% to assess the changes in pavement condition and user costs. The table below outlines the changes in travel-time cost per 1,000 VMT, average speed, and pavement smoothness (IRI) under the different funding scenarios. If the budget levels are not maintained, user costs increase and travel speed decreases because highway conditions deteriorate.

Changes in Highway System Performance as a Result of Hypothetical Budget Constraints

Funding Level (Percent of Baseline)	Predicted Values for 2024		
	Travel Time	Average Travel Speed (mph)	Average IRI (in/mi)
100%	$340	67.4	108
75%	$348	66.1	122
50%	$369	62.8	146
25%	$404	56.9	184

The Total Economic Effects of Highway Infrastructure Funding. The total economic impacts of the HERS-ST budget-constrained scenarios were estimated using a REMI analysis of the changes in improvement cost, maintenance cost, vehicle-operating cost, safety cost, emission cost, travel time, and hours of delay. A baseline forecast was generated, based on current conditions and compared against three adjusted forecasts to reflect the system changes predicted by HERS-ST. In the HERS-ST/REMI analysis, reducing the budget to 75% of the projected highway needs would result in a $412 million reduction in gross regional product (GRP). A reduction to 50% of current funding would result in a $1.356 billion reduction in GRP. Finally a reduction to 25% of current funding levels would result in a $3.909 billion reduction in GRP.

Changing Grain Transportation Patterns. In analyzing the effects of highway load limits, it is important to focus on the transportation of grain and other key commodities. A survey of grain elevators across the state was conducted to determine the types of trucks used to deliver grain to elevators. Semitrailers and tandem trucks were used in the greatest percentages to deliver grain. However, the use of trucks differs significantly between shuttle-train and other elevators. Approximately two-thirds of the grain delivered to shuttle-train elevators is moved in semitrailers. In comparison, only 47% of the grain delivered to other elevators is moved in semitrailers. The use of single-unit trucks is proportionately greater at elevators without shuttle-train service. As the distance of haul increases, larger-volume trucks are used at greater percentages than for shorter hauls.

Manufacturing Shipping Patterns. A manufacturing survey was conducted to determine the shipping patterns of North Dakota's manufacturers. For outbound shipments, the respondents indicated that 64.55% occurred by truckload shipment, 19.68% by less-than-truckload, 14.04% by rail and intermodal, and 8.6% by air freight. Inbound shipments occurred 70.16% by truckload, 24.73% by less-than-truckload, 5% by rail and intermodal, and less than 1% by air freight. The weight-constrained truckload shipments from this survey were used in the highway load limit analysis.

Benefits and Costs of Eliminating Spring Load Restrictions. A GIS network with data on grain production and distribution, manufacturing production, and North Dakota's highway and rail infrastructure was created to estimate the economic impacts of seasonal (spring) load limits. The cost of upgrading the entire state highway system to legal, unrestricted weight is estimated to be $292 million. The cost to raise all state highway segments to the 8-ton weight restriction is estimated at $141 million, and the cost to raise all segments to the 7-ton weight restriction is estimated at $40 million. The benefits of raising the entire network to legal weight are the transportation cost savings as a result of direct fully-loaded movements. For the agricultural sector, it is estimated that elimination of seasonal weight restrictions will result in a reduction of more than 570,000 miles of truck travel at a cost savings of $1.22 million. The manufacturing sector will benefit by a reduction of 1.7 million miles of travel at a cost savings of $1.3 million. A total economic analysis of increasing load limits concludes that the costs associated with eliminating seasonal limits far outweighs the benefits of doing so.

Recommendations on Highway Infrastructure. The NDDOT should continue to focus on a preservation program that keeps pavements in good condition. These programs generate substantial economic benefits and should be continued. Over time, NDDOT should continue to improve alignments and shoulders where needed, achieving greater standardization in key interregional corridors that are heavily traveled by trucks. Key industrial and agricultural facilities such as shuttle-train elevators, processing plants, potential ethanol facilities, and other key industrial facilities should be analyzed on a case-by-case basis. UGPTI should work with NDDOT to analyze highway access to these facilities and better understand their transportation needs. The benefits and costs of eliminating seasonal load limits should be analyzed on a case by case basis. Continued research into new mechanistic pavement analysis techniques should be undertaken to improve forecasting of pavement lives and conditions. Improved methods may make it possible to shorten the durations of spring load restrictions and possibly identify more cost-effective designs.

Benefits of Rail Freight Service. Rail freight service is important to North Dakota's agricultural industry. Farm products comprise 54% of the freight tonnage originated by railroads in North Dakota. To estimate the benefits of maintaining the branch line and regional railroad system in North Dakota, an analysis was performed to compare incremental grain handling cost increases as a result of complete branch line abandonment. All grain originating at a branch line elevator would, on average, require an additional truck trip of 35.1 miles. The impact of the additional truck miles on highway infrastructure, fuel taxes, grain transportation cost, and handling cost were estimated. The total economic impact of the increase in agricultural transportation and grain handling cost was estimated using REMI Transight. If the grain is transshipped from the branch line elevator to the mainline, the economic impact to the state of North Dakota is estimated to be $30.9 million. If farmers haul production directly to the mainline, the economic impact to the state is estimated at $20.2 million.

Recommendations Regarding Railroad Infrastructure. Large benefits are derived from the branch line and regional railroad network. Much of the network should be preserved. The NDDOT offers rail assistance programs which allow for the improvement and maintenance of rail lines within the state. However, the demands for assistance funding are expected to grow. The state should continue these programs to increase the viability of branch and regional railroad lines and evaluate the needs for additional funding.

Economic Impacts of Airport System. The North Dakota system of public-use airports is an integral component of the state's overall transportation system and is also an important stimulus for economic growth and development in North Dakota. Airports are significant generators of revenue, jobs, and wages, as general aviation alone creates thousands of jobs and produces thousands of dollars of economic impact throughout North Dakota each year. It is estimated that the total direct and induced expenditures as a result of North Dakota's airports totaled $1 billion in 2004. This impact resulted in more than 11,000 jobs directly generated or induced by the airport system.

Significance of Specially-Situated Airports. The larger commercial airports in North Dakota are specially situated to participate in the current and future growth of air cargo and regional jet services. The continued viability of these airports is critical to the state. In general, the growth in regional and business jet service is a very positive development that offers economic development potential. Several smaller airports in the state are strategically located and have considerable economic significance. For example, some airports provide business access to ethanol processing facilities and power plants. However, some airports face physical constraints that prevent needed expansions. Improvements in general aviation terminals are needed at many airports to enhance business access.

Issues Facing Airports in North Dakota. As passenger and air cargo volumes continue to grow and decentralize, many airports will need to expand in order to accommodate their tenants. The typical issues faced by airports in need of expansion include: infrastructure and capacity constraints that limit growth and expansion to accommodate increased demand, encroachment of incompatible land development with concerns over aircraft noise and safety, and funding limitations. Airports that do not qualify for federal funding often have difficulty raising funds from other sources. The North Dakota Aeronautics Commission is evaluating needs on a case-by-case basis. However, the needs exceed the available funding.

Caveats. The highway construction and user costs used in this study do not reflect recent price escalations. The prices of bituminous and concrete paving materials have increased significantly during the last year. Similarly, the vehicle-operating costs generated from HERS-ST reflect 2004 prices for gasoline and oil. In effect, the cumulative benefits presented in this report are conservative forecasts. In actuality, both the costs and benefits of highway improvements in 2006 dollars are greater than the estimates presented in this report. However, the general conclusions of the study are valid: highway investments yield large economic development benefits to the state.[1]

[1] This paragraph was added after the report was presented to the Legislative Council to address the Council's questions regarding the effects of increased fuel prices.

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1. Study Objectives

The primary objective of this study is to describe how improvements to the state's transportation infrastructure might "enhance the business climate and the state's competitive position in economic development, with a focus on the potential to expand the sale of goods to markets outside the state by strengthening the state's transportation infrastructure." Specifically, the study calls for an analysis of:

- The benefits and costs of potential enhancements to the state's highways to allow load limits to be raised to more efficiently move goods to market
- The decline of rail freight service and prospects for offering incentives to rail service providers to expand the availability of rail for transportation of goods to market and the associated costs and benefits
- The feasibility of identifying and assisting airports that are specially situated to assist in economic development
- The projected economic development impacts associated with recommended infrastructure improvements

The study's focus is on the potential role of transportation infrastructure in expanding sales of goods outside the state. Much of the freight exported from North Dakota moves by rail. Therefore, both highway and railroad systems are analyzed. To the extent possible, the benefits and costs associated with infrastructure improvements are quantified.

2. Research Approach

Throughout the study, we consulted with the North Dakota Department of Transportation (NDDOT) and the North Dakota Aeronautics Commission (NDAC). During these consultations, we received valuable feedback on the practicality of potential enhancements or improvements. We used the NDDOT's highway design standards and costs in our analysis. The NDDOT critiqued our draft highway analysis report. Moreover, we coordinated the rail component of this study with the North Dakota Rail Plan Update. In doing so, we solicited input from regional railroads. We worked closely with the NDAC on the air services component. In addition, we reviewed similar studies in other states, including a recent study of seasonal load limits in Minnesota.

A study of this scope requires the integration of several models, as well as the collection of survey data. The total economic effects of highway infrastructure improvements can only be estimated by integrating a highway investment model such as the Highway Economic Requirements System with a regional economic model such as REMI. Moreover, surveys of elevators and manufacturers are needed to gather detailed information about truck shipments and the impacts of highway load limits.

The first nine months of the study consisted mostly of model-building, surveying, and data development. The following models were calibrated and used in this study:

- The Highway Economic Requirements System–State Version (HERS-ST) was used to estimate the direct benefits of highway investments.
- The REMI model was used, in conjunction with HERS-ST, to estimate the total economic effects of highway infrastructure improvements.
- The Cube Transportation Planning software was used to model commodity movements over highways and to analyze the effects of seasonal highway load limits.

In addition, several GIS models were constructed which link agricultural and industrial facilities to the state and local highway and railroad networks. These models include: (1) a statewide agricultural land-use model which describes crop production in sub-county zones, as well as the locations and characteristics of elevators and processing plants; and (2) a statewide manufacturing facility model which describes the locations and logistics of manufacturing plants.

3. Overview of Key Models

The key models used in this study are highlighted in this section of the report. Each model encompasses many algorithms and procedures. Only the essential features of the models are described in this overview. However, detailed descriptions are available from the references listed in the bibliography.

3.1 Highway Economic Requirements System

The state version of the Highway Economic Requirements System was used to estimate the direct benefits of making highway infrastructure improvements and to forecast the performance of the highway system in future years. HERS-ST is widely used at the federal and state levels. The national HERS model was developed by U.S. Department of Transportation (USDOT) in the early 1990s. It is used to help prepare biennial reports for Congress describing the condition and status of the nation's highways and to estimate the investment levels necessary to maintain or improve highway conditions. The state version of HERS is frequently used by transportation departments to estimate highway needs and investment benefits.

HERS-ST estimates traveler, societal, and transportation agency benefits resulting from highway investments. Highway user benefits include reductions in vehicle-operating costs, travel-time costs, and crash costs. Reductions in vehicle emissions are classified as societal benefits. Traveler and societal benefits are estimated by comparing the levels of vehicle, user, crash, and emission costs that would occur if an improvement is made to the projected levels of these variables with no improvement.[2] HERS-ST also estimates the maintenance cost savings resulting from timely resurfacing improvements, as well as the residual value of investments that continue to provide traffic or structural capacity beyond the end of the analysis period.

Analysis Process. HERS-ST uses the state Highway Performance Monitoring System (HPMS) sample. Starting from the base year, HERS-ST forecasts when a pavement- or capacity-related deficiency will occur based on pavement and travel conditions. Pavement-related deficiencies are identified by comparing a section's condition to NDDOT standards. Capacity-related deficiencies are identified by comparing a section's volume-capacity ratio to congestion boundary values. When a pavement- or capacity-related deficiency is identified, HERS-ST assesses the benefits of simultaneously making other improvements, such as improving shoulders or alignment. When a pavement deficiency is identified, HERS-ST further determines if a capacity deficiency will occur on the same highway section, and in which funding period the capacity deficiency will occur. If it is economical to combine a capacity improvement (e.g., widening or adding lanes) with a pavement improvement (e.g., resurfacing or reconstruction), HERS-ST determines the optimal timing of the combined improvement.

Analysis Period. The base year of the analysis is 2004 (the most recent year of HPMS data). Results are forecast for a 20-year period. The 20 years are partitioned into four five-year "funding periods." Each funding period is analogous to a transportation improvement program (TIP) period. HERS-ST analyzes each sample section over the 20-year period and selects the improvements that will eliminate or mitigate deficiencies and provide the greatest net benefits. For each section, HERS-ST computes the benefit-cost ratio of the selected improvements as well as performance indicators such as average travel speed and the percentage of highway miles and vehicle-miles of travel (VMT) that occur under deficient conditions.

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[2] A scenario which envisions no highway improvement is referred to as a "base case." Normally, a base case envisions no investment at all. However, some pavement improvement will be made eventually; the only question is when? Alternatively, if the highway isn't improved, it will be downgraded – e.g., a paved road will be converted to a low-type (gravel) surface. In effect, the pavement condition rating at which a surface conversion or delayed improvement occurs defines the base case for a resurfacing improvement.

HERS-ST computes these performance measures for the base year and the last year of each funding period. By tracking these indicators, highway performance can be projected well into the future based on starting conditions and the effects of improvements. Travel-time, vehicle-operating, crash, emission, and routine maintenance costs are also computed for the base year and the last year of each funding period.

Budget-Constrained Analysis. HERS-ST is a powerful tool for monitoring a state's highway condition and performance. However, the real power of the model lies in its capability to quantify the benefits of investments and to simulate the effects of changes in funding levels on highway system performance. In a budget-constrained analysis, HERS is restricted from implementing all needed improvements. Moreover, some improvements are postponed until later funding periods, thereby increasing pavement rehabilitation costs. Budget-constrained scenarios are useful ways of quantifying the effects of highway infrastructure investment.

Calibration. Several important steps have been taken to ensure that HERS-ST predicts realistic results for North Dakota. (1) The HPMS sample, based on federal highway classifications, has been restructured to fit NDDOT's priority classification system. This allows the specification of highway design standards and calibration factors for individual highway classes. (2) Where applicable, the default federal deficiency indicators and inputs used in HERS-ST have been replaced by North Dakota values. (3) Rates of pavement deterioration have been calibrated so that the pavement lives predicted by HERS-ST agree with NDDOT's resurfacing cycles. The cycles are 20 years for flexible pavements and 30 years for concrete pavements. (4) Adjustments have been made to normal resurfacing costs to account for anticipated reconstructions because of inadequate roadway widths.[3]

In the **baseline run**, HERS-ST was allowed to implement all of the selected improvements. Because of the calibration process, HERS-ST replicated the NDDOT's resurfacing cycles. Moreover, the predicted annualized costs closely agree with recent expenditures for pavement rehabilitation and capacity enhancements. The baseline scenario represents the minimum set of improvements and capital expenditures needed to preserve pavement condition and add capacity.

3.2 REMI Model

REMI Policy Insight® is probably the most widely applied regional economic policy analysis model in North America.[4] It integrates input-output, general equilibrium, econometric, and economic geography methodologies. Moreover, the model is dynamic. The forecasts and simulations—which reflect behavioral responses to wages, prices, and other economic factors—are generated on an annual basis. Thus, the model produces year-by-year estimates of the total effects of policies such as alternative infrastructure investment levels.

Internally, the REMI model consists of thousands of simultaneous equations that represent dynamic relationships and interactions over time and distance. REMI accounts for: (1) substitution among factors of production in response to changes in relative factor costs; (2) migration responses to changes in expected income and commodity access; (3) labor participation rate responses to changes in real wage and employment conditions; (4) wage-rate responses to labor-market changes; (5) consumer-consumption responses to changes in real disposable income and commodity prices; and (6) local, regional, and

[3] HERS-ST predicts situations where highways must be reconstructed because the pavement has deteriorated so badly. However, HERS-ST does not consider reconstruction where the roadway width is insufficient for the placement of an overlay while maintaining cross section and geometry. Thus, an adjustment to HERS-ST was needed to reflect these engineering realities.

[4] The description of the REMI models presented in this section of the report is paraphrased from the *Policy Insight Users Guide*.

national market-shares responses to changes in regional production costs and agglomeration economics. In contrast to models based only on input-output multipliers, the REMI model achieves its results by incorporating market signals such as prices, wages, input factor substitution, and labor migration within a dynamic time-oriented framework. The model applies econometric response data to general equilibrium equations and inter-industry transactions to track the time path of responses in product and factor markets. Each year's solutions are used to drive the next year's economic processes.

In traditional economic models, transportation has been treated as an industry sector. In comparison, REMI Policy Insight® captures the effects of improved transportation on commuter behavior and the competitiveness of other industries. The mechanism for this type of analysis is the *transportation cost matrix* which allows changes to commuting, accessibility, and transportation costs. The REMI model captures North Dakota's trade and travel interactions with the rest of the United States and simulates changes in transportation costs and accessibility as a result of infrastructure investments. Moreover, REMI captures the short-run economic stimulus that results from spending on highways.

In this study, the results of the HERS-ST analysis are input to REMI. In this way, the total economic benefits of highway infrastructure improvements are estimated. The REMI model is also used in the railroad portion of the analysis to determine the total economic effects of railroad infrastructure investments on transportation productivity and shipper costs, as well as in the air services component to estimate the total economic effects of air services.

3.3 Cube Transportation Planning Software

Cube is one of the most widely-used transportation planning software systems in the world. Cube allows the prediction of personal and freight trips within a network based on land-use, travel demand, and highway performance. Cube uses spatial interaction models to simulate flows of people and goods among zones. In Cube, these flows are based on travel demands. However, the highway routes used and the predicted traffic volumes are based on travel impedances, which reflect travel time and cost.

In this study, crop production zones, elevators, and manufacturing facilities are represented in a GIS network within Cube. Farm-to-market and manufactured goods movements are predicted within this network and routed over highways. Unlike HERS-ST, the Cube model can simulate changes in flows and costs when impedances are changed as a result of seasonal load restrictions.

4. Benefits and Costs of Highway Infrastructure Improvements

Most commodities produced in North Dakota are initially transported from their places of production to markets or transfer points in trucks. Thus, North Dakota's highway system is essential to the movement of goods within the state and the positioning of goods for export. Moreover, the highway system is essential to business travel and labor mobility—both of which impact the state's competitiveness and business climate.

In this section of the report, the benefits and costs of highway infrastructure investments are quantified. These improvements reduce the cost of freight movements, business travel, and commuting. In doing so, they enhance the economic performance and attractiveness of North Dakota for new business growth. In the highway analysis, the direct benefits of infrastructure investments are estimated using HERS-ST. The results of the HERS-ST analysis are input to REMI to estimate the total economic effects of highway investments.

4.1 HERS-ST Analysis

4.1.1 Objectives and Calibration Procedures

The primary objectives of this component of the study are to estimate the benefits of: (1) preserving North Dakota's state highway system through the timely resurfacing of pavements, (2) eliminating alignment and shoulder deficiencies, and (3) adding highway capacity to heavily-traveled segments. The analysis is based on NDDOT's highway performance classification system. The 2004 HPMS sample, which is designed to provide information for standard FHWA functional classes, has been reorganized so that it is consistent with NDDOT's classification system. Each highway class is analyzed separately. Moreover, each highway class is subdivided into groups based on pavement type (flexible, concrete, and composite) and pavement thickness (very heavy, heavy, medium, and light).[5]

Specific inputs have been developed for each highway class and subgroup. Pavement resurfacing, shoulder, and reconstruction costs have been estimated by NDDOT. Other highway improvement costs such as minor widening and alignment improvements have been adjusted to reflect North Dakota construction costs. Lane width, right-shoulder width, and other geometric design inputs have been derived from NDDOT's Design Manual. Pavement deficiency levels such as the resurfacing pavement condition level have been defined by NDDOT.

HERS-ST uses the American Association of State Highway and Transportation Officials (AASHTO) pavement design equations to estimate the maximum traffic life of each HPMS segment. In addition, HERS-ST uses an environmental deterioration model to simulate pavement condition loss due to environmental forces. Using these models, HERS-ST forecasts the condition of each pavement section during the design period.

As noted earlier, HERS-ST has been calibrated so that it predicts an average resurfacing cycle of 20 years for flexible pavements. Twenty years is the expected time for a flexible pavement to deteriorate from its design present serviceability rating (PSR) to its terminal PSR, or deficiency level. However, NDDOT uses a 30-year resurfacing cycle for concrete pavements. If necessary, the rates of pavement deterioration

[5] At present, HERS does not allow the specification of pavement deterioration rates for individual segments. The greatest degree of control over the pavement deterioration model can be achieved by running each highway class, pavement type, and pavement thickness group separately and aggregating the results to the overall highway class.

are adjusted so that the improvements forecast by HERS-ST are consistent with NDDOT's expected resurfacing cycles.[6]

4.1.2 Improvement Types and Costs

The primary pavement-related improvements considered by HERS-ST are *reconstruction* and *resurfacing*. If possible, HERS-ST resurfaces pavements in a timely manner to avoid higher reconstruction costs. Simple resurfacing is defined as the overlay of an existing pavement, including the costs of resurfacing the shoulders and bringing them up to grade. Minor drainage work is also included. Pavement reconstruction includes the complete rebuilding of surface and base layers and the increasing of shoulder widths to design standards, if feasible. Other shoulder or drainage deficiencies are also corrected. If the section has vertical or horizontal alignment deficiencies, reconstruction may be combined with an alignment improvement.

The reconstruction and resurfacing costs used in this study are shown in Table 4.1. Although resurfacing and reconstruction are the basic categories of pavement improvements, HERS-ST may combine either of them with widening improvements. *Resurfacing with major widening* reflects the addition of lanes to an existing highway. If lanes are added in excess of the widening feasibility code, they are added at high cost.[7] Otherwise, lanes are added at normal cost, which reflects the cost of additional lanes, as well as the resurfacing cost of existing lanes and minor shoulder and drainage work. *Resurfacing with minor widening* is similar to major widening except that no new lanes are added. Additional capacity is gained by widening lanes and/or shoulders.[8] *Resurfacing with shoulder improvements* reflects the overlay of an existing pavement plus the widening of shoulders to design standards if feasible, or the complete reconstruction of shoulders to provide additional strength. A minor amount of additional right-of-way may be acquired.

4.1.3 Forecasted Improvements and Benefits

The forecasted highway improvements from 2005 through 2024 are shown in Table 4.2. HERS-ST simulates the reconstruction of 44 lane-miles because the pavement conditions of these sections are too low to resurface. Moreover, HERS-ST adds 76 lane-miles because of projected traffic growth and rising

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[6] HERS-ST produces realistic results for very heavy and heavy flexible pavements. In these classifications, each lane-mile is typically resurfaced once during the 20-year analysis period. Moreover, the improvements are distributed somewhat uniformly among funding periods. Typically, HERS-ST resurfaces medium-strength flexible pavements once during a 20-year period. However the improvements may be distributed unevenly. For example, they may be bunched during the first two funding periods or concentrated toward the end of the 20-year period. In these situations, the rate of flexible pavement deterioration is adjusted to produce a more uniform distribution of improvements. The largest pavement deterioration rate adjustments are made for light flexible pavements. After HERS-ST overlays a concrete pavement, the segment is treated as flexible for the remainder of the analysis period. Therefore, the adjustment process for concrete pavements may include an adjustment to the rate of flexible pavement deterioration incurred by the section after resurfacing.

[7] The widening feasibility code reflects environmental and land use constraints that prevent the addition of lanes at normal costs. For example, additional right-of-way may be very expensive in developed urbanized areas where commercial or industrial enterprises are adjacent to the existing right-of-way or in sensitive environmental areas where mitigation costs may be great.

[8] Reconstruction widening improvements are similar to the improvements described for resurfacing. *Reconstruction with additional lanes* is the complete reconstruction of an existing pavement with the addition of lanes to the section. As in the case of resurfacing, these lanes are added at high cost if the widening feasibility code is exceeded. Otherwise, the lanes are added at normal cost. Shoulder and drainage deficiencies are also corrected. In comparison, no lanes are added during *reconstruction to wider lanes*. The pavement is completely reconstructed and the existing lanes are widened. Shoulder and drainage deficiencies are also corrected.

volume/capacity ratios in some urban areas.[9] HERS-ST resurfaces the remaining 16,142 lane-miles at least once during the 20-year period.

In some cases, the highway sections identified for resurfacing by HERS-ST must be reconstructed because of insufficient roadway space. Thus, the resurfacing costs shown in Table 4.2 reflect a mixture of simple resurfacing events and structural overlays or reconstructions for reasons other than deteriorated pavements. These improvements are referred to as *resurfacing and realignment* to distinguish them from simple resurfacing. As shown in Table 4.2, HERS-ST simulates resurfacing with shoulder improvements to nearly 1,500 lane-miles.

Table 4.1 Resurfacing and Reconstruction Costs per Lane-Mile Used in North Dakota Highway Analysis

Highway Classes	**Reconstruction Cost per Lane Mile ($000)**	**Resurfacing Cost per Lane Mile ($000)**	**Resurfacing Assumptions**	**Resurfacing with Shoulder Improvements ($000)**
Rural Interstate	650*	165	Asphalt Class = 33; Right Shoulder = 10'; Overlay = 5"	200
Rural Interregional Corridor	400	100	Asphalt Class = 33; Right Shoulder = 4'; Overlay = 3.5"	125
Rural State Corridor Rural District Corridor	350	75	Asphalt Class = 31; Right Shoulder = 2'; Overlay = 3.0"	90
Rural Collector	300	30		40
Urban Freeway Urban Expressway	850	200		250
Urban Other Divided	950	250		300
Urban Other Undivided	850	200		350

*Applies to PCC pavements
Source: North Dakota Department of Transportation

Benefits of Highway Investments in North Dakota. According to HERS-ST, at least $3.15 billion should be invested between 2005 and 2024 to preserve highway pavements and add capacity.[10] The weighted-average benefit/cost ratio of these improvements is 4.9, meaning that these investments will result in approximately $15.3 billion of direct benefits between 2005 and 2024. As shown in Table 4.2, all

[9] The average cost of adding a lane-mile is approximately $770,000.
[10] This capital investment estimate is stated in 2004 dollars. It must be recognized that actual future investments will be significantly higher in future dollars. However, so will the projected benefits, which are also stated in constant 2004 dollars. The full funding scenario represents improvements that correct any highway condition which is below specified thresholds. There is no upper limit on the amount of funding in the analysis. Since actual highway spending does have an upper limit, it is estimated that actual funding is less than the full-funding scenario.

types of improvements generate attractive benefit/cost ratios. However, resurfacing improvements and capacity enhancements generate the greatest benefit/cost ratios.

Table 4.2 Forecasted Improvements to Highway Pavements in North Dakota: 2005-2024

Improvement Type	Lane-Miles Improved	Cost of Improvements ($000)	Benefit/ Cost Ratio
Reconstruction due to Pavement Condition	44	36,342	3.50
Major Widening with Avg. Cost Lanes	76	58,597	7.78
Resurfacing with Minor Widening	-	780	-
Resurfacing with Shoulder Imps.	1,491	368,652	1.78
Resurfacing and Realignment	14,626	2,676,805	5.20
All	16,263	3,145,014	4.89

Reductions in Alignment and Shoulder Deficiencies. The improvements identified by HERS-ST will practically eliminate shoulder and alignment deficiencies on highways with flexible pavements. For example, the percent of highway miles with shoulder-width deficiencies will be reduced from 13.1 to 1.8%. The traffic volumes on the remaining 1.8% of roadway miles are insufficient to warrant shoulder improvements, or the segments have constraints which prevent upgrading.[11]

Projected Traffic Growth. Traffic growth is a reflection of commerce, business activity, and enhanced personal mobility in the state. With the improvements identified by HERS-ST, highway traffic in North Dakota will continue to grow. Annual vehicle-miles of travel (VMT) will increase by 44%, from 4.72 billion VMT in 2004 to 6.80 billion VMT in 2024. This represents an annualized growth rate of 2.2%.

Enhanced Pavement Smoothness. Pavement roughness is measured by the International Roughness Index (IRI). The improvements identified by HERS-ST will maintain pavement smoothness at its current "good" level. In fact, the average IRI is projected to drop from 114 in 2004 to 108 in 2024.

Lower Highway User Costs. As shown in Table 4.3, the highway improvements identified by HERS-ST will reduce highway user costs during the next 20 years in spite of substantial increases in traffic. Vehicle-operating costs are projected to drop from 35.4 cents per VMT to 34.6 cents per VMT. This is a significant decrease, given the 6.8 billion VMT projected for 2024. Reduced vehicle operating cost represents a savings to highway users of $55 million in 2024. Travel time and crash costs per VMT are also projected to decrease during the period.

4.1.4 Effects of Budget Constraints on Highway Performance and User Costs

In the baseline (unconstrained) analysis, HERS-ST identifies investment needs of approximately $157 million per year in pavement-related capital improvements. This forecast does not include the cost of new construction, high-cost lanes, bridges, and other highway structures, maintenance, and administration.

To illustrate the effects of infrastructure investment levels on highway performance and user costs, the unconstrained budget is reduced to 75, 50, and 25% of the base. With budget constraints, HERS-ST can no longer improve each highway segment during the 20-year period (Table 4.4). In effect, the number of lane-miles improved drops in proportion to the funding level. Moreover, the number of lane-miles

[11] For example, a curbed shoulder in a developed area cannot be widened even if the width is classified as deficient.

reconstructed due to poor pavement condition increases from 44 to 142. Therefore, the average capital cost per lane-mile increases, as does the average annual maintenance cost per roadway mile. As shown in Table 4.4, the projected maintenance cost during the 20-year analysis period increases from $166.39 million to $228.69 million as capital investment declines from $3.145 billion to $0.786 billion.

Table 4.3 Forecasts of Highway User Costs in North Dakota ($/1,000 vehicle-miles) from 2004 to 2024

Highway User Costs	**2004**	**2024**
Travel Time Costs	$342.85	$340.43
Vehicle Operating Costs:		
4-Tire Vehicles	$250.90	$241.54
Trucks	$828.43	$820.12
All Vehicles	$353.79	$345.77
Crash Costs	$111.91	$110.21
Total User Costs	**$809.49**	**$797.63**

Table 4.4 Changes in Lane-Miles Improved, Improvement Costs, and Routine Maintenance Costs as a Result of Hypothetical Budget Constraints

Funding Level (Percent of Baseline)	**Lane Miles Improved: 2005-2024**	**Capital Improvement Cost (Million $): 2005-2024**	**Maintenance Cost (Million $): 2005-2024**
100%	16,263	$3,145.01	$ 166.39
75%	12,658	$2,358.76	$ 180.29
50%	8,469	$1,468.33	$ 200.73
25%	4,309	$786.25	$ 228.69

Table 4.5 illustrates the effects of funding reductions on annual VMT, average travel speed, and average IRI. The values shown in Table 4.5 are forecasts for 2024—the last year of the analysis period. As the table shows, the projected VMT drops from 6.80 billion to 6.35 billion as investment decreases to 25% of the base. The projected IRI increases from 108 (good) to 184 (poor) as investment drops to 25% of the base. Moreover, average travel speed is projected to decrease by 10.5 mph as investment drops to 25% of the base.

As shown in Table 4.6, travel-time and vehicle-operating costs are projected to increase as highway investment declines. In this projection, the time component of travel cost increases from 34 to 40.4 cents per VMT. Moreover, the average operating cost of vehicles increases in spite of a drop in VMT and slower speeds due to rougher pavements. The crash cost per VMT remains essentially unchanged in spite of fewer vehicle-miles. This result may seem counterintuitive. However, HERS-ST cannot improve highway alignments or widen shoulders because of budget constraints. Consequently, the crash cost per VMT remains the same even though vehicle-miles of travel are reduced.

Table 4.5 Changes in Highway System Performance as a Result of Hypothetical Budget Constraints

Funding Level (Percent of Baseline)	Predicted Values for 2024		
	VMT (billions)	**Average Travel Speed (mph)**	**Average IRI (in/mi)**
100%	6.80	67.4	108
75%	6.73	66.1	122
50%	6.57	62.8	146
25%	6.35	56.9	184

Table 4.6 Changes in Highway User Costs as a Result of Hypothetical Budget Constraints

	Projected User Costs per 1,000 Vehicle-Miles in 2024	
Funding Level (Percent of Baseline)	**Travel Time**	**Vehicle Operating**
100%	$340	$346
75%	$348	$350
50%	$369	$354
25%	$404	$358

4.2 REMI Analysis

The REMI analysis utilizes two software applications. REMI Policy Insight® is a macroeconomic forecasting model that shows the total economic, demographic, and fiscal effects of policy questions on local regions. Transight® integrates the REMI model with transportation planning and travel demand models to show the total economic, demographic, and fiscal effects of transportation infrastructure projects.

4.2.1 REMI Procedure

The REMI models estimate the total economic impact due to changes in key policy variables. The first step in the procedure is to formulate a policy question. In the HERS-ST analysis, three budget-constrained scenarios were simulated. For these runs, the policy question is: What is the economic impact of not maintaining the current highway system? The baseline HERS-ST results provide information about the cost of maintaining the current highway system. The budget-constrained runs provide information about system deterioration if the funding levels are not met.

The next step is to define the key variable changes which result from the policy in question. The key policy variables generated from the HERS-ST analysis include the improvement cost, maintenance cost, vehicle operating cost, safety cost, emission cost, travel time, and hours of delay. These variables can be divided into four groups for the REMI analysis: agency, user, quality of life, and time.

4.2.2 Key Inputs

Agency costs refer to changes in improvement and maintenance costs as a result of changes in funding levels. Improvement and maintenance costs are incurred by the NDDOT to improve and maintain the highway system. REMI uses the sum of the changes in these costs on an annualized basis as an input to the construction sector. It is assumed that 80% of the highway funding is acquired from the federal government with the remainder being acquired from the State of North Dakota. In each scenario, when there is a reduction in construction spending, a reduction in state government spending is also included.

The total annual user costs predicted by HERS-ST are used as inputs to the REMI models. In the REMI analysis, it is assumed that consumers have a fixed consumption budget, a component of which is transportation expenditures. If highway operating costs increase, there will be less money available to spend on non-transportation consumption. Conversely, if there is a reduction in operating costs, consumers will have more of their budgets to spend elsewhere. The consumption reallocation variable is used to maintain this balance.

Quality of life variables refer to the changes in safety and emission costs estimated by HERS-ST. In REMI, these changes are input as non-pecuniary amenities, which represent changes in the attractiveness of North Dakota as a place to live because of changes in safety and the environment.

The time variables refer to changes in hours of delay and travel time. With the aid of REMI Transight®, these variables are used to calculate the transportation cost matrix. The transportation cost matrix represents a proportional change in the "effective distance" between North Dakota and the rest of the nation.[12] The cost matrix consists of three components: transportation cost, accessibility cost, and commuting cost. Transportation cost refers to the cost of delivering North Dakota's production to demand sources. Accessibility cost reflects the cost of obtaining intermediate inputs, while commuting cost refers to the accessibility of labor.

4.2.3 REMI Results

Baseline Scenario. The REMI analysis generates a baseline forecast for North Dakota's economy upon which to compare the adjusted forecast. Figure 4.1 shows the forecasted expansions in Gross Regional Product (GRP), imports, and exports over the 20-year analysis period. If the current highway system and conditions are maintained, REMI forecasts a growth in GRP of $8.13 billion (in 2004 dollars). Along with the increase in production comes an increase in imports and exports.

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[12] Effective distance describes the logistical efficiency between regions. The concept is based on an economic geography gravity model. A gravity model describes how firms in similar industries tend to gravitate towards each other to keep production costs low. The amount of gravitation towards the economic center of a region depends on the effective distance between firms. A firm will want to decrease its effective distance to reduce its production costs.

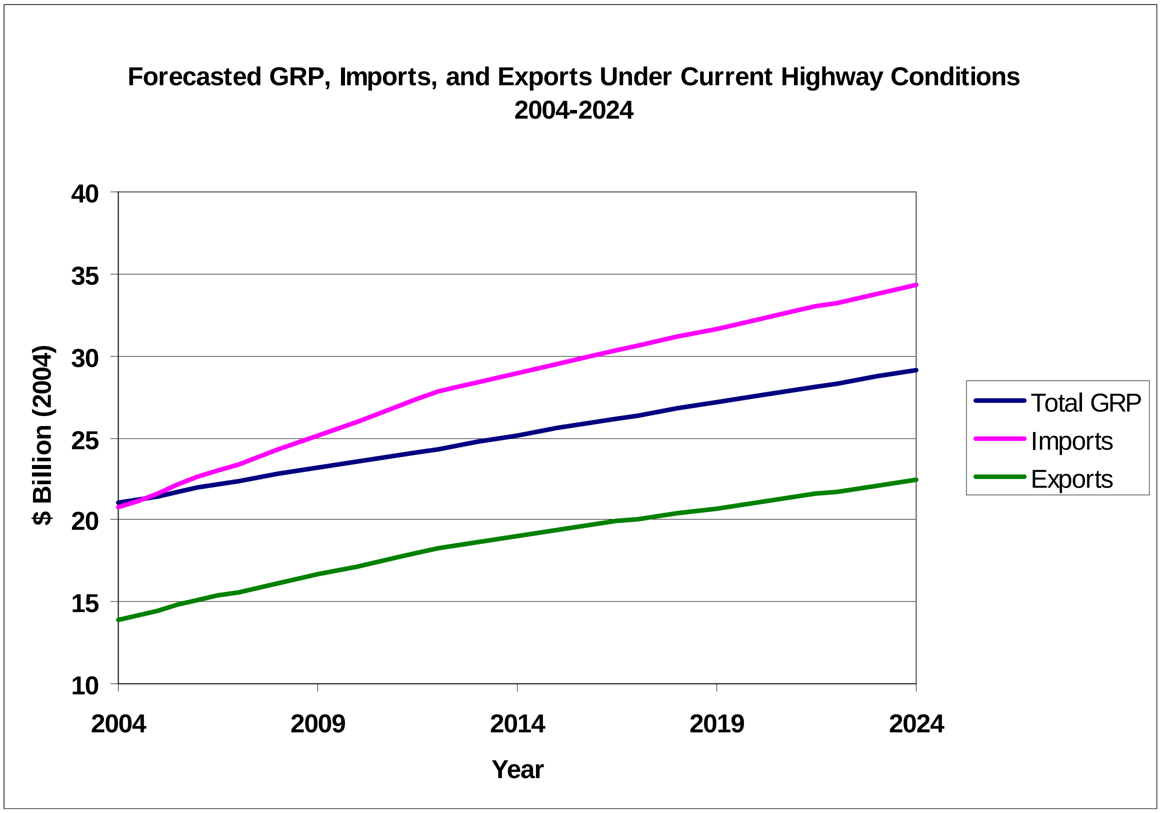

Figure 4.1 Baseline REMI Forecasts of GRP, Imports, and Exports under Current Highway Conditions: 2004-2024

Figure 4.2 shows the forecasted employment over the 20-year analysis period. If the current highway system and conditions are maintained, REMI is forecasting an increase in total employment of more than 36,000 to 497,138 jobs by the year 2024.

Budget-Constrained Scenarios. The REMI models can generate adjusted forecasts which consider changes to key policy variables. Upon comparison to the baseline forecast, the total economic impacts of changes in policies or funding levels can be assessed. As in the HERS-ST analysis, the three alternative scenarios represent various levels of highway budget constraints. As the highway budget is constrained, fewer miles are rehabilitated, resulting in a highway system which exhibits increased pavement deterioration and congestion. These changes, in turn, result in increased operating and travel-time costs, which negatively affect all traffic moving in and out of North Dakota. In effect, increased highway deterioration and transportation cost increase the cost of doing business in the state and limit the potential for economic growth. The total economic impacts of these constraints are shown in Tables 4.7 and 4.8. Table 4.7 outlines the changes in total employment, labor force and GRP in the last year of the analysis period. Table 4.8 expresses the same information in terms of percentage changes from the baseline forecast. The 100% baseline shows a forecasted total employment of 497,138, a labor force of 376,295, and a GRP of $29.14 billion in 2024 (in 2004 dollars).

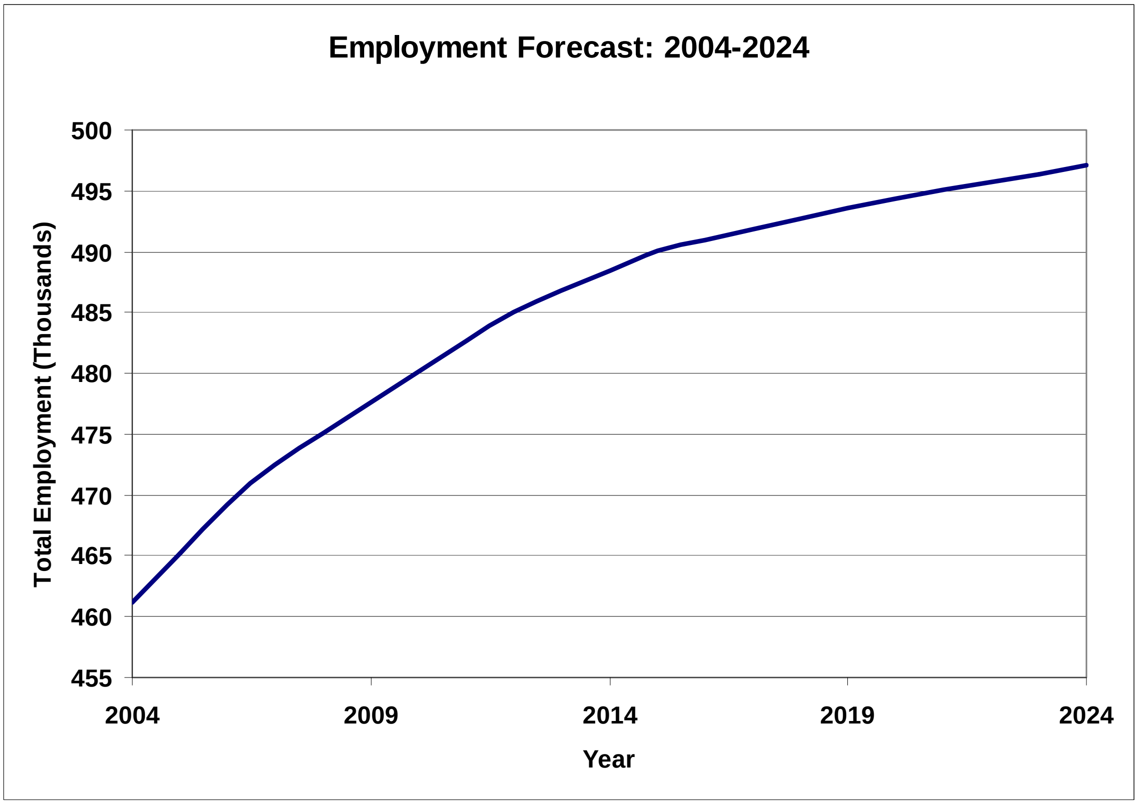

Figure 4.2 Baseline REMI Employment Forecast: 2004-2024

Table 4.7 2024 North Dakota Employment and Gross Regional Product Estimates Under Different Highway Funding Scenarios

	Percent of Baseline Funding			
	100%	**75%**	**50%**	**25%**
Total Employment (Thousand)	497.138	489.922	473.17	430.758
Labor Force (Thousand)	376.295	370.002	351.468	320.035
GRP (2004 Billion $)	29.140	28.728	27.784	25.231

Table 4.8 Percentage Changes from the 2024 Baseline Forecast Under Different Highway Funding Scenarios

	Percent of Baseline Funding		
	75%	**50%**	**25%**
Total Employment	-1.45%	-4.82%	-13.35%
Labor Force	-1.67%	-6.60%	-14.95%
GRP	-1.41%	-4.65%	-13.41%

Results of 75% Budget. The first budget-constrained scenario represents a 25% reduction in total highway spending on resurfacing and reconstruction. Section 4.1.4 outlines the changes in pavement conditions and user costs. The 75% scenario represents an increase in IRI from 108 to 122 and a reduction in travel speed of 0.6 miles per hour. The decrease in pavement condition and travel speed, along with other vehicle factors result in a decrease of more than $376 million in GRP (a decline of 1.41%) by the final year of the analysis period (Table 4.7). Because of the decrease in the state's output relative to the baseline scenario, total employment and labor force decrease by 1.45% and 1.67%, respectively, as compared to the base (Table 4.8). These changes correspond to a decrease of more than 6,000 in the labor force, and more than 8,000 jobs.

Results of 50% Budget. The second budget constrained-scenario represents a 50% reduction in total highway spending on resurfacing and reconstruction. The highway impacts of the reduced spending include an increase in IRI from 108 to 146, a reduction in travel speed of 4.6 miles per hour, and an increase in vehicle operating cost of $12 per 1,000 VMT. In effect, the projected pavement condition in 2024 drops from "good" to "fair." In the REMI analysis, these changes correspond to a decrease of nearly 24,000 jobs and workers, and a reduction of $1.35 billion of GRP (in 2004 dollars) in 2024. (Table 4.7) These decreases represent a 4.82% reduction in jobs, a 6.60% reduction in the labor force, and a 4.65% reduction in the GRP (Table 4.8).

Results of 25% Budget. The final budget-constrained scenario represents a 75% reduction in total highway spending on resurfacing and reconstruction. With this budget constraint, HERS-ST estimates that the average IRI in 2024 will be 184 instead of 108 (the forecasted value for the 100% funding level). In effect, average pavement condition will be classified as "poor" instead of "good." Because of poor highway conditions, the average travel speed decreases by 10.5 miles per hour, vehicle-operating cost increases by $14 per 1,000 VMT, and travel-time cost increases by $64 per 1,000 VMT. The REMI models project a decrease of more than 66,000 jobs, more than 56,000 workers, and $3.9 billion in GRP (in 2004 dollars) in the last year of the analysis (Table 4.7). These changes correspond to a 13.4% decrease in jobs, a 14.9% decrease in workers, and a 13.4% decrease in GRP (Table 4.8).

Effects on Imports and Exports. The percentage changes in imports and exports in 2024 are presented in Table 4.9. Imports from the rest of the nation consist of goods that originate outside of the state, but are consumed within the state. Exports to the rest of the nation refer to production originating within the state that is consumed outside of the state. Both imports and exports are affected by changes in supply, demand, or cost of production in the rest of nation, or changes in supply, demand, cost of production, or labor productivity in the state. Because the majority of North Dakota's production is consumed outside of the state, the exports to rest of nation values are indicative of the impact on the economy. Exports decrease by 1.9% in the 75% scenario, by 5.52% in the 50% scenario, and by 19.33% in the 25% scenario.

Table 4.9 Percentage Change in Imports and Exports Under Different Highway Funding Scenarios

	75%	**50%**	**25%**
Imports from Rest of Nation	-1.25%	-4.04%	-11.33%
Exports to Rest of Nation	-1.90%	-5.52%	-19.33%
Relative Cost of Production	0.53%	2.29%	5.87%
Relative Delivered Price	0.21%	0.88%	2.36%

Effects on Production Costs. The relative cost of production represents a cost index of production in North Dakota relative to the rest of the nation. For example, a 1% increase in the relative cost of production implies that it costs 1% more to produce in North Dakota than elsewhere in the United States. The relative cost of production is affected by changes in labor cost, the costs of structures, equipment, land, fuel, and the delivered price of intermediate inputs. As transportation costs increase, the composite cost of production increases because of the increased cost of obtaining these inputs. In the most extreme scenario, the relative cost of production is 5.87% higher than in the base scenario.

Effects on the Delivered Prices of Goods. The relative delivered price represents the price index of North Dakota production at the demand destination. The relative delivered price is affected by changes in production cost and changes in transportation cost to the final destination. For example, if transportation costs increase, both the cost of acquiring intermediate inputs and shipping production to destinations will increase. In turn, the relative delivered price will increase.

Effects on State Government Revenues. Changes in North Dakota's economy will result in changes to the revenues collected by the state. State revenue is estimated to decrease by 1.39% in the 75% scenario relative to the baseline. In the 50% scenario, REMI estimates that state revenue will decrease by 5.18%. Finally, in the 25% scenario, it is estimated that state revenue will be 12.64% less than in the baseline forecast.

Timing of Impacts. If the highway budget is reduced, pavement condition and congestion will worsen over time. The economic effects of less spending may be unnoticeable until 2010 (Figure 4.3). Most of the reduction in expected GRP growth will occur from 2012 to 2024. These effects will become more pronounced each year as highway conditions and congestion worsen. In turn, transportation costs will increase each year and the desirability of North Dakota as place for business growth will diminish.

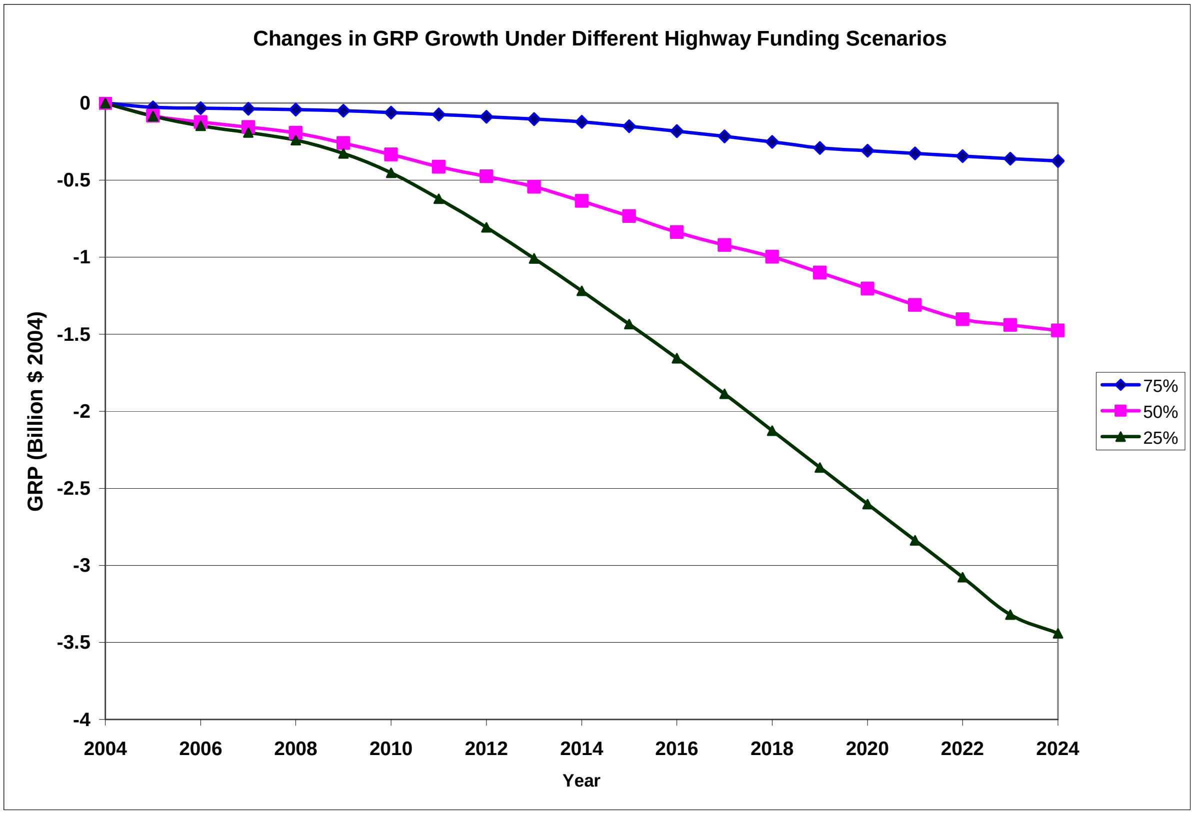

Figure 4.3 Projected Changes in GRP Growth in North Dakota as a Result of Different Highway Budget Constraints

5. Characteristics of Key Commodity Movements

The HERS-ST/REMI analysis encompasses all commodities and types of travel in North Dakota and, therefore, is comprehensive. Nevertheless, it is important to focus on major commodity flows in the state, especially in terms of changing traffic patterns and the effects of highway load limits.

As shown in Table 5.1, cereal grains, milled grain and bakery products and other foodstuffs comprise approximately 28% of the tonnage originated in North Dakota and 25% of the value of shipments. Coal comprises roughly 44% of the tonnage originated in North Dakota, but less than 2% of the value of shipments. Although machinery comprises 12% of the value of shipments, it comprises only .4% of the tonnage.

As Table 5.1 suggests, it is important to focus on grain, food processing, and manufacturing. To gain additional information, surveys of these industries were conducted. These surveys fulfill several purposes. They: (1) identify shipment volumes and traffic characteristics that are not available from published sources, (2) identify specific issues with highway load limits, and (3) collect critical information needed for model-building and analysis. The surveys are discussed next.

Table 5.1 Commodities that Comprise at Least 5% of the Value or Tonnage of Goods Originated in North Dakota

Commodity Group	**Percent of State Total**	
	Value	**Tons**
Cereal grains	12.0	21.5
Other agricultural products	5.2	4.2
Milled grain and bakery products and other foodstuffs	12.8	6.1
Coal	1.8	44.4
Gasoline and aviation turbine fuel	5.4	4.4
Machinery	12.2	0.4
Electronic, electrical, and office equipment	5.9	-
Motorized and other vehicles (including parts)	8.8	0.3
All Commodities	100	100

5.1 Survey of Grain Elevators

Farm-to-market movements are critical to North Dakota's economy. Most of the crops grown in North Dakota are of sufficient weights and densities to be affected by truck weight limits.[13] Therefore, it is important to analyze these movements in detail.

[13] For example, the volumetric capacity of a 48' x 102' semi-trailer is approximately 3,500 cubic feet. A commodity with a density of 16 lb/cu ft or greater will achieve a gross truck weight of 80,000 pounds before exhausting the internal capacity of the trailer. In comparison, the densities of wheat and barley are 48 and 39 lb/cu ft, respectively. In effect, most crops grown in North Dakota are constrained by truck weight limits, particularly with respect to movements in standard truck configurations.

Most elevators report their outbound shipments to the North Dakota Public Service Commission. However, these reports do not describe inbound movements. Approximately 400 elevators were surveyed to determine inbound shipment characteristics. The questionnaire is shown in Appendix A. Of this group, 120 usable questionnaires were returned.[14] These returns were matched with grain movement reports filed with the North Dakota Public Service Commission so that outbound elevator shipment information could be analyzed.

5.1.1 Importance of Shuttle-Train Elevators

Shuttle-train elevators ship more than 100 cars in a single unit train and, therefore, receive the lowest railroad rates. Shuttle-train elevators comprise only 14% of the respondents. Yet, these elevators account for 47% of the grain represented in the survey.

Shuttle facilities enhance North Dakota's capability to export large volumes of grain at the lowest transportation cost. This latter benefit is illustrated in Figure 5.1, which depicts a relationship between shuttle-train and single-car shipment costs at distances ranging from 250 to 2,000 miles. These costs have been computed from the Uniform Railroad Costing System (URCS) developed by the U.S. Surface Transportation Board. As shown in Figure 5.1, the cost incurred by railroads to move grain in single cars is 1.65 times the cost of movements in shuttle trains. At a distance of 1,500 miles, the difference in cost between these two options is more than $1,200 per car.

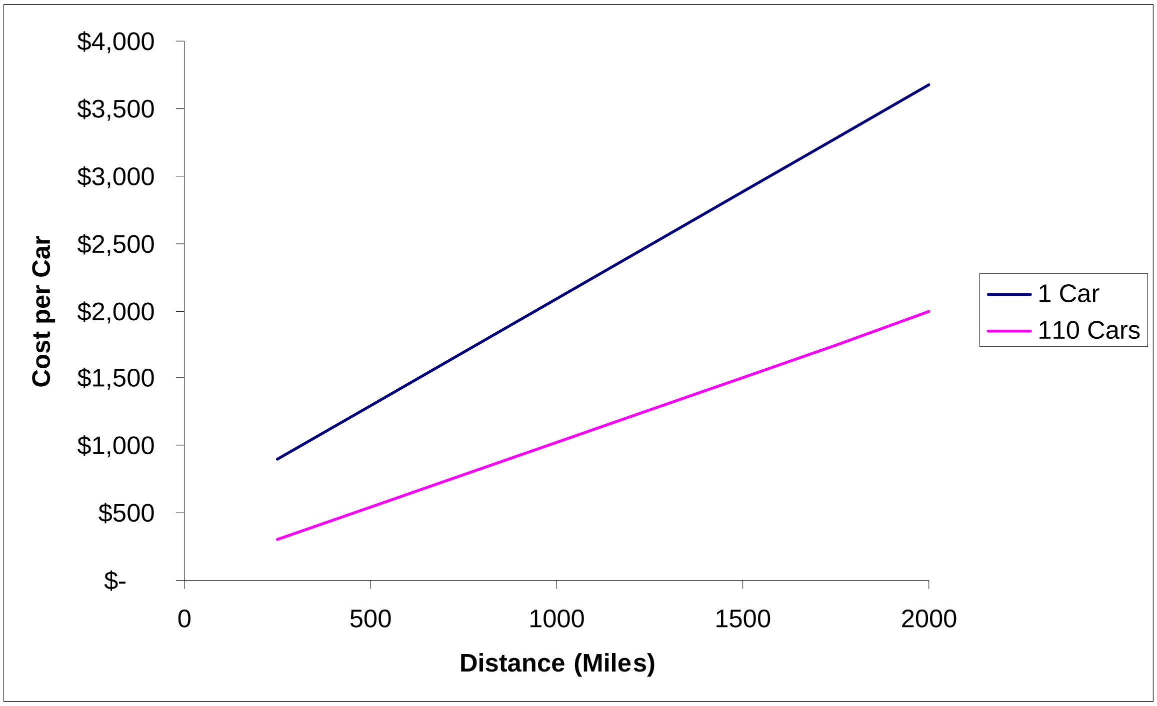

Figure 5.1 Illustration of Shuttle-Train and Single-Car Rail Costs

[14] However, some surveys did not include responses to all questions. Because of non-item response, the number of observations used in the statistical analyses is often less than 120.

As the illustration suggests, shuttle trains create efficiencies in the export movement of grain. Therefore, highway access to these facilities is of critical importance in enhancing the state's competitive position and increasing the potential for the sale of goods outside of the state.

5.1.2 Grain Delivery and Trucking Patterns

Approximately 81% of the grain received by elevators that responded to the survey was delivered directly from farms. Only 14% of the grain was received from another elevator. However, shuttle facilities received more than 18% of their grain from other elevators.

As shown in column 2 of Table 5.2, approximately 57% of the grain was delivered to elevators in semitrailers. Approximately 24% was delivered in single-unit tandem-axle trucks. Another 12% was transported in triaxle single-unit trucks. Rocky Mountain Doubles (a semitrailer with a pup) moved 4%. The other category includes older farm trucks such as the single-unit single-axle truck, which is primarily used on farms or for very short deliveries.

Table 5.2 Weighted-Average Percentages of Grain Deliveries to Elevators by Type of Truck and Class of Elevator

Truck Type	Elevator Class		
	All	**Shuttle**	**Non-Shuttle**
Single-Unit Tandem-Axle	24%	17%	31%
Single-Unit Triaxle	12%	10%	14%
Semitrailer	57%	67%	47%
Semitrailer with Pup Trailer	4%	4%	4%
Other	3%	2%	4%
Total	**100%**	**100%**	**100%**

Source: UGPTI Grain Elevator Survey 2005

The use of trucks differs significantly between shuttle-train and other elevators. As shown in column 3 of Table 5.2, approximately two-thirds of the grain delivered to shuttle-train elevators is moved in semitrailers. In comparison, only 47% of the grain delivered to other elevators is moved in semitrailers. The use of single-unit trucks is proportionately greater at elevators without shuttle-train service.

As shown in Table 5.3, Rocky Mountain Doubles are used primarily for long-distance travel. Approximately 75% of the grain transported in Rocky Mountain Doubles is moved farther than 20 miles. The use of semitrailers also increases with distance. In contrast, most deliveries in single-unit tandem-axle trucks travel less than 10 miles. Most deliveries in single-unit triaxle trucks travel between 10 and 20 miles. Collectively, these delivery patterns reflect the relative economics of truck types.

Table 5.3 Percentages of Grain Deliveries to Elevators by Distance Interval and Type of Truck

Truck Type	Distance Interval			
	< 10 mi.	**10 to 20 mi.**	**> 20 mi.**	**Total**
Single-Unit Tandem-Axle	51%	34%	15%	100%
Single-Unit Triaxle	36%	42%	22%	100%
Semitrailer	25%	35%	40%	100%
Semitrailer with Pup Trailer	7%	18%	75%	100%
Other	52%	28%	20%	100%

Source: UGPTI Grain Elevator Survey, 2005

5.1.3 Highway Access

Approximately half of the elevators that responded to the survey are located on or within one-half mile of a state highway. Another 40% are located within five miles of a state highway. Only 10% of these elevators are located farther than five miles from a state highway. The average distance to the nearest state highway is 1.67 miles for this group.

5.1.4 Agricultural GIS Network

A detailed GIS network of crop flows has been created using data from the elevator survey and other sources. This network consists of crop production zones, elevators, and the highways connecting them. In constructing the network, each county was subdivided into crop production zones. Centroids (or central traffic loading points) were defined for each zone. These crop centroids comprise the origins of the land-use network, while the elevators comprise the destinations. Collectively, these zones are referred to as *transportation analysis zones* (TAZ).

The annual crop production in each zone was estimated from satellite images of crop coverage and yields per acre. Estimates were generated for individual crops. These estimates were converted to truckloads using the percentages of grain transported in each type of truck, as derived from survey data. The annual demands at each elevator were estimated from grain movement reports filed with the Public Service Commission.

The estimated truckloads at the production zones were distributed among elevators using a gravity model. This model distributes crop production to elevators so that elevator demands are met and as much grain as possible is moved from farms. The distribution is inversely related to transportation cost, which is a function of distance and time. In effect, transportation cost is the impedance to flow within the network.

The GIS network and gravity model are used within Cube to route grain trucks from production zones to elevators and assign these trips to the highway network. The trips on each highway segment are accumulated to derive annualized estimates of truck travel. To analyze the effects of seasonal load limits, the estimated trips are partitioned into unrestricted and seasonally-restricted quantities. The seasonally-restricted trips are those which occur during the spring months when load limits are applied. This process is detailed in section 6.

5.2 Survey of Manufacturers and Processors

5.2.1 Sample Frame and Survey Methods

A preliminary survey was sent to 1,400 manufacturing and processing businesses from a company list supplied by the North Dakota Department of Commerce. The purpose of the preliminary survey was to ensure that the initial contact information was correct and to determine who was responsible for the shipping and/or logistics functions of the company. The individual responsible was asked to verify the company's information and indicate if the company used a third party for transportation and logistics. If respondents answered "Yes" to this question, they were asked to provide additional information on the third party.[15]

After the preliminary survey, a more extensive questionnaire was mailed to 1,031 manufacturing and processing businesses who indicated some interest in responding. Because of the low initial response rate to the mailed questionnaire, companies were randomly selected from the contact list for follow-up telephone interviews. During the telephone survey, we discovered that numerous companies on the contact list do not utilize truck, rail, container, or air freight shipping services. After accounting for these situations, we found that 847 companies should be included in the survey. Altogether, 188 responses were received from these companies through mail or telephone surveys. This response rate of 22% is satisfactory considering the length and scope of the survey.

5.2.2 Expanding the Survey

The information obtained from the sample was expanded to the population of manufacturers located in North Dakota. In doing so, the NAICS codes and the reported number of employees were used. For each industry, it is assumed that the number of employees is directly correlated to the volume of business activities, and thus to transportation levels.

The expansion process follows. (1) The respondents are divided into NAICS groups. (2) The average value of each sample variable (x) is estimated for each NAICS category. (3) A series of ratios are computed. The ratio R_x represents the ratio of the average value of a survey variable (e.g., inbound truckloads) to the average number of employees for the respondents in the NAICS group. (4) The number of employees for each manufacturer in the population database is multiplied by the series of ratios or R_x values specific to the NAICS code of the company. In this way, population values are estimated from sample values.

5.2.3 Use of Transportation Modes

If the survey is representative of the population, North Dakota manufacturers originated 1.179 million outbound shipments in 2004 (Table 5.4). These shipments represented 18.642 million tons of freight. Approximately 44% of these tons moved in truckload shipments. Another 24% moved as less-than-truckload (LTL) freight. Nearly 32% of the tons moved in rail carloads. Less than one percent of the originated tonnage was shipped in containers or as air freight. However, air freight comprised nearly 9% of originated shipments.

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[15] The manufacturer/processor contact list compiled from the preliminary survey and the original contact list from the North Dakota Department of Commerce includes company names, addresses and contact information; North American Industry Classification System (NAICS) code and category; business description and number of employees; and whether or not the business is an exporter.

Table 5.4 Percent of Outbound Shipments from Manufacturers and Processors by Mode of Shipment

Mode of Shipment	Percent of Shipments	Percent of Tons
Truckload (TL)	64.55%	43.66%
Less-Than Truckload (LTL)	19.68%	23.85%
Rail Carloads	5.19%	31.69%
20' Containers	0.25%	0.10%
40' Containers	1.73%	0.61%
Air Freight (Motor Carrier Pickup & Delivery)	8.60%	0.09%

If the survey is representative of the population, North Dakota manufacturers received 6.17 million shipments in 2004. These shipments represented 15.34 million tons of freight. Approximately 69% of these tons consisted of truckload freight (Table 5.5). Another 20% moved as LTL freight. Only 11% moved as rail freight. Less than 1% of the tonnage received by North Dakota manufacturers was shipped in containers or as air freight.

Table 5.5 Percent of Inbound Shipments to Manufacturers and Processors by Mode of Shipment

Mode of Shipment	Percent of Shipments	Percent of Tons
Truckload (TL)	70.16%	68.82%
Less-Than Truckload (LTL)	24.73%	19.98%
Rail Carloads	4.86%	10.98%
20' Containers	0.01%	0.04%
40' Containers	0.14%	0.15%
Air Freight (Motor Carrier Pickup & Delivery)	0.10%	0.03%

5.2.4 Manufacturing/Processing GIS Network

In the survey, manufacturers and processors were asked to distribute their inbound and outbound shipments among regions or zones. This information was used to create an origin-destination matrix and GIS network. In this process, counties in North Dakota were defined as transportation analysis zones. A matrix was estimated of inbound flows of materials from counties to cities, and outbound flows of finished goods from cities to counties. In the GIS network, trip attraction zones were defined for both in-state and out-of-state locations. The out-of-state zones include: Minnesota, South Dakota, Saskatchewan and West Canada, and Manitoba and East Canada. The trip matrix was linked to the Cube transportation planning software and the truck trips were assigned to the highway network. This information was used in the highway load limit analysis described in section 6.

6. Analysis of Highway Load Limits

In this section of the report, the effects of highway load limits are explicitly analyzed. Two aspects of load limits may pose issues: (1) seasonal (spring) load restrictions, and (2) legal load limits that apply during the remainder of the year. This latter category reflects published gross vehicle weight limits for state and county roads, which are typically 80,000 or 105,500 pounds.[16]

Seasonal load restrictions are usually applied between mid-March and mid-May. However, the duration of these restrictions is typically eight weeks or less in any area of the state. Seasonal load limits affect only a small portion of truck movements. Many trucks are lightly loaded with goods that utilize the cubic cargo space of trailers before seasonal limits necessitate a reduction in tonnage. Most LTL shipments fall into this category, as well as many truckload shipments of electronics and other consumer goods. However, shipments of equipment, heavy machinery, grain, crude oil, and indivisible bulk or neo-bulk goods may be impacted by seasonal load restrictions.

6.1 North Dakota Spring Load Restrictions

The current NDDOT spring load restrictions are summarized in Table 6.1. At the 8-ton limit, a five-axle tractor-semitrailer can weigh 80,000 pounds (the legal limit) only if 16,000 pounds can be distributed to the steering axle. Typically, this is impractical, as tire weight regulations and other considerations prevent the steering axle weight from reaching this limit. At the 7-ton limit, a five-axle tractor-semitrailer can weigh 70,000 pounds if 14,000 pounds can be distributed to the steering axle. At the 6-ton limit, a 5-axle tractor-semitrailer can weigh only 60,000 pounds. The five- and six-ton limits are very restrictive, but are not frequently encountered on state highways.

Table 6.1 Spring Load Restrictions on State Highways in North Dakota

Class	Single Axle	Tandem Axle	3 Axles	Gross Vehicle Weight
Legal Weights	20,000 lb	34,000 lb	48,000 lb	105,500 lb
8-ton	16,000 lb	32,000 lb	42,000 lb	105,500 lb
7-ton	14,000 lb	28,000 lb	36,000 lb	105,500 lb
6-ton	12,000 lb	24,000 lb	30,000 lb	80,000 lb
5-ton	10,000 lb	20,000 lb	30,000 lb	80,000 lb

6.2 The Cost of Removing Seasonal Highway Load Limits

Gross vehicle weight (GVW) limits and spring load restrictions are commonplace in the northern tier of the United States and in the Canadian Provinces. Restrictions are needed to protect the investment in the highway network year round and from the damage that can occur during the spring thaw period. Adjust-ments are also made seasonally to increase the allowable loads in winter to enhance the economic movement of commerce.[17] The state highway system utilizes spring load restrictions on various segments of roadway to reduce the potential for damage when the roadbed is in a weakened state during thaw. The

[16] With few exceptions, trucks weighing 105,500 pounds are allowed to operate on state highways except during temporary periods of load restriction. Therefore, the state highway analysis focuses on the benefits of eliminating or reducing spring load restrictions rather than changing legal weight limits.

[17] Typically, the NDDOT allows a 10% increase in loads on trucks hauling agricultural commodities from December to March. This is a substantial benefit to producers that may offset some of the impacts of spring load restrictions.

alternative to placing spring restrictions is to increase the structural capacity of those segments restricted during thaw each year.

Following are the results of an analysis undertaken to determine the costs of completely eliminating the need for spring restrictions on all segments as well as incrementally raising segments to a higher level of restriction—one which is less restrictive to commerce. In order to conduct the analysis, several assumptions were made. The original analysis used just two alternatives; a structural overlay or reconstruction where the roadway segment wasn't wide enough to accommodate the overlay alternative. The original analysis estimated costs well in excess of a half billion dollars to remove restrictions on all segments of state highway. Because of the excessive costs, a second analysis was completed using different strategies consisting of either an overlay or, in the case where the roadway wasn't wide enough, an overlay with a wedge widening of the segment on State Corridors, District Corridors, and District Collectors. The analysis was further expanded to investigate costs by system to raise the spring capacity to levels of lesser restriction; for example, raising all 6-ton roads to 7-ton roads, raising all 6- and 7-ton roads to 8-ton roads, and raising all roads to the year-round legal GVW. The overlay thickness for each of the different strategies was estimated using the AASHTO pavement design guide.

The strategies and unit costs are listed in Table 6.2 for individual Highway Performance Classification Systems (HPCS). The unit costs are incremental. They reflect the additional thickness needed beyond a simple resurfacing overlay to eliminate the spring load restriction. Either structural overlays or reconstruction are used for interregional highways because they carry high traffic levels.

The results of the second analysis are lower than the first, yet there is a substantial cost to completely remove load restrictions. The costs for each strategy, arranged by system, are summarized in Table 6.3. To raise all state highways restricted to 6-ton limits to 7 tons would cost $39.225 million. To raise all state highways restricted to 6- and 7-ton limits to 8 tons would cost $141.3 million. To raise all state highways restricted to 6-, 7-, or 8-ton limits to legal weights would cost $292.1 million.

The costs shown in Table 6.3 do not include the cost of eliminating spring load restrictions on county roads. Even if spring load limits are eliminated on state highways, substantial costs would be incurred to eliminate restrictions on county roads. Otherwise, the full benefits of improvements to state highways may not be realized. Moreover, the unit costs shown in Table 6.2 are based on 2005 construction costs and are quite conservative. The costs of bituminous and concrete have increased 20 to 30% since these unit costs were developed. In effect, the cost estimates to remove spring load restrictions are significantly greater than the estimates we have used.

Table 6.2 Strategies and Unit Costs to Eliminate Spring Load Restrictions on State Highways

Restriction Level	HPCS and Pavement Type	Overlay Treatment	Overlay Cost/Mile	Overlay with 3ft (both sides) wedge widening
	State Collector			
8 to none	AC	2 inch overlay	$60,000	$85,000
7 to 8	AC	2 inch overlay	$60,000	$85,000
7 to none	AC	4 inch overlay	$100,000	$125,000
	District Corridor			
6 to 7	AC	2 inch overlay	$50,000	$75,000
6 to 8	AC	3 inch overlay	$75,000	$100,000
7 to 8	AC	2 inch overlay	$50,000	$75,000
None	AC	4 inch overlay	$100,000	$125,000
	District Collector			
6 to 7	AC	2 inch overlay	$50,000	$75,000
6 to 8	AC	3 inch overlay	$75,000	$100,000
7 to 8	AC	2 inch overlay	$50,000	$75,000
None	AC	4 inch overlay	$100,000	$125,000

Table 6.3 Costs to Eliminate Some or All Spring Load Restrictions on State Highways

	The Costs to Raise All State Highway Segments to:		
HPCS	**Legal Weight**	**8-Ton**	**7-Ton**
Interregional	$23,000,000		
State Corridor	$27,100,000		
District Corridor	$122,000,000	$62,575,000	$6,600,000
District Collector	$120,000,000	$78,725,000	$32,625,000
Total	$292,100,000	$141,300,000	$39,225,000

6.3 The Effects of Seasonal Load Limits on Grain

Impacts on grain transportation are estimated using the GIS-Cube model described previously. In this model, 2004 crop production levels and the volumes of grain handled at individual elevators are used to compute an origin-destination trip matrix. The annual grain movements from production zones to elevators are partitioned into two sets: (1) those movements subject to seasonal load restrictions, and (2) those movements subject to legal load limits. This partition is based on the percentages of each crop marketed during the year (Table 6.4). The load restriction period is assumed to apply for an eight-week period.

Table 6.4 Percent of Crops Marketed by Month

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wheat	11	9	9	5	3	3	9	14	11	7	8	11
Barley	8	8	9	4	2	11	5	18	11	8	7	9
Oats	13	3	10	15	3	4	6	11	10	8	7	10
Corn	15	11	9	7	5	6	6	6	2	9	13	11
Sunflowers	10	8	11	5	2	4	5	2	3	29	11	10
Beans	10	9	9	7	6	4	6	3	17	13	4	12
Soybeans	15	6	3	2	1	1	2	1	6	40	14	9

North Dakota Agricultural Statistics 2005. North Dakota Agricultural Statistics Service, ND-NASS, Fargo, N.D., 2005.

6.3.1 Impacts of Load Limits on Grain Trucking Cost

To assess the impacts of seasonal load limits, it is necessary to estimate trucking costs with and without the limits. Truck costs are measured on a ton-mile basis. Only variable costs are used in the analysis because fixed ownership costs and annual fees are not affected by route selection or individual trip decisions. However, the cost of fuel, labor, tires, truck maintenance, and other use-related expenditures are directly affected by seasonal load limits. Farmers must detour around the load restriction (and incur additional vehicle-miles and vehicle-hours of travel) or make more trips via the same route with reduced loads. In either case, farmers incur additional transportation costs that are not incurred when the seasonal load limits are lifted.

Table 6.5 shows estimated cost relationships for farmer-owned trucks at various weight restrictions.[18] Columns 3, 4, and 5 depict the ratios of variable trucking cost at 8-ton, 7-ton, and 6-ton restrictions to the unrestricted trucking cost at the legal weight (which is 80,000 pounds for the trucks shown in Table 6.5). As the table shows, the cost per ton-mile of a single-unit tandem-axle truck under a 6-ton load restriction is 1.51 times the cost of the same truck operating at the legal weight. Similarly, the cost per ton-mile of a tractor-semitrailer under a 6-ton load restriction is 1.62 times the cost of the same truck operating at the legal weight.

[18] The cost to transport one ton of grain in a fully loaded Rocky Mountain Double is less than the cost of moving one ton in a five-axle tractor-semitrailer at commercial utilization rates of 100,000 miles per year. However, most farmer-owned trucks are utilized much less. Therefore, the costs per ton-mile of operating farmer-owned trucks are much higher than commercial truck costs. When low utilization rates are considered, the cost per ton-mile of operating a Rocky Mountain Double may actually be greater than the cost of a five-axle tractor-semitrailer. This is one reason why very few deliveries made by farmers utilize Rocky Mountain Doubles. For these reasons, the seasonal load limit analysis focuses on the five-axle tractor-semitrailer.

Table 6.5 Costs per Ton-Mile for Farmer-Owned Grain Trucks at Various Levels of Spring Highway Load Restrictions in Relation to Truck Costs at Legal Weights

Truck Configuration	Restricted by Legal Weight	8-Ton Restriction	7-Ton Restriction	6-Ton Restriction
Single-Unit Tandem-Axle	1.00	1.07	1.27	1.51
Single-Unit Triaxle	1.00	1.17	1.41	1.72
Tractor-Semitrailer (5-axle)	1.00	1.07	1.28	1.62

6.3.2 Annual Cost Impacts on Grain

The annual impacts of seasonal load limits on grain transportation are summarized in Table 6.6. Using the Cube/GIS models, we estimate that seasonal load limits result in an additional 570,734 vehicle-miles of travel and an additional 8,786 hours of travel. The additional distance and time result in an annual cost of approximately $1.23 million.

Table 6.6 Annual Impacts of Seasonal Highway Load Limits on Grain Transportation Cost

Impact Factor	Annual Value
Incremental Vehicle-Miles of Travel	570,734
Incremental Vehicle-Hours of Travel	8,786
Incremental Cost	$1,227,599

6.4 Annual Impacts on Manufactured and Processed Goods

As noted earlier, a GIS network model was created from survey data and county statistics. All 837 manufacturing and processing companies in the population database were located according to their geographic references. The reported shipments of the 188 companies that responded to the survey were used to compute the annual truck trips generated from (or attracted to) these facilities. For all other companies, the trips generated and attracted were estimated from the number of employees, using the ratios described previously. The predicted trips for all facilities were aggregated to the city and county levels. This origin-destination matrix was then linked to Cube and the predicted trips were routed and assigned to highway segments.

Most manufactured goods are transported by commercial trucking companies. Commercial trucking rates vary widely and are unknown. In this study, truck rates are assumed to be greater than or equal to the full cost of private trucking at commercial utilization rates. Using the Cube/GIS model and full trucking costs, we have estimated that seasonal load limits in North Dakota result in an additional 1.73 million vehicle-miles of travel and an additional 29,242 hours of travel for manufactured and processed goods. The additional distance and time result in an annual cost of approximately $1.3 million.

Table 6.7 Annual Impacts of Seasonal Highway Load Limits on the Transportation Cost of Manufactured and Processed Goods in North Dakota

Impact Factor	Annual Value
Incremental Vehicle-Miles of Travel	1,733,224
Incremental Vehicle-Hours of Travel	29,242
Incremental Cost	$1,288,634

6.5 Economic Impacts of Load Limits

In this section of the report, the economic impacts of eliminating spring load limits are examined. There are several key assumptions in this analysis. The highway improvements are completed over a five-year period. The total cost of $292 million is divided evenly over the five-year period from 2005-2010. It is assumed that the projects are funded through a $23.446 million increase in state fuel tax, and a $23.446 million increase in state income tax over the same five-year period. The transportation cost savings for the agricultural and manufacturing industries are phased in as the improvements are implemented, reaching their full impact in 2010 and remaining throughout the analysis period.

As Figure 6.1 shows, there is an initial increase in output over the first year of construction. The initial impact is $8.7 million. Over the next few years, the impacts of the construction spending are muted by the impacts of the increased income and fuel taxes. Once 2010 is reached, the impact of the construction spending is over, yet the impact of the tax increases remain. The impact drops from $5.3 million to -$2.4 million. The impact of the increased fuel and income tax relative to the baseline forecast are evident. As the tax increase is completed in 2010, the economy rebounds over the next 15 years to -$307,000 in 2024. In effect, the negative tax-related effects of obtaining the additional construction funds outweigh the transportation cost savings and economic spending effects.

6.6 Conclusions: Highway Load Limits

It is not cost-effective to remove spring load limits from all state highways. The total estimated cost is $292 million. To justify this expenditure, the present value of all future cost savings must be equal to $292 million. If freight benefits are projected over a 20-year period, approximately $20 million in annual cost savings are needed to achieve a minimum B/C ratio of 1.0. The estimated cost savings to grain and manufactured goods are roughly $2.6 million per year. Other cost savings may be quantified for potatoes, sugarbeets, oil, and other goods. However, the cumulative effects of these impacts are unlikely to equal $20 million per year. Nevertheless, the B/C ratios of projects that would eliminate spring load restrictions on certain key highways (such as highways providing access to shuttle-train elevators, processing plants, and industrial parks) may be quite good. Therefore, UGPTI should work with NDDOT to conduct individual analyses of key highways and determine if these highways should be improved to eliminate spring load restrictions.

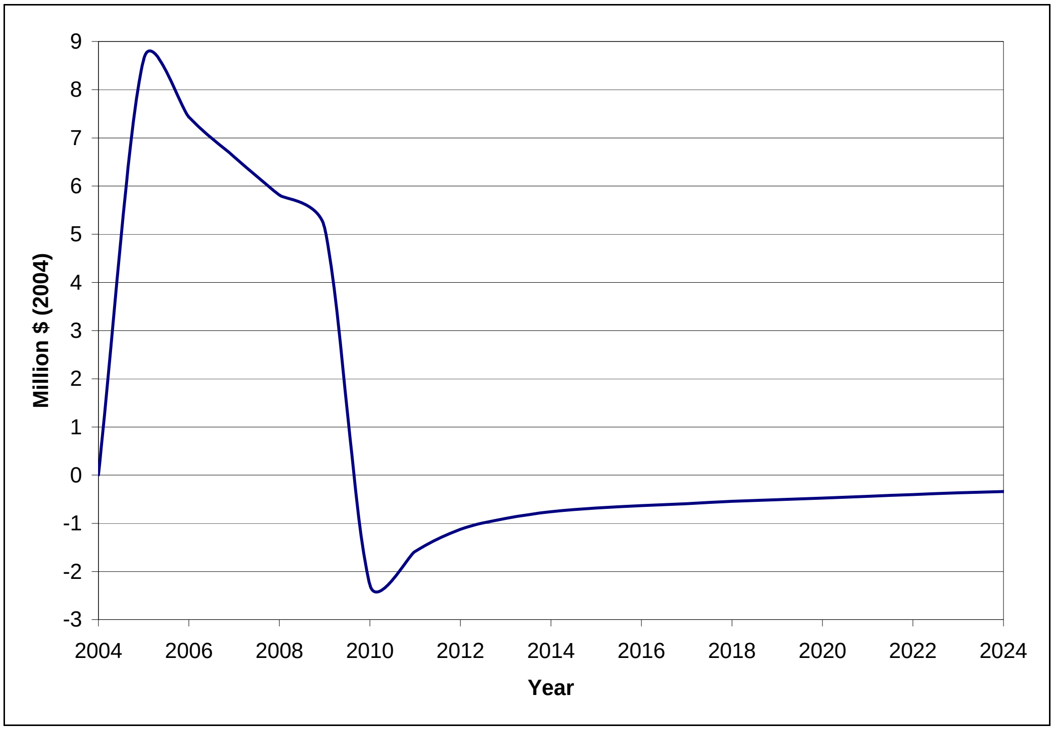

Figure 6.1 The Economic Effects of Eliminating Spring Load Restrictions in North Dakota

In the future, more precise modeling of subgrade soils and truck damage during spring thaw may be possible using new mechanistic procedures contained in the 2002 pavement design guidelines. More precise modeling of effects may allow the durations of load limits to be reduced in some cases, thereby reducing the impacts. However, at present, these shorter durations cannot be quantified to the extent that benefits can be measured.

6.7 Gross Vehicle Weight Limits

With few exceptions, the state highway system is open to Rocky Mountain Doubles. The state supports an extensive truck network which allows the operation of 53-ft semitrailers and twin 28-ft trailers throughout the state.[19] With trip permits, truckers can use triple trailers, turnpike doubles, and Rocky Mountain Doubles on Interstate highways. In effect, the state truck network and permitting system allow access for larger efficient trucks. However, the weights of these vehicles must conform to Bridge Formula B.

For the most part, it is practical for truckers to operate efficient vehicles in North Dakota with gross vehicle weights of 105,500 pounds. However, these same trucks are not allowed in Minnesota and in some counties in North Dakota. Thus, the primary issue with respect to gross vehicle weight limits is the inconsistency among counties and states.

A separate UGPTI study sponsored by NDDOT has examined truck size and weight limits. The final report from that study should be published soon. However, the truck size and weight study does not quantify the benefits and costs of raising county road weight limits. Such a study would require the development of detailed data and cost estimates for county roads. In addition to economic considerations, safety and other issues must be addressed. A potential cost-effective approach would be to select several

[19] A few exceptions exist because of roadway geometry or safety issues.

counties as case studies, and work with the counties to develop the inputs needed to quantify the benefits and costs.

6.8 Recommendations Regarding Highway Infrastructure Investment

The HERS-ST/REMI analysis in section 5 quantified the benefits of full funding of highway improvements to preserve the condition of the system, mitigate alignment and shoulder deficiencies, and add needed capacity. The effects of spring load restrictions were analyzed in section 6. Several recommendations regarding highway infrastructure are presented in this section.

1. The NDDOT is focused on a preservation program that keeps pavements in good condition. These programs generate substantial economic benefits and should be continued. Over time, NDDOT should continue to improve alignments and shoulders where needed, achieving greater standardization in key interregional corridors that are heavily traveled by trucks.
2. Access to key industrial and agricultural facilities should be analyzed on a case-by-case basis. These facilities include shuttle-train elevators, processing plants, and other key industrial facilities. The potential may exist for significant expansion of ethanol processing in North Dakota. New facilities may be constructed in the next two years. UGPTI should work with NDDOT to analyze highway access to these facilities and better understand their transportation needs.
3. The benefits and costs of eliminating or mitigating spring load limits on key highway segments should be analyzed on a case-by-case basis, especially those segments with higher traffic levels that serve facilities which export commodities from the state. For example, Figure 6.2 shows the highways which have traffic diverted from them during spring restrictions. In some cases, clusters of segments are located in the vicinities of shuttle elevators. Subsets of these highway segments should be analyzed individually to determine if the benefits of removing the restrictions exceed the costs.
4. New mechanistic pavement analysis techniques offer the potential for improved forecasting of pavement lives and conditions. When combined with life-cycle cost analysis, these improved methods may make it possible to shorten the durations of spring load restrictions in some cases, and identify more cost-effective designs. Thus, it is important to develop the data and inputs necessary to fully utilize these advanced procedures.
5. Selective case studies should be undertaken of highway load limits in counties. A great deal of information must be developed to assess the benefits and costs of uniform county load limits. Thus, a cost-effective analysis plan must be developed that includes representative counties throughout the state.

Several key trends are likely to affect the future demand for highway services in the state. Shuttle elevators will become increasingly important to the export of grains from North Dakota. Year-round (unrestricted) highway access to these facilities will become more important. However, some shuttle facilities may have locational advantages over others. Although the network is approaching maturity, it is somewhat fluid. Future additions and disappearances of facilities are likely. Therefore, highway investment plans to serve shuttle facilities must consider potential changes in the network of facilities. Moreover, broader changes in the agricultural economy may affect the shuttle network. In particular, the growth of ethanol processing and the location of new facilities may affect crop patterns and elevator utilization.

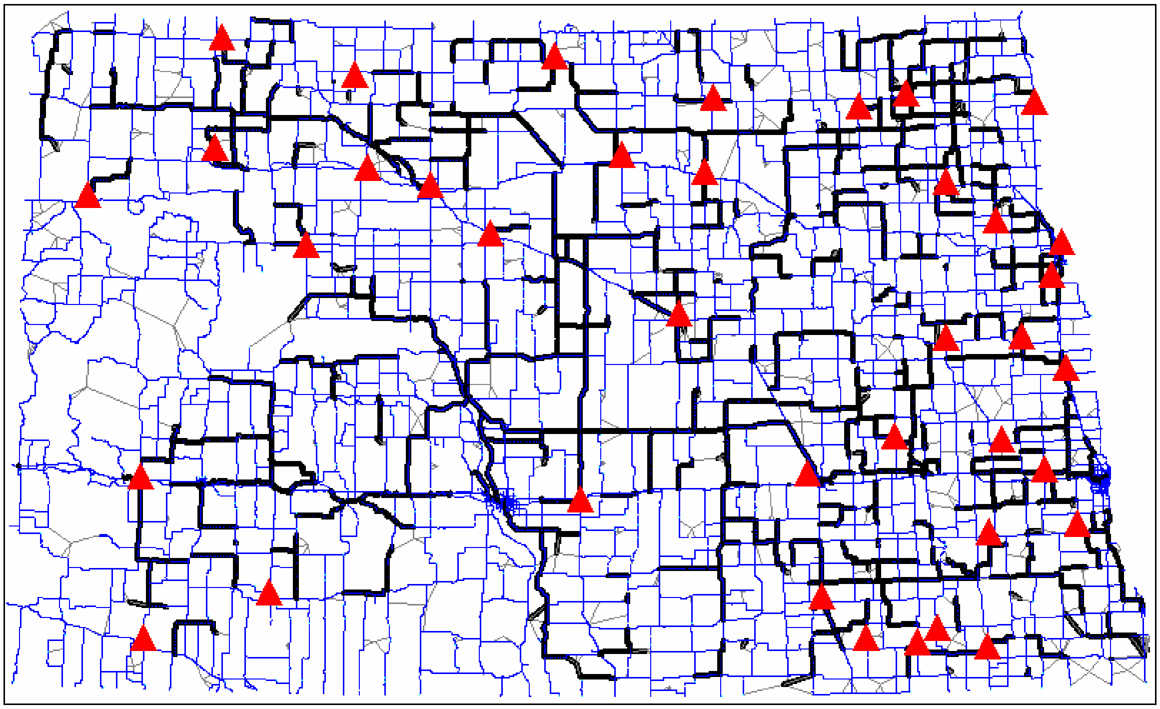

Figure 6.2 Highway Segments Impacted by Spring Load Restrictions and the Locations of Shuttle-Train Elevators in North Dakota

7. Railroad Analysis

The legislative language directs us to analyze an apparent decline in rail services and the prospects of offering incentives to railroad companies to provide more services. In this section of the report, an overview is presented of railroad transportation. Afterwards, a quantitative analysis is presented of the benefits of preserving the regional and branch line network in North Dakota. In conclusion, an overview is presented of the North Dakota rail investment program and potential incentives to encourage expanded rail services.

Rail Freight Services

Major Commodities Transported by Rail. As shown in Table 7.1, farm products comprise 54% of the freight tonnage originated by railroads in North Dakota. Coal and chemicals is the second largest commodity group. However, coal comprises 61% of the freight tonnage terminated by railroads in North Dakota (Table 7.2). In comparison, grain comprises only 10% of the freight tonnage terminated by railroads in North Dakota.

Table 7.1 Top Commodities Originated by Railroads in North Dakota

Commodity	**Tons of Freight**	**Percent of Total**
Farm Products	12,234,397	54
Coal & Chemicals	4,934,702	22
Food Products	4,465,102	20
Waste & Scrap	488,196	2
Petroleum or Coal Products	214,412	1

Source: American Association of Railroads, 2005.

Table 7.2 Top Commodities Terminated by Railroads in North Dakota

Commodity	**Tons of Freight**	**Percent of Total**
Coal	5,562,028	61
Farm Products	863,190	10
Chemicals	721,128	8
Glass & Stone Products	556,040	6
Nonmetallic Minerals	555,144	6

Source: American Association of Railroads, 2005.

Railroad Share of Grain Traffic. In most crop years, railroads transport more than 70% of the grains and oilseeds originated from North Dakota. In crop year 2004-2005, railroads transported 78% of these crops. Although the railroads’ share may fluctuate from year-to-year, railroads are the principal mode of grain transportation in the state. More than 60% of the grain tonnage is shipped in blocks of 50 cars or more.

Miles of Rail Line Abandoned. Approximately 1,650 miles of railroad have been abandoned in North Dakota since 1936. Only 26 of these miles were abandoned prior to 1970. Most of the rationalization occurred during the 1980s, when 715 miles of line were abandoned. Since 2000, 373 miles have been abandoned in the state. The timing of abandonment reflects deregulation and the cumulative impacts of deferred track maintenance during the 1960s and 1970s.

Use of Heavy Axle-Load Cars. A transition to heavier rail cars has been underway in the United States for some time. In the 1970s, much of the branch line network was restricted to gross car weights of 220,000 pounds, which allowed net loads of 70 to 80 tons. However, the need for effective use of 100-ton hopper cars resulted in branch line capacity limits being raised to 263,000 pounds. Today, most Class I railroad main lines allow 286,000-pound or 143-ton cars, which allow loads of 110 to 115 tons, depending on the commodity density and tare weight of the freight car. Some railroads operate 315,000-pound cars in designated mainline corridors. These 315-kip (315,000-pound) cars accommodate net loads of 125 tons. The term *heavy axle load* (HAL) is used to describe cars with gross loads of 263,000 pounds or greater.

Efficiency Gains of Large Cars. Larger rail cars offer many cost savings to mainline railroads because of their higher net weight-to-tare weight ratios. Higher net-to-tare weight ratios reduce the annual car miles required to haul a given tonnage, and thus reduce car ownership costs per ton. Higher net-to-tare ratios also reduce the number of axles required to haul an equivalent train weight, which reduces train resistance and fuel cost per ton-mile. Finally, larger cars used in unit train service reduce labor costs per ton-mile because a given train length is comprised of more revenue tons.

Impacts of Heavy Axle-Load Cars on Railroad Infrastructure. While the gross weights of freight cars have been increasing over time, the basic axle design has remained the same. Most freight cars still have the same number of axles (four) and wheels (eight). Although the diameters of car wheels have increased over time, wheel loads have increased with gross car weights. The axle and wheel loads are important because the weight of the railcar is transmitted to the rails and underlying track structure through them.

Specific Branch Line Issues. HAL cars may pose problems for regional railroads and branch lines. Regional railroads interchange most of their traffic with Class I carriers. To remain viable in the future, these railroads need to handle HAL cars. However these cars exacerbate four branch line problem areas: (1) light rails (e.g., rail weighing 100-pounds per yard or less), (2) thin ballast sections (e.g., less than a foot of ballast under the ties), (3) deferred tie maintenance, and (4) old bridges. Much of the branch line network in North Dakota is built with 90-pound rail or lighter. In hard financial times, some of these lines may have suffered from deferred maintenance. According to survey data, many of these miles have thin ballast sections and a substantial number of defective crossties. Most branch line bridges were built decades ago in an era of relatively light car weights. Many of these older bridges are timber structures that have been exposed to the elements for more than 100 years.

Slow-Speed Operations. Today, some regional railroads are handling HAL cars by moving at very slow speeds (e.g., less than 10 mph). This is a short-run response to a long-run problem. Higher speeds increase the dynamic effects of wheel loads. Car wheels tend to move about on the rail surface in response to irregularities. Moreover, the jointed rails that are present in many branch line tracks increase car motion and amplify periodic oscillations. On the positive side, higher speeds offer many efficiency benefits and may be necessary for long-term survival. It is doubtful that regional railroads can make the transition to HAL cars simply by operating at very slow speeds. The opportunity cost of the freight cars, crews, and other productive assets is too great for these types of operations. Moreover, slow-speed operations diminish the attractiveness of rail services for manufacturing and processing industries.

7.2 Analysis of the External Benefits of North Dakota's Branch Line and Regional Railroad Network

Maintaining the branch line and regional railroad network in North Dakota ensures a cost-effective means of transportation between grain-producing areas of the state and regional, national, and world markets. This analysis estimates the external benefits of the branch line and regional railroad network to rail shippers and the state as a whole.

In this analysis, it is assumed that Class I mainlines will exist in North Dakota, even if there is no traffic originating or terminating in the state. All four of the state's mainlines consist of a large volume of through traffic which is assumed to continue into the future. The remaining lines are the subject of this analysis. These lines include the Northern Plains Railroad, Red River Valley & Western Railroad, Dakota Missouri Valley & Western Railroad, and the Canadian Pacific Railway and BNSF Railway branch lines.

The vast majority of shippers located on the branch line and regional railroad system in North Dakota are grain elevators, which are the primary focus of this study. To assess the economic impact of rail service to these elevators, a scenario analysis is performed. Two specific scenarios are presented. The first represents a scenario where branch line elevators lose rail service, but remain in business. It is assumed that if rail service is lost, these elevators will truck their grain throughput to the closest mainline elevator. The incremental cost in the first scenario represents an increased transportation and grain-handling cost. The second scenario represents the closing of branch line elevators, requiring farmers to travel to the mainline to sell grain. The incremental cost of this scenario is the increased transportation cost.

7.3 Scenario 1: Branch line Elevator to Mainline Elevator Shipment

Key Assumptions. It is assumed that the rail system will remain operable with no routine maintenance for eight years, deteriorating in a linear manner. It is also assumed that all shipments from the branch line elevators will be trucked to the nearest mainline elevator or mainline shuttle elevator. No backhaul from the mainline elevator is estimated. The final assumption is that all grain transported to the mainline elevator will be transported in five-axle tractor-semitrailer (3-S2) trucks.

Background. The distances from each branch line elevator to the nearest mainline elevator and the nearest mainline shuttle elevator were calculated. The averages were then weighted by the elevator throughput.[20] The average distance to the nearest mainline elevator, weighted by throughput, is 35.10 miles. If the branch line system in North Dakota did not exist, all branch line shipments, on average, would travel via truck 35.10 miles to the nearest mainline elevator.

Incremental Truck Trips. As mentioned above, it is assumed that all shipments will occur in 3-S2 trucks. The total number of trips generated in this scenario is estimated to be 234,266 loaded trucks. An increase in the number of loaded truck trips has an impact on the deterioration rate of pavements in the areas surrounding mainline elevators. Table 7.3 outlines the marginal pavement cost of truck travel on rural highways per loaded mile by highway type.

[20] Elevator grain movement data obtained from North Dakota Public Service Commission Grain Movement Database.

Table 7.3 Estimated Marginal Pavement Costs of Truck Travel on Rural Highways (2004 Dollars)

Type of Highway	Cost per Loaded Mile
Rural Interstate	$ 0.134
Principal Arterial	$ 0.187
Minor Arterial	$ 0.858
Major Collector	$ 3.134
Minor Collector	$ 5.150

Direct Impacts. If no rail investment is made, it is assumed that the current rail system will deteriorate until it is completely abandoned in 2013. It is estimated that at the end of this eight-year period, when all traffic has shifted to highways, the total transportation cost increase for the transshipment of grain will be $7.08 million per year (Table 7.4). Also, the elevator handling cost will increase by $0.05 per bushel for a total increase of $10.83 million. The addition of 234,266 additional truck trips on North Dakota's highway system is expected to increase highway spending by $8.883 million per year to maintain current highway conditions (Table 7.4). These truck trips would result in an increased special fuel tax on road diesel fuel of $332,286 (Table 7.4).

Secondary and Net Economic Effects. The secondary impacts of branch line investment include the impacts of the increased agricultural production cost on the state's economy. Transportation is an input to the agricultural production process. As variable trucking and handling costs increase, the cost of delivering grain to the final destination increases. The secondary impact of the increased agricultural production cost is $4.526 million (Table 7.4). The net economic impact of the branch line system under the transshipment scenario is $30.997 million in the final year of the analysis (Table 7.4).

Table 7.4 Direct and Secondary Costs Associated with Transshipment Scenario in 2024 (Stated in 2004 Dollars)

Variable Trucking Cost	$7,082,039
Handling Cost	$10,838,432
Highway Improvement Costs	$8,883,165
Secondary Impact of Production Cost Increase	$4,526,587
Total Cost	**$31,330,224**
Special Fuel Tax Receipts	$332,286
Net Impact	**$30,997,938**

7.2.2 Scenario 2: Farm to Elevator Direct Shipment

Key Assumptions. It is assumed that the rail system will remain operable with no routine maintenance for eight years, deteriorating in a linear manner. It is also assumed that all shipments will go directly from the farm to a mainline elevator or shuttle elevator. The truck configurations for farm deliveries are shown in Table 7.5. No backhaul from the mainline elevator is estimated. The final assumption is that production is evenly distributed around the branch line elevators, and the average additional distance accrued is equal to the distance from the branch line elevator to the nearest mainline elevator or the nearest mainline shuttle elevator.

Background. The distance from each branch line elevator to the nearest mainline elevator and the nearest mainline shuttle elevator were calculated. The averages were then weighted by the elevator throughput.[21] The weighted-average increase in trucking distance was 35.10 miles. That is, if the branch line system in North Dakota did not exist, all branch line production, on average, would travel via truck 35.10 miles to the nearest mainline elevator.

Incremental Truck Trips. As mentioned above, it is assumed that all shipments will occur in the truck configurations reported in the Grain Elevator Survey. The total number of truck trips generated in this scenario is estimated to be 264,592 loaded trucks. A breakdown by truck type is given in Table 7.5.

Table 7.5 Number of Truck Trips by Truck Type in the Farm to Mainline Scenario

Truck Type	Number of Trips per Year
Single Axle	12,219
Tandem	39,221
Triaxle	26,473
Semi	186,678

Direct and Secondary Impacts. It is estimated that at the end of this eight-year period, when all traffic has shifted to the highway system, the total transportation cost increase for the shipment of grain is $7.53 million per year. As the grain moves directly from the farm to the mainline elevator, no additional handling costs are incurred. The addition of 264,592 additional truck trips on North Dakota's highway system is expected to increase highway spending by $10.034 million per year to maintain current highway conditions. These truck trips result in an increase in special fuel tax receipts for road diesel fuel of $375,366. The secondary impact of the increased agricultural production cost is $4.526 million. This brings the net economic impact of the branch line system to $20.281 million in the final year of the analysis period.

Table 7.6 Direct and Secondary Costs Associated with Farm to Mainline Scenario in 2024 (Stated in 2004 Dollars)

Variable Trucking Cost	$7,535,229
Handling Cost	$0
Highway Improvement Costs	$10,034,828
Secondary Impact of Production Cost Increase	$3,087,124
Total Cost	**$20,657,181**
Special Fuel Tax Receipts	$375,366
Net Impact	**$20,281,815**

[21] Elevator grain movement data obtained from North Dakota Public Service Commission Grain Movement Database.

7.3 North Dakota Rail Investment Programs

Local Rail Freight Assistance Program. The state of North Dakota has been making investments to preserve rail lines since 1980. The initial rail assistance provisions were finalized in the Local Rail Services Assistance (LRSA) Act of 1978, which was further modified in 1984. In 1985, NDDOT established a revolving loan fund with dollars from its LRSA grant. LRSA became Local Rail Freight Assistance (LRFA) in 1989, when Congress once again modified the program and changed its name. In addition to the name change, Congress restricted LRFA funds to lines with less than five million gross tons per mile, but at least 20 carloads per mile, in the year previous to the year of application for assistance.

Reduced Interest Loans. The North Dakota LRFA loan program makes available reduced interest loans, primarily for infrastructure projects on short line railroads. The funds retain their federal identity. The program was created to keep the state rail assistance funds from being depleted and to provide railroads with an alternative to commercial lending sources. The low interest rates and longer pay back period help improve railroad cash flow. The LRFA loan fund retains the principal from repaid loans, plus the interest the LRFA account itself bears.

The Freight Rail Improvement Program. In 1997, NDDOT established a second revolving loan fund, called the Freight Rail Improvement Program (FRIP) fund, using interest from repaid LFRA loans as a funding source. FRIP is similar in purpose to LRFA, but the funds are state funds and there is more latitude allowed in their use. FRIP is funded with interest from repaid LRFA loans, principal and interest from repaid FRIP loans, and the interest the account itself bears. FRIP project applications are evaluated on the basis of six criteria, each with a weighted value. The rating system generates a score for establishing project qualification and ranking. The six criteria are: (1) benefit-cost ratio, (2) line traffic density, (3) system connectivity enhancement, (4) enhancement to North Dakota's economy, (5) safety and security enhancement of North Dakota rail system, and (6) environmental and community impacts.

Benefits of Rail Freight Assistance Programs. NDDOT has provided more than $43 million in assistance since 1979 to rehabilitate more than 500 miles of rail line in the state and to help improve rail related facilities. Without state assistance, some of the rail line might have been abandoned. Preservation of the lines has helped maintain rail access, in some cases to more than one carrier, for many North Dakota producers and manufacturers, resulting in transportation cost savings for them. Although safety benefits are difficult to quantify, it is clear that state rehabilitation funding assistance has reduced the probability of derailments on many miles of improved lines and has had a positive effect on railroad safety. In addition, the preservation of rail lines has helped slow the increase of heavy truck axle loads on the state's highways, particularly the rural collectors. Finally, the freight rail assistance programs have allowed some rural communities to maintain connectivity with the national freight rail system, helping to maintain the economic base of rural areas of the state.

Branch Line Weight Limits. The rail assistance programs can be used to modernize regional railroad tracks and make them viable for HAL cars and new businesses. Figure 7.1 shows the average gross weight limit for each railroad in the state. The values reflect the controlling limit for each segment, weighted by the segment length. As the chart shows, all of the Dakota Missouri Valley & Western (DMVW) system is apparently limited to 134-ton cars or 100 tons of cargo. Much of Red River Valley & Western's (RRVW) system is subject to similar limits. However, Northern Plains Railroad's (NPR) system is unrestricted, even though much of it consists of 80-pound rail. This anomaly may reflect the substantial amount of tie and ballast work done on the Wheat Lines between 1983 and 1997, when approximately $11 million of rail assistance funds were invested. It should be noted that track weight limits are set by the railroads and are subject to change. Moreover, weight limits are a compromise based on economics and engineering judgment.

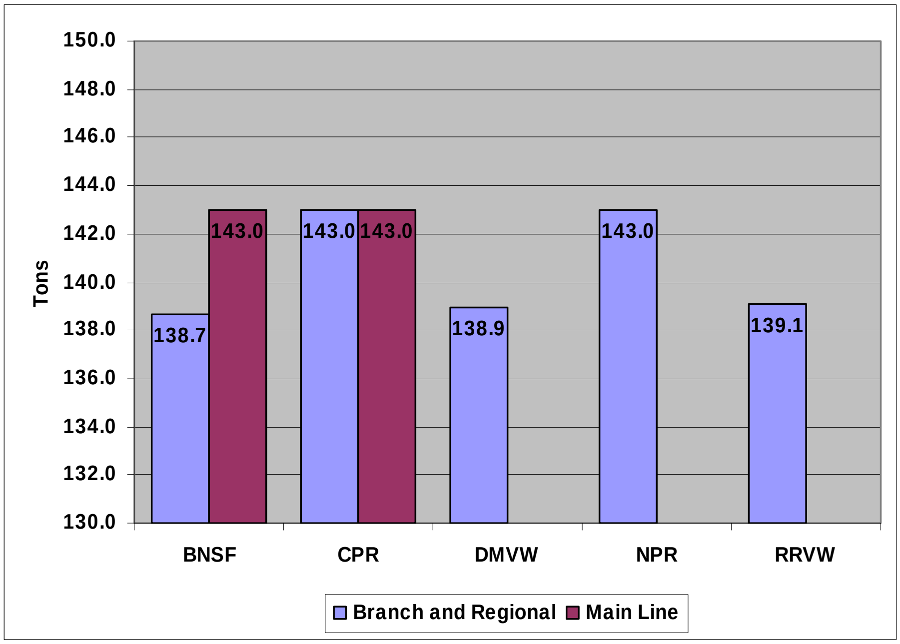

Figure 7.1 Average Gross Weight Limit of North Dakota Rail System, Weighted by Segment Length.

Sources: 2002 Railroad Timetables or Most Current Available Data

Recommendations. NDDOT should continue its rail investment programs. However, these programs cannot provide for all of the track modernization needs in the state. Additional funds are needed to increase the efficiency of branch line operations and make the state more attractive for business development. New businesses are reluctant to locate on rail lines with speed embargoes and outdated facilities. Recent changes in federal tax legislation have created tax incentives which encourage investment in regional railroad infrastructure. Apparently, there are issues with these programs which may limit their benefits to railroads. In the future, both loan and tax incentive programs are needed. The demand for rail freight assistance is at record levels in the state, in part due to the need for access tracks to intermodal facilities. With the potential growth in ethanol processing, additional funds are needed for the rail assistance programs.

8. Air Services Analysis

The North Dakota system of public-use airports is an integral component of the state's overall transportation system, and is also an important stimulus for economic growth and development in North Dakota. Airports are significant generators of revenue, jobs, and wages, as general aviation alone creates thousands of jobs and produces thousands of dollars of economic impact throughout North Dakota each year. The state airport system provides a safe and efficient method for the movement of people and goods, improving the quality of life of North Dakotans. Additionally, the visitors that arrive in North Dakota via air travel each year support a variety of business activities such as lodging, dining, retail, and entertainment. North Dakota airports also serve as the base of operations for numerous businesses, including airlines, concessions, air cargo companies, flight schools, government and military entities, agricultural sprayers, and many others.

The study language directs us to analyze the "feasibility of identifying and assisting airports that are specially situated in order to assist in economic development." In this, the final section of the report, we will examine the impacts of the aviation system on economic development in North Dakota—starting with an overview of the system and its components.

8.1 North Dakota's System of Public Use Airports

To help understand how the system of airports is significant to the state's economy and quality of life, the North Dakota State Aviation Plan identifies airports by Federal Aviation Administration (FAA) definitions and by the state's own classifications based on characteristics of each airport, the services provided, and the roles played in the system. Although the classifications are broken down by areas of emphasis, airports often include other types of services. For example, most commercial airports also have a contingent of charter and general aviation operators using their airport. Since scheduled passenger service fluctuates, especially at less active airports, some airport classifications change over time.

8.2 Commercial Service Airports

The Federal Aviation Administration considers an airport to be a commercial service airport when it receives scheduled air carrier passenger service and has 2,500 or more enplaned passengers annually. There are currently eight commercial service airports in North Dakota. In 2004, there were four airlines serving North Dakota's eight commercial air service airports. These airlines enplaned/boarded more than 586,000 passengers in 2004. One of these airlines (Northwest Airlines) is a major carrier. The other three carriers are commuter airlines—Big Sky, Mesaba, and United Express—which have code sharing agreements with Northwest, United, or other major carriers.

In 2004, Northwest carried about 66% of all passengers across the eight commercial service airports in North Dakota. United Express accounted for about 24% of all passengers. Great Lakes Aviation and Mesaba accounted for 6 and 3%, respectively.

8.3 General Aviation Airports

General Aviation airports provide access to small communities and rural locations. These airports can accommodate a range of aircraft but they serve mostly single-engine and small twin-engine aircraft and provide basic or limited services for pilots and aircraft. They may also have few or no based aircraft and no services for pilots or aircraft. However, these airports are very important to the communities. They provide access to otherwise remote areas for many critical needs. Some examples are: agriculture, medical emergencies, disaster response, and recreation. The quality of life is greatly increased for communities that have airports. Doctors and medical supplies can be provided to these areas in a matter of minutes by air, and patients can be evacuated by air much more quickly than by ground transport. They also provide access to larger communities and provide pilots with alternative landing sites in case of emergencies.

There are 81 public-use general aviation airports in North Dakota. These airports house 767 airplanes and accommodate a little over 180,000 operations. (Aeronautics 1994 Report)

8.4 Airport Tenants

Commercial Service Airport Tenants – North Dakota has eight airports offering commercial air service. A summary of air travel service provided by each of these airports is shown in Table 8.1.

Table 8.1 Commercial Service Airport Activity Levels

Airport	2004	
	Enplanements	**Total Operations**
Bismarck	159,963	55,164
Devils Lake	2,946	23,342
Dickinson	5,081	11,396
Fargo	256,004	75,753
Grand Forks	89,301	268,312
Jamestown	2,495	35,796
Minot	74,085	38,473
Williston	6,144	38,473
State Total	586,471	530,996

Source; North Dakota Aeronautics Commission
Operations include not only commercial service operations, but also general aviation and military operations.

Tenants at these airports consist of at least one of the following:

- Airlines – Commercial air service airlines (Northwest) and commuter airline operators (Big Sky, Mesaba, United Express, and others).
- Concessions – Rental cars, food and beverage operations, gift and news stores, parking, airline concessions companies, and others.
- Government/Military – Airport management, state agencies, FAA tower, weather services, and National Guard units located on airport property.
- Air Freight – Federal Express, UPS, and others.
- Miscellaneous tenants – Office and/or hanger rental, agricultural tenants, and others.

General Aviation Airport Tenants – North Dakota has 81 general aviation airports throughout the state. Tenants at the general aviation airports are primarily agricultural sprayers and fixed based operators. These tenants may also serve as the management for the airport's operations.

- **General Aviation Management**

- **Agricultural sprayers** – Based on North Dakota Aeronautics Commission (NDAC) records, there are 147 agricultural sprayers registered in North Dakota. Most of these (64%) operate primarily as an agricultural sprayer, with the remainder involved in other FBO business activities.

- **FBOs/others** – The NDAC data shows 63 FBO's within the state. These firms are involved with air repair, dealerships, and air taxi services.

- **Air travel visitors** – The NDAC completed a survey of passengers utilizing the eight commercial airports in the state regarding their expenditures while visiting the state. The economic impacts of their expenditures are included in the analysis.

- **Travel agencies and Motels/Hotels** – The NDAC economic study assesses the impacts of North Dakota's airport system on local travel agencies and places of lodging.

8.5 Economic Impacts

A recent study by the North Dakota Aeronautics Commission estimated the economic impacts of the activities at the commercial and general aviation airports in the state, as well as the estimated spending effects of the visitors to these airports. Table 8.2 outlines the spending and the employment impacts. Each impact is divided by airport and spending category.

The direct expenditures refer to payroll, taxes, capital improvements, and other operating expenses incurred during business operation. The induced expenditures are generated from the direct impacts of expenditures within the local or state economy. The induced multiplier for expenditures, as calculated by the Department of Agricultural and Applied Economics at North Dakota State University is 1.5. For example, part of an employee's salary is used to pay for housing, food, insurance, and other items. The recipient of the payment for these expenses will spend a portion of this money again, creating the multiplier effect. The direct employment refers to all employees within each subcategory. The induced employment is generated from the direct impacts of the air-related employment. The induced employment multiplier is 1.0.

As Table 8.2 shows, of commercial tenants, the government and miscellaneous tenants comprise the largest share of the expenditures with $30.145 million and $42.658 respectively. Air freight and the airline expenditures were $12.59 million and $10.68 million respectively. Concessions were $3.02 million. At the general aviation airports, general aviation management comprises nearly two-thirds of the expenditures with $40.3 million. Services connected with air transportation include lodging and travel agencies, which spent a combined $43.78 million in 2004. The total direct economic impact of tenants and services was $216.78 million. The induced expenditures total $325.17 million for a total direct and induced tenant and service expenditure of $541.9 million.

The final expenditures refer to traveler expenditures while in the state. NDAC's survey of commercial passengers resulted in traveler expenditures of $180.3 million. General aviation and air taxi passengers reported spending $13.1 million. The total direct and induced traveler expenditures is equal to $438.575 million.

Commercial tenants were responsible for 2,622 direct employees. The induced employment totaled 2,622 for a total direct and induced employment of 5,244. General aviation tenants were responsible for 4,481 direct and induced jobs for a total of 8,692. Services contributed 2,290 direct and induced employment for a total impact of 11,252 jobs in 2004.

Table 8.2 Aviation-Related Expenditures and Employment in North Dakota: 2004

	2004 Expenditures (Thousand $)			**2004 Employment**		
	Direct	**Induced**	**Total**	**Direct**	**Induced**	**Total**
Commercial Tenants						
Airline	$10,681	$16,022	$26,723	171	171	342
Concession	$3,018	$4,529	$7,547	131	131	262
Gov't/Military	$30,145	$45,379	$75,623	756	756	1,512
Air Freight	$12,591	$18,887	$31,478	383	383	746
Misc	$42,658	$63,987	$106,645	1,191	1,191	2,382
Tenants Total	$106,092	$159,138	$265,230	2,622	2,622	5,244
General Aviation Tenants						
GA Management	$40,316	$60,474	$100,790	148	148	296
Ag Sprayers	$5,758	$8,637	$14,395	1,025	1,025	2,050
FBOs/Others	$20,836	$31,254	$52,090	686	686	1,372
Tenants Total	$66,910	$100,365	$167,275	1,859	1,859	3,718
Total Tenant Impact	**$173,002**	**$259,503**	**$432,505**	**4,481**	**4,481**	**8,962**
Services						
Hotels/Motels	$1,803	$2,705	$4,508	70	70	140
Travel Agencies	$41,973	$62,960	$104,929	1,075	1,075	2,150
Services Total	$43,776	$65,665	$109,437	1,145	1,145	2,290
Totals	**$216,778**	**$325,168**	**$541,942**	**5,626**	**5,626**	**11,252**
Air Travelers and Visitors						
Commercial	$180,349	$270,524	$450,873			
GA/Air Taxi	$13,081	$19,622	$32,703			
Visitor Total	$193,430	$290,145	$438,575			
Grand Total	**$403,209**	**$604,813**	**$1,008,023**	**5,626**	**5,626**	**11,252**

8.6 Recent Trends in Aviation

8.6.1 Growth in Commercial Carriers and Regional Jets

The events of Sept. 11, 2001, had an enormous effect on aviation. The events on that day led to a sharp decrease in air traffic levels. This decline in demand for air transportation services was followed by a period of slow, steady recovery. By March 2002, air traffic on a national level was 11% lower than in 2001, with major airports losing a higher percentage of their volume than smaller airports. The airlines suffered greatly. They were further affected by advances in telecommunications such as e-mail, cell phones, faxes, video conferencing, and the Internet which all contributed to weakened demand for business travel.

However, the demand characteristics of shorter haul service from medium hubs or secondary metropolitan airports greatly increased the popularity of regional jets, and the events of Sept. 11 accelerated the growth in the use of regional jets by existing and new carriers. A typical regional jet will seat from 30 to 100 passengers and may have one or two cabin crew. There are a number of advantages of the regional jets. These include: superior operating economics, cruising speeds much faster than the turbo props historically used to serve these smaller markets, reduced loading and unloading times when compared to the large commercial jets, the ability to serve airports more convenient to passengers' origin and destination, and further convenience to the passenger where the rental cars are within walking distance rather than a shuttle bus ride away from the terminal.

8.6.2 Growth in the Use of General Aviation Airports

There has been an overall increase in general aviation throughout the United States. North Dakota is no different. Currently, there are 200,000 aircraft operations occurring at 82 general aviation airports. This number is slightly up from 1999 (NDAC). The general aviation sector is made up of many entities. These include:

- Commercial service airport tenants (157)
- General aviation management (98)
- Agricultural sprayers (147)
- Fixed base operators (FBO's)/others (63)
- Air travel visitors (290,798)
- Commercial service airports (8)
- Travel agencies (31)
- Hotels/motels (45)

Growth of Air Cargo

Air cargo grew very rapidly in the past decade. The factors that contributed to this growth included the decade of rapid global economic expansion and the increasing popularity of on-line purchases by consumers necessitating air shipments. It should also be noted that air cargo was not as dramatically affected as passenger travel by the events of Sept. 11. In addition, new freight companies have been established and the competition is fierce. There are three major air freight companies in North Dakota. They are Federal Express, UPS, and DHL. There are other smaller delivery services and FBO's offering overnight delivery as well.

8.7 Local Issues Facing Airports

As passenger and air cargo volumes continue to grow and decentralize, many airports will need to expand to accommodate their tenants. While aviation planning takes place on the state and regional levels, local airports commonly face challenges when trying to expand. The inevitable need for increased airport capacity and infrastructure affects policy makers, planners, and airport administrators throughout North Dakota. The typical issues faced by airports in need of expansion include:

- Infrastructure and capacity constraints that limit growth and expansion to accommodate increased demand
- Encroachment of incompatible land development with concerns over aircraft noise and safety
- Funding limitations as limited local, state and federal dollars are dedicated to other priorities

The larger commercial airports in North Dakota are specially situated to participate in the growth of air cargo and regional jet services. The continued viability of these airports is critical to the state. In general, the growth in regional and business jet service is a very positive development that offers economic development potential. Several smaller airports in the state are strategically located and have considerable economic significance. For example, the airport at Washburn provides business access to ethanol processing facilities. The expected growth in ethanol processing may make other small airports strategically important for enhancing business growth. Hazen is another specially-situated airport that provides access to power plants. Bowman is an example of a specially-situated airport that faces physical constraints. The lack of space has prevented a needed runway extension. Many smaller airports would like to have automated weather services, but do not have the minimum 10 planes per day, or cannot guarantee the minimum maintenance expenditures per year. Finally, improvements in general aviation terminals are needed at many airports to enhance business access.

In all of these situations, funding is a key constraint. Airports that do not qualify for federal funding often have difficulty raising funds from other sources. The North Dakota Aeronautics Commission is evaluating needs on a case-by-case basis. However, the needs exceed the available funding.

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