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20-Year Traffic Forecasting Factors

Study SD1999-04
Final Report

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DISCLAIMER

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16. Abstract

An investigation of the production of 20-year traffic forecasting factors at the South Dakota Department of Transportation (SDDOT) identified the necessary procedural improvements to develop and document a new, well-suited procedure to generate forecasting factors. The primary improvements include more finite traffic analysis zones, incorporation of supplemental data for use as analysis criteria, inherent graphical analysis tools, increased capabilities for making logical factor adjustments, and a final 20-year traffic forecasting factor array table that is greatly expanded over the output of the previous procedure.

In-depth interviews of traffic forecasting personnel at state DOTs and reviews of literature relevant to recent trends in traffic forecasting resulted in the accumulation of a variety of material on progressive traffic forecasting techniques and traffic model development. Most notably, the primary traffic forecasting developments are taking place at states with larger and denser populations where sophisticated automated processes, more abundant data, and traffic modeling software are being employed. Less populated rural states are having apparent difficulties implementing advanced traffic forecasting procedures and traffic models that are normally structured with an emphasis on urban perspectives. Conditional differences at rural states and less available resources at rural state DOTs are suggested as the primary factors contributing to this traffic forecasting developmental lag.

The investigations of the existing 20-year traffic forecasting procedure at the SDDOT included analysis of traffic data derivations, the sequence of events involved in the procedure, procedural components, automated processes, methodologies to produce forecasting factors, and coordination with Metropolitan Planning Organizations (MPOs) in the state. Analysis findings led to the essential conclusion that implementation of the improved procedure will specifically address the SDDOT's traffic forecasting needs. Implementation of the improved procedure is supported by additional recommendations that point to better traffic forecasting coordination with MPOs and ways to gain more procedural efficiency through software development. The recommendations have been prepared in expectation of immediate results, as well as the anticipation of long-term benefits from ongoing enhancements to coordinating activities with MPOs and the ultimate migration to a significantly enhanced traffic forecasting model.

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EXECUTIVE SUMMARY

PROBLEM DESCRIPTION

The 20-year traffic forecasting procedure performed by the Office of Data Inventory at the South Dakota Department of Transportation (SDDOT) has been time-consuming, labor-intensive, and has produced traffic forecasting factors where accuracy is questionable. The processes involved in the traffic forecasting procedure have been influenced in various ways, and many of these influences were identified in the SDDOT's Request for Research Proposal for this project. In the procedure to produce 20-year traffic forecasting factors, some of the identified influences included:

- The current interval of 4 years between each cycle of calculations is rather lengthy.
- Currently, there is no fully documented procedure for performing the factor calculations.
- Nonhomogeneous traffic patterns were not fully accounted for in larger planning districts.
- Forecasting of demographic trends was not a strong consideration, and population increases were not fully accounted for.
- Vehicle miles of travel (VMT) were averaged over the entire state for each functional highway classification, which could then contain misrepresentations.
- South Dakota counties that have a Metropolitan Planning Organization (MPO) may not have been adequately addressed by the statewide traffic forecasting procedure considering the urban characteristics.
- Methodologies for handling traffic forecasting near DOT/MPO interfaces have been lacking.

All of these circumstances indicated a strong need to address the SDDOT procedure for producing 20-year traffic forecasting factors by conducting a thorough research effort and identifying the necessary procedural improvements. The development and documentation of a new, well-suited procedure to generate statewide 20-year traffic forecasting factors needed to improve the SDDOT's confidence in formulating traffic forecasting factors. Further, software needed to be identified to match the SDDOT's needs, and the software has to be capable of computing the 20-year traffic forecasting factors to a higher order of accuracy.

To develop, document, and implement a new procedure for calculating 20-year traffic forecasting factors, it was known that a thorough analysis of the current sequence of the procedure would need to be performed. An analysis of the existing procedure would begin with the raw traffic data, the manner in which that data is managed, and the information system technology that is employed to prepare the traffic forecasting factors. The actual procedure and inherent operations would also need to be reviewed to determine if there were any inconsistencies, outdated processes, or operations based on ill-founded criteria. It was readily understood that adverse impacts arising out of error-prone data, information systems inconsistencies, and ill-conceived procedural operations could become broadly compounded for all SDDOT offices that rely heavily on the traffic forecasting factors.

This research effort was undertaken to address the full scope of the problem, including the SDDOT's current traffic data management, forecasting procedure, departmental needs, and institutional constraints.

RESEARCH OBJECTIVES

The current study was designed to address the following two key objectives:

1. Document SDDOT's current 20-year traffic forecasting procedure.
2. Develop and document new procedures or processes to enhance or replace SDDOT's present forecasting procedure.

Qualitative assessments were included in the documentation of the current traffic forecasting procedure for SDDOT Research Project SD1999-04. Defined improvements to the present forecasting methodology were used to develop and document a new traffic forecasting procedure for the SDDOT.

RESEARCH APPROACH

Twelve specific tasks were performed to satisfy the research objectives.

1. Review and summarize literature relevant to traffic forecasting or traffic modeling.
2. Meet with the technical panel to review the research topic and work plan.
3. Document SDDOT's present procedure, software, and data used to compute 20-year forecasting factors by interviewing necessary SDDOT personnel recommended by the technical panel.
4. Summarize each MPOs present traffic forecasting procedure as well as its forecasting coordination with DOT.
5. Summarize the traffic forecasting procedures and data collection methods of other states. (At a minimum, survey a representative sample of other rural Midwest states.)

6. Submit a technical memorandum that summarizes the findings of the literature review, survey procedures, required data, and software that will improve South Dakota's present traffic forecasting procedure.
7. Based on the tasks above and approval of the preliminary recommendations from the technical panel, develop and document a practical 20-year traffic forecasting procedure for SDDOT which will improve the accuracy of the computed forecasting factors.
8. In conjunction with DOT's Data Inventory and Planning & Programs personnel, use the recommended procedure to develop and validate 20-year traffic forecasting factors using DOT's most recent data.
9. Recommend coordination between the DOT and MPOs for determining the forecasting factors.
10. Recommend software and its functional requirements that will automate the 20-year traffic forecasting factors computations.
11. Submit a final report summarizing relevant literature, forecasting methodology, interview and survey results, developed procedures, recommended software, conclusions, and recommendations.
12. Make an executive presentation to the SDDOT Research Review Board summarizing the findings and conclusions.

Traffic forecasting procedures at the SDDOT, other state transportation agencies, and MPOs within the state of South Dakota were completely defined through the reviews performed under Tasks 1 through 6. Investigations performed under Tasks 7 through 12 provided all the definitions to fully develop and document a new, practical 20-year traffic forecasting procedure for the SDDOT, as well as formulate the necessary recommendations to automate the procedure and improve traffic forecasting coordination with MPOs.

GENERAL FINDINGS

In-depth interviews of traffic forecasting personnel at state DOTs and reviews of literature relevant to traffic forecasting resulted in the accumulation of a variety of material on progressive traffic forecasting techniques and traffic model development. The most notable observations included:

- Most traffic forecasting models are based on urban scenarios, but applied statewide.
- Traffic forecasting models and complex procedures at states with large populations are based on sophisticated automated processes that normally require a wide variety and abundance of data.

- There are apparent difficulties to implement advanced traffic forecasting procedures and/or models for less-populated, rural states that commonly have DOTs with limited resources and personnel.
- Many states with large populations represent destination points under regional/national traffic scenarios that lend themselves well to “modeling;” whereas, states that merely carry a lot of traffic across the state to east/west, north/south destinations (bridge states) have a more difficult time modeling these situations.
- Historical traffic data are primary to most statewide traffic forecasting procedures.

All of these observations were significant in the research efforts to investigate and seek improvements for traffic forecasting at the SDDOT.

The investigations of the existing 20-year traffic forecasting procedure at the SDDOT included analysis of the derivation of traffic data, the sequence of events involved in the procedure, procedural components, automated processes, and methodologies to produce forecasting factors. Primary analysis findings were:

- Beyond adherence to guidelines provided in the Traffic Monitoring Guide (TMG) [FHWA, 1992], there is no formal plan in place for the selection and placement of automated traffic recorder (ATR) sites around the state.
- Although “raw” traffic counts are available in electronic form, a permanent database for the storage and management of historical VMT data used in existing traffic forecasting procedures was never implemented.
- Data input has been minimal, consisting only of statewide historical VMT data and occasional subjective use of economic trends around the state.
- Older, outdated Quattro Pro spreadsheet programs used to perform the procedure on a personal computer (PC) platform were recently lost in a system failure.
- The procedure is based on six large traffic analysis regions comprised of several counties per region.
- Forecasting factors are essentially “backed into” through a series of straight-line regression analyses and apportioning of the statewide VMT total into the six traffic analysis regions by vehicle type and functional roadway classification.
- Factors are only produced every 4 years, and only for ‘Regular’ and ‘Commercial’ vehicle types on ‘Interstate,’ ‘Arterials & Collectors,’ and ‘Other’ functional roadway classifications.

Essential findings of the investigations performed for traffic forecasting at MPOs and SDDOT/MPO traffic forecasting coordination were:

- Rapid City and Sioux Falls are the two MPOs in-state where SDDOT/MPO traffic forecasting coordination is a strong consideration.
- North Sioux City, South Dakota, is included in the out-of-state Siouxland Interstate Metropolitan Planning Council (SIMPCO) of Sioux City, Iowa.
- Rapid City is in a transition state where traffic forecasting activities are concerned.
- Sioux Falls is committed to progressive traffic forecasting operations.

The existing statewide traffic forecasting procedure at the SDDOT is not equipped to fully address the urban forecasting conditional requirements posed by MPO interfacing.

RECOMMENDATIONS AND CONCLUSIONS

The investigations performed for SDDOT Research Project SD1999-04 identified a number of specific recommendations and strategies that the SDDOT should strongly consider. Recommendations provided were formulated on objective analysis findings that define an improved 20-year traffic forecasting procedure for the SDDOT, allow better SDDOT/MPO traffic forecasting coordination, and satisfy the need to gain more procedural efficiency through software development.

Recommendations

Ten specific actions are recommended to improve the statewide 20-year traffic forecasting process at the SDDOT. The recommendations pertain to changes in traffic data collection and management, implementation of the new 20-year traffic forecasting procedure, actions to establish better SDDOT/MPO traffic forecasting coordination, and software design and development to automate the new procedure.

Changes in Traffic Data Collection and Management Practices

Project investigations resulted in two recommendations specific to SDDOT traffic data collection and associated data management practices. These are based on interviews of SDDOT personnel and departmental *Documentation of ATR Groupings & Sample* Size whereby the term "professional judgement" is the common term to describe ATR placements. To support implementation of the new traffic forecasting procedure, the Department should perform two essential activities:

1. *Review current policies for the designation and placement of ATRs.*

   – Current practices in traffic data collection should be the primary focus.

   – Hierarchical grouping of ATRs should be considered.

– Historical traffic data are primary to statewide traffic forecasting at rural, sparsely populated states.

2. *Initiate efforts to establish a permanent database to support ongoing traffic forecasting activities and enhance ongoing management of related data.*

– The data need to be securely stored and maintained by the SDDOT (as opposed to past practice).

– Validation of forecasting factors will then be possible (as opposed to past practice).

– Data development for this project represents important groundwork that should not be lost.

– The data generated under this project is structured to readily migrate to a supporting database.

– Definition of database requirements should be included as an integral part of the software development plan to automate the new procedure.

Implementation of the New 20-Year Traffic Forecasting Procedure

In light of the current lack of an established 20-year traffic forecasting procedure, immediate implementation of a 20-year traffic forecasting procedure specific to the needs at the SDDOT is essential.

3. *Implement the new procedure as soon as possible.*

   Implementation of the new procedure will:

– Replace processes and expertise that were recently lost.

– Improve the quality and integrity of traffic forecasting at the SDDOT.

– Improve the Department's confidence in, and use of, traffic forecasting factors.

– Facilitate implementation of emerging, nationwide trends in traffic forecasting.

4. *Establish a 2-year traffic forecasting cycle versus the current 4-year cycle.*

   A shorter forecasting cycle will:

– Make factors readily available, more current, and also more practicable for departmental needs.

– Emphasize continued review and enhancement of the forecasting procedure.

Note that the new SDDOT procedure was developed using Microsoft Excel, primarily to facilitate storage and manipulation of data during the project. Although software development to automate the procedure was outside the project scope of work, documentation of the new procedure has been included so that SDDOT personnel can perform the procedure followed in producing the factors developed during the current effort through "manual operations" in lieu of an automated procedure.

Improvement of SDDOT/MPO Traffic Forecasting Coordination

Recommendations to improve SDDOT/MPO traffic forecasting coordination vary significantly for each of the MPOs in South Dakota. The following recommendations are specific to improved SDDOT coordination with each South Dakota MPO.

5. *Because there is no sustaining planning authority for coordinated efforts in North Sioux City (e.g., it is too small a community to maintain full-time planning functions), the SDDOT should take advantage of proposed weight-in-motion/automatic vehicle identification (WIM/AVI) technology implementation at the new North Sioux City, Iowa, POE.*

   – Traffic forecasting collaboration or add-on capabilities should be considered at the new POE.

   – Relevant data provided by the proposed WIM and AVI technologies should be incorporated in the traffic forecasting process as it becomes available.

6. *In the near term, the SDDOT should maintain a lead role versus the role of a coordinating partner for traffic forecasting in the Rapid City, South Dakota, area.*

   Since Rapid City is in a transition phase with regard to transportation planning and traffic forecasting activities, internal capabilities are currently restricted. The SDDOT can function as a lead in:

   – Assisting as necessary with the Rapid City's ongoing endeavors to enhance transportation planning/traffic forecasting activities.

   – Providing more feedback to the Rapid City MPO concerning factors produced by the new SDDOT procedure.

   – Gaining feedback from the city when circumspect conditions arise.

   – Maintaining open communications so that each entity can react accordingly to enhancements instituted at the city and to enhancements implemented by the SDDOT.

7. *The "microscopic" traffic analysis at Sioux Falls MPO should be given substantive consideration compared to the statewide "macroscopic" traffic forecasting approach of the SDDOT.*

   The city of Sioux Falls utilizes several data resources and planning tools to support transportation planning activities and is improving traffic forecasting by implementing improved traffic modeling software to replace the current TModel 2 software. Sioux Falls began using traffic forecasting factors from the SDDOT statewide procedure in 1997. To improve traffic forecasting coordination with the Sioux Falls MPO, the SDDOT should consider the following:

– After developing factors with the new statewide procedure, the SDDOT should request traffic forecasting factors produced by the city of Sioux Falls for comparison with the factors produced by the new procedure.

– Discrepancies should be rectified through a thorough SDDOT review of updated Sioux Falls planning documents and other available information. If warranted, statewide 20-year traffic forecasting factors should be adjusted for the Sioux Falls urbanized area.

– Implementation of new traffic modeling software at Sioux Falls will require careful acceptance but should be tempered with the realization that Sioux Falls' traffic forecasting factors are based on more detailed information.

– Both entities should collaborate to produce, agree upon, and use the same forecasting factors for the urbanized area of Sioux Falls, South Dakota.

Efforts to improve coordination with South Dakota MPOs should be afforded more suitably once the new SDDOT 20-year traffic forecasting procedure is implemented. Factors produced by the new procedure should prove to be in closer harmony with MPO factors because:

- Traffic forecasting regions are broken down to county levels.
- Urban/urbanized areas are treated more realistically.
- Analysis capabilities are increased with the incorporation of additional data.
- More criteria are now employed to add to factor integrity.

In general, the new SDDOT procedure includes additional data and provides improvements in traffic forecasting for urban/urbanized conditions that will help considerably in each of these areas.

Software Design and Development to Automate the New Procedure

The remaining three recommendations address the critical need to automate the 20-year traffic forecasting process and emphasize the importance of planning to ensure that both current and future SDDOT traffic forecasting needs are met.

8. *Initiate a system planning effort to fully define the system requirements, specifications, and design.*

– System developers and SDDOT personnel with interests in the traffic forecasting procedure will be those primarily involved.

- The effort will ensure the desired implementation of a traffic forecasting software system specific to the needs of the SDDOT.
- The approach will define the budget and resource considerations for the software development effort.

9. *Empower the procedure through software development.*

- Increase efficiencies and maximize time savings.
- Minimize the possibilities for introducing errors during the procedure.
- Minimize subjective analysis to gain more objective output.
- Instill consistency, uniformity, and better maintenance of the procedure over time.
- Provide a reliable integration path to other important SDDOT systems that could utilize the forecasting factors.

For planning purposes, the level of effort to design, develop, and populate a database and subsequently structure, design, and develop software that automates data management and procedural calculations included in the working spreadsheets used for this project is roughly estimated to be $30,000. (This basically includes the first three primary software requirements identified in Section 10.1). Budget and resource requirements for the full software development effort will not be identified until Recommendation 8 is completed. Development costs can be expected to increase, however, with full automation of the forecasting process and incorporation of functions and calculations beyond those already included in the working spreadsheets.

10. *Anticipate eventual migration to significantly enhanced SDDOT traffic forecasting software.*

- Include planning in the software development for a well-conceived migration path to the enhanced traffic forecasting software.
- Maintain project focus on the development of a new traffic forecasting procedure that is structured to accommodate the significantly enhanced traffic forecasting capabilities.
- Prepare to facilitate continually refined enhancements to the traffic forecasting procedure over time.
- Give careful consideration to components that would work well and that are already in place, supported, and maintained at the SDDOT for the enhanced software.

These recommendations have been provided to ensure that SDDOT traffic forecasting needs are met and to facilitate ongoing enhancement of SDDOT traffic forecasting capabilities. The procedure will need to be performed manually until the Department initiates a software development effort. System planning and design efforts will be crucial to the success of this software development effort.

Conclusions

Investigations of SDDOT traffic forecasting needs and traffic forecasting practices at the SDDOT and in other states with similar traffic forecasting conditions failed to identify a traffic forecasting model that was suitable for implementation by the SDDOT. Most traffic forecasting models that are being applied on a statewide basis are based on urban scenarios, a situation that presents significant problems for sparsely populated rural states that have limited resources and personnel and limited data to support these models.

Subsequent research efforts led to the development of a new SDDOT 20-year traffic forecasting procedure that is consistent with traffic forecasting conditions in South Dakota and is based on data that are readily available. The new procedure, which incorporates a great number of improvements in the traffic forecasting process, represents the first step toward future development of significantly enhanced SDDOT traffic forecasting software.

Significant essential improvements that are reflected in the new traffic forecasting procedure include the following:

- The six traffic analysis regions of the existing procedure have been eliminated, and traffic forecasting factors can now be produced for each South Dakota county (which closely approximate traffic analysis zones (TAZs) in a traffic forecasting model).
- The procedure begins with one regression analysis against VMT data to prepare it and make it directly applicable, so iterative linear regression analyses in attempts to apportion statewide VMT into the six traffic analysis regions, across functional roadway designations, and by vehicle type will no longer be necessary.
- The procedure is enhanced by using South Dakota “County Business Patterns” data to adjust VMT growth projections as necessary and couples county population and building permits data with assessments by the transportation planner to adjust traffic forecasts.
- Guidelines are included to allow criteria to be applied logically, verify processes, and make the procedure more adaptable to changing needs.
- Adjustments to traffic growth projections are now interactive processes based on reviews of the criteria provided by all the data prepared for the revised traffic forecasting procedure whereby useful insights are gained on adjustment suitability.
- Graphical analysis was conceived as the most expeditious means to allow rapid and direct comparative analysis of traffic growth projections and has been incorporated in the new procedure.

- Instead of one 'Commercial' vehicle category, forecasting factors are now produced for two commercial vehicle types that are Class 5-9 Commercial and Class 10-13 Commercial.
- Removal of urban VMT in Minnehaha and Pennington Counties is no longer necessary since the new procedure analyzes historical rural/urban VMT at the county level.
- The final 20-year traffic forecasting factor array table is expanded greatly over the old factor array and can be utilized in more SDDOT operations by having extensive factors produced for counties, by various vehicle types, over broad functional roadway classifications, and by rural/urban designations.

The new traffic forecasting procedure has been developed to specifically address the statewide needs of the SDDOT and is structured with a logical decision-making process that will lend itself well to automation. The impelling reasons to proceed immediately with a software development effort to automate the new traffic forecasting procedure are to:

- Increase efficiencies and maximize time savings.
- Empower the procedure with a well-structured database and congruous applications development software.
- Minimize the possibilities for introducing errors during the procedure.
- Minimize subjective analysis to gain more objective output.
- Provide reliable integration and corresponding input paths for important SDDOT systems that include: pavement/roadway design systems, pavement management systems, and transportation project planning and prioritization systems.
- Instill consistency, uniformity, and better provisions to maintain the procedure over time (as compared to recent losses of data, loss of personnel with procedural expertise, etc.).
- Facilitate continued enhancement of the traffic forecasting procedure over time.

These concepts were key considerations throughout the development of the new traffic forecasting procedure. Further, the approach in this research project has included a concentrated focus that anticipates ongoing refinements to traffic forecasting practices and eventual migration to significantly enhanced traffic forecasting software at the SDDOT.

Specific implementation recommendations that have been provided encompass all aspects of the forecasting process from initial forecasting data collection and management activities through system planning and software development activities that will be essential to implement the procedure. System planning and software design and development efforts included in these recommendations will be critical in defining a system architecture that will: (1) accommodate immediate automation of the procedure documented herein, (2) support future efforts to evaluate and potentially implement emerging traffic forecasting enhancements, and

(3) facilitate future development of a true forecasting model. The significantly enhanced traffic forecasting software envisioned as a result of this study would take advantage of components that are already in place, supported, and maintained at the SDDOT.

SDDOT action on each of these recommendations will be essential to realize the full potential of the new forecasting procedure. Foresight to impending automation of the new procedure through software development efforts that includes careful planning for the eventual migration to a true traffic forecasting model will ensure that the SDDOT will enjoy the benefits of a significantly improved statewide 20-year traffic forecasting procedure far into the future.

1.0 INTRODUCTION

1.1 PROBLEM DESCRIPTION

The 20-year traffic forecasting procedure performed by the Office of Data Inventory at the South Dakota Department of Transportation (SDDOT) has been time-consuming, labor-intensive, and has produced traffic forecasting factors where accuracy is questionable. The processes involved in the traffic forecasting procedure have been influenced in various ways, and many of these influences were identified in the SDDOT's Request for Research Proposal for this project. In the procedure to produce 20-year traffic forecasting factors some of the identified influences included:

- The current interval of 4 years between each cycle of calculations is rather lengthy.
- Currently, there is no fully documented procedure for performing the factor calculations.
- Nonhomogeneous traffic patterns were not fully accounted for in larger planning districts.
- Forecasting of demographic trends was not a strong consideration, and population increases were not fully accounted for.
- Vehicle miles of travel (VMT) were averaged over the entire state for each functional highway classification, which could then contain misrepresentations.
- South Dakota counties that have a Metropolitan Planning Organization (MPO) may not have been adequately addressed by the statewide traffic forecasting procedure considering the urban characteristics.
- Methodologies for handling traffic forecasting near DOT/MPO interfaces have been lacking.

All these circumstances showed a strong need to address the SDDOT procedure for producing 20-year traffic forecasting factors by conducting a thorough research effort and identifying the necessary procedural improvements. The development and documentation of a new, well-suited procedure to generate statewide 20-year traffic forecasting factors would need to improve the SDDOT's confidence in formulating traffic forecasting factors. Further, software would have to be identified to match the SDDOT's needs, and the software would need to be capable of computing the 20-year traffic forecasting factors to a higher order of accuracy.

To develop, document, and implement a new procedure for calculating 20-year traffic forecasting factors, it was known that a thorough analysis of the current sequence of the procedure would need to be performed. An analysis of the existing procedure would begin with the raw traffic data, the manner in which that data is managed, and the information system technology that is employed to prepare the traffic forecasting factors. The actual procedure and inherent operations would also need to be reviewed to determine if there were any inconsistencies, outdated processes, or operations based on ill-founded criteria. It was readily understood that adverse impacts arising out of error-prone data, information systems inconsistencies, and ill-conceived procedural operations could become broadly compounded for all SDDOT offices that rely heavily on the traffic forecasting factors. A few of the many critical and important departmental functions that could be impacted include:

- Design and construction of highway projects.
- Funding processes where federal, state, and local revenues are involved.
- Highway project planning and prioritization processes.
- The political ramifications that often arise from questions about where and why highway projects are chosen that often need to be addressed.
- Other information systems and programs that rely on traffic forecasting factors, such as Roadway Environmental Subsystem (RES), Pavement Management System (PMS), design systems, Highway Performance Monitoring System (HPMS), and many others.

The effects of these impacts would also need to play a large part in the analysis, development, and implementation of a new procedure to generate better traffic forecasting factors under the guise of this research project.

This final report describes the research effort undertaken to address the full scope of the problem, including the SDDOT's current traffic data management, forecasting procedure, needs from a departmental standpoint, and institutional constraints.

1.2 RESEARCH OBJECTIVES

SDDOT Research Project SD1999-04, *20-Year Traffic Forecasting Factors*, was initiated just prior to May 1, 1999, to address the circumstances cited above. The proposed effort entailed defining improvements to the Department's traffic forecasting procedure and was designed to address the following two key objectives:

1. Document SDDOT's current 20-year traffic forecasting procedure.
2. Develop and document new procedures or processes that will enhance or replace SDDOT's present forecasting procedure.

In order to accomplish these objectives, a thorough review of the current ways and means employed by the SDDOT to compute and generate traffic forecasting data needed to be performed and the process had to be thoroughly documented. Present data management practices, the automated processes employed, and the operational procedures used to compute traffic forecasting factors also had to be examined. Qualitative assessments of the suitability of the 20-Year Traffic Forecasting Factor output could then be made.

1.3 RESEARCH SCOPE

Twelve specific tasks were performed to satisfy the research objectives:

1. Review and summarize literature relevant to traffic forecasting or traffic modeling.
2. Meet with the technical panel to review the research topic and work plan.
3. Document SDDOT's present procedure, software, and data used to compute 20-Year Forecasting Factors by interviewing necessary SDDOT personnel recommended by the technical panel.
4. Summarize each MPOs present traffic forecasting procedure as well as its forecasting coordination with DOT.
5. Summarize the traffic forecasting procedures and data collection methods of other states. (At a minimum, survey a representative sample of other rural Midwest states.)
6. Submit a technical memorandum that summarizes the findings of the literature review, survey procedures, required data, and software that will improve South Dakota's present traffic forecasting procedure.
7. Based on the tasks above and approval of the preliminary recommendations from the technical panel, develop and document a practical 20-year traffic forecasting procedure for SDDOT which will improve the accuracy of the computed forecasting factors.
8. In conjunction with DOT's Data Inventory and Planning & Programs personnel, use the recommended procedure to develop and validate 20-year traffic forecasting factors using DOT's most recent data.
9. Recommend coordination between the DOT and MPOs for determining the forecasting factors.
10. Recommend software and its functional requirements that will automate the 20-year traffic forecasting factors computations.
11. Submit a final report summarizing relevant literature, forecasting methodology, interview and survey results, developed procedures, recommended software, conclusions, and recommendations.
12. Make an executive presentation to the SDDOT Research Review Board summarizing the findings and conclusions.

Tasks 1 through 6 were designed to review and summarize traffic forecasting procedures at the SDDOT, other state transportation agencies, and MPOs within the state of South Dakota.

Tasks 7 through 12 were designed to develop and document a practical 20-year traffic forecasting procedure for the SDDOT, to provide recommendations for automating the procedure, and to identify ways in which traffic forecasting coordination with MPOs can be improved.

2.0 LITERATURE REVIEW

Task 1: Review and summarize literature relevant to traffic forecasting or traffic modeling.

Prior to initiating the search for publications on current state-of-the-art traffic forecasting methods, several members of the project's technical panel were contacted and interviewed. The primary intent was to determine if panel members were generally aware of any existing or evolving traffic forecasting methodologies with direct applicability to the research efforts for this project. Since the Request for Proposal (RFP) for the project specified that the literature review was to be conducted prior to the initial meeting with the technical panel, the RESPEC project team felt that contact with selected members would be an appropriate activity. The primary interest was to determine if the panel had an awareness of any intriguing traffic forecasting methods in use by other rural states, either through professional associations, work-related interests, or personal attendance at conferences/seminars.

A primary document referred to in the interviews was subsequently located and acquired. The reference [Horowitz, 1999] is a research publication sponsored by the Federal Highway Administration (FHWA). This document, which was released in March of 1999, is a nationwide compendium of current travel forecasting practices, emerging trends, and theoretical approaches for the development of new forecasting techniques. In addition to providing overviews of various travel forecasting procedures and the rationalizations behind their employment, the guidebook provides a lengthy set of references which was used to complement the literature search efforts for this particular SDDOT research project.

Literature relevant to this project was obtained through computerized database searches via the Internet whereby traffic forecasting was the primary cross-reference from within the highway transportation sector as a whole. Known references were acquired initially and used as lead sources to investigate the availability of additional material. Literature searches thereby expanded, but maintained an interest specific to the research at hand, resulting in continually refined reference accumulation.

Reviews were performed with intentions of finding the material that was most directly relevant to the unique conditions presented by traffic forecasting at the SDDOT. Some of the primary conditions include:

- A "bridge state" situation whereby the state's transportation network carries significant passenger vehicle traffic and commercial freight movements across the state to east-west coastal destinations or other distant metropolitan destinations.
- Rather large geographic area with small population.
- Primarily rural agricultural.

- A highway network that is fairly diverse across the state.
- Only two in-state MPOs and one South Dakota area included within the boundaries of an out-of-state MPO, all widely scattered.
- Combined operational, administrative, and political environment unique to SDDOT.
- Limited DOT resources for performing traffic forecasting.
- Limited traffic data collection capabilities.
- Inherent recognition that traffic forecasting can impact many DOT operations.

Finally, searches for published material on new and emerging traffic modeling concepts were conducted. Subsequent research indicated that most of these concepts have shortcomings when analyzed relative to SDDOT needs. The prominent trends in the advancement of statewide traffic modeling techniques include the following:

- Most models are based on urban scenarios, but applied statewide.
- Conjunctive multimodal analyses are generally used.
- Data input is based on a wide variety and abundance of sources.
- Procedures are based on fairly complex automated processes.

A driving force in the advancement of traffic forecasting techniques and traffic model development is a common recognition that traffic forecasting can impact a wide array of DOT operations. Traffic forecasting data are considered important input criteria for many transportation agency operational areas that include pavement management, roadway design, pavement design, transportation project planning/prioritization, highway safety, highway geometry, and infrastructure management. When such strong emphases are involved, DOTs will naturally be willing to allocate more funding and resources to traffic forecasting operations.

2.1 URBAN MODELS AS THE BASIS FOR STATEWIDE TRAFFIC FORECASTING MODELS

Urban models make use of traffic analysis zones (TAZs) whereby an urban area is divided into zonal districts with unique and distinct traffic flow characteristics [Crevo, 1991; Horowitz, 1999]. Analysis in an urban traffic forecasting model is performed internal to each zone and then works toward analysis of travel trips generated externally to other zones. The forecasting models rely on a dense, spatially confined study area which lends itself well to the analysis of route alternatives, various types of intersections, travel modes, traffic patterns, and driver behaviors. Also, the models rely on a variety of extensive and readily available data which urban planning offices are certainly more apt to generate than the regional planning offices of sparsely populated rural areas.

The advancements in statewide travel forecasting are based primarily on the application of urban modeling concepts to a statewide highway network. These applications generally require a few minor modifications to the data input criteria for the model and the ways in which analyses are subsequently performed. The levels of refinement that can be achieved in the production of traffic forecasting factors are then affected accordingly. Basically, when urban modeling concepts are applied on a statewide basis, estimates of travel trips are generated between "nearby" cities. Urban areas are treated as travel trip generators and/or travel trip attractors, and it is assumed that cities are in near enough proximity to have regular average daily traffic occurring multilaterally.

Statewide Traffic Models in Relation to Traffic Forecasting at the SDDOT

The application of traffic forecasting models based on trip generation between cities is basically unfeasible in South Dakota. North Sioux City, Rapid City, and Sioux Falls are the only three urbanized areas in the state, and they are widely scattered. North Sioux City is simply an outlying, nonjurisdictional urban sprawl of Sioux City, Iowa, with only a few thousand residents. Rapid City and Sioux Falls are urbanized areas with in-state MPOs but are widely separated by a distance of about 400 miles. This essentially leaves primarily rural agricultural traffic analysis conditions that are spread over a large geographic area.

In addition to rural conditions with a significant lack of urbanized areas, South Dakota's geographic location in the center of the nation presents another set of unique traffic forecasting conditions. Population centers and travel destinations to the east and west of South Dakota present situations where a lot of "through" traffic is simply being carried across the state's transportation network. Also, the flow of freight and goods via commercial trucking across the state, between the east and west coasts, creates the phenomenon commonly referred to as a "bridge state" condition. A statewide traffic forecasting model at the SDDOT cannot fully account for these conditions without good, quality traffic data representing national and/or historical perspectives.

2.2 MODAL DISTRIBUTIONS IN FORECASTING MODELS

The ability to analyze multimodal travel distributions is becoming increasingly emphasized in many of the statewide traffic forecasting models [Barton-Aschman Associates, 1991; Hamburg and Page, 1994; Horowitz, 1999; URS Consultants, Inc., 1995]. Again, most urban modeling techniques have included these capabilities for some time, and the advent of statewide models seems to be including these facets in the carryover to statewide forecasting models. Urban areas have traditionally maintained travel alternatives such as bus transit, other forms of mass transit, and car pooling. Urban cities are also the main terminus points for major airline, train, waterway, and other forms of travel. Urban traffic forecasting models have included analysis of these multimodal considerations in conjunction with passenger car/commercial truck forecasting in attempts to gain more realistic forecasts of future traffic growth. Also prevalent is how multimodal forecasts might be affected by transmigrations to other forms of travel as alternatives become available or fade over time.

Some state DOTs have included multimodal analysis based on the perceived applicability to their own particular statewide traffic forecasting needs [Wilbur Smith Associates, 1996]. For instance, any state with a significant amount of freight that is carried over waterways might include data and subsequent analysis on this transportation mode as forecasting model criteria. It then becomes necessary to include logic in the model to relate waterway freight movements against other alternative transportation modes for moving freight (such as trains, commercial trucking, etc.) to verify and continually refine forecasting factors.

Modal Distributions in Relation to Traffic Forecasting at the SDDOT

There is not a great diversity of transportation modes in South Dakota. There are bus lines operating in South Dakota with bus transit existing in the city of Sioux Falls and minimal bus transit in Rapid City and other communities across South Dakota. There are essentially no other forms of mass transit in the state. Mass transit refers to passenger movements of large magnitude, is often an interchangeable term with urban transit systems, and thereby excludes rural transit systems. Also, Sioux Falls and Rapid City are the only terminus points for major airlines. Freight movements by waterways are essentially nonexistent.

The primary multimodal forecasting analysis to be considered on a statewide basis by the SDDOT is freight movements, by either train or commercial trucking. Shippers of grain, livestock, and other agricultural products to stockyards, auction barns, grain elevators, etc., will logically choose the most expedient and economical means to transport those commodities. Areas opened up in the state by new routing among those transportation modes, reductions in shipping charges, and other beneficial changes that might impact or divert the movement of goods from one transportation mode to another could certainly be considered in a traffic forecasting analysis. The only limitations would be the availability of, and access to, data whereby future plans and schedules for the commercial trucking and freight train industries in South Dakota could somehow be captured.

2.3 FORECASTING MODEL DATA INPUT

Like all decision-making processes, traffic forecasting will rely heavily on an abundance of good quality data. Most of the traffic forecasting software models and programs currently in existence have a wide variety and range of input variables that can be used at the discretion of the transportation planner/engineer. Data input requirements of Tmodel 2 Software [Tmodel Corporation, 1997], currently installed at the cities of Sioux Falls and Rapid City, were part of the reviews performed for this study. This software package typifies the industry in that there are a few primary data items that are essential for input (such as traffic counts). However, simply applying the minimum critical input tends to remove much of the true traffic simulation and the ultimate forecasting capabilities of the modeling software.

As alluded to previously, urban planning offices have always maintained some distinct advantages in being able to rely on better and more abundant data sources than rural planning districts. Urbanized areas have data available from MPOs, databases from national/federal studies, statistical files available from chambers of commerce and businesses themselves, as well as many other sources. The main problems faced at urban planning offices are not necessarily the availability of data, but instead the time and resources needed for data input, data maintenance, and database management [Glass et al., 1990; Meyer and Mazur, 1995].

Data Considerations for Traffic Forecasting at the SDDOT

Being primarily rural, agricultural, and sparsely populated presents a unique lack of planning data in the state of South Dakota. Beyond the two MPOs represented in the state, most other municipalities do not even maintain a municipal planning office. Counties in South Dakota also lack the tax bases to fund and maintain planning offices for instituting and then maintaining good zoning, land use, and other planning functions. These missing resources would normally provide good data sources for a statewide traffic forecasting procedure at the SDDOT. Therefore, there are three primary resources identified that the SDDOT will need to rely on for data input to traffic forecasting procedures. These sources are:

- Internal data at the SDDOT that are deemed applicable to traffic forecasting.
- Relevant data made available from the MPOs at Rapid City and Sioux Falls.
- National traffic, population census, and/or economic data available from the federal government, or data available from national statistical clearinghouses representing industry sectors, such as the trucking industry.

The most important internal data at the SDDOT are traffic count data, which includes all traffic data collection schemes and historical traffic counts that might be available. DOT/MPO interfaces are the most important traffic data consideration where the urbanized areas of Rapid City and Sioux Falls are concerned. Population census and economic statistics are already being used to some extent at the SDDOT, but only as a check and not as a part of the input criteria or procedure itself. All these data conditions will need to be scrutinized further and prior to any new definitions of traffic forecasting procedures at the SDDOT.

2.4 AUTOMATED PROCEDURES OF FORECASTING MODELS

Algorithms and processing in traffic forecasting models become more complex as the numbers of input criteria increase. Comparative reviews of the various criteria, the building of matrices based on analysis, and the reduction of selection sets to feasible parameters are all processes that become compounded as the number of input variables grows. Software models with considerable input criteria and sophisticated algorithms will often require changes to the data input and subsequent rerunning of the software programs when manipulation of factor output is desired. Also, larger and variable data input requirements will correspondingly increase the data maintenance/management requirements and support needs for the software modeling system [Nagel et al., 1996; Spear, 1994].

Although urban traffic forecasting models are being attempted on statewide forecasting basis', states without significant urbanized areas recognize that rural situations present conditions whereby data input requirements should only include the basic, essential items deemed relevant. Software developed at the Wyoming DOT includes more user-interactive program logic that allows diverse judgments to be made by the transportation planner/engineer throughout the process to ultimately produce forecasting factors [Wang and Wilson, 1995]. Drawbacks to traffic forecasting software that is developed "in-house" are that the programs are highly specific to the DOT's needs, software is therefore somewhat proprietary, and the programs become difficult to borrow and/or modify because they are not standardized.

Automated Procedures in Traffic Forecasting at the SDDOT

Automating the traffic forecasting procedure at the SDDOT was accomplished through the use of Quattro Pro spreadsheets. Although the spreadsheet programs appear to have performed forecasting tasks adequately, increasing demands to produce factors to higher accuracy standards and to expand the use of factor output are indicators that new automated processes need to be considered.

The data-intensive procedures of traffic forecasting software programs, such as those based on urban models would require more time and resource allocations for data collection, data maintenance, database management, and system support. Questions then arise as to the resource availability at the SDDOT or the Bureau of Information and Telecommunications (BIT) to support such a traffic forecasting information system (IS) environment.

Automated traffic forecasting programs based on user-interactive procedures would require a high degree of traffic forecasting expertise by SDDOT personnel, as well as more time and money spent by those personnel on traffic forecasting functions. It is highly likely that this software would also involve customized programming efforts. Again, similar questions arise as to the support requirements for traffic forecasting systems that become too specialized and/or "nonstandardized."

3.0 REVIEW OF SDDOT'S CURRENT 20-YEAR TRAFFIC FORECASTING PROCEDURES, SOFTWARE, AND DATA

Task 2: Meet with the technical panel to review the research topic and work plan.

Task 3: Document SDDOT's present procedure, software and data used to compute 20-year forecasting factors by interviewing necessary SDDOT personnel recommended by the technical panel.

Initial reviews of the SDDOT's traditional 20-year traffic forecasting procedure took place at a work plan review meeting on June 7, 1999. A general overview of the entire procedure was provided by members of the DOT technical panel where copies of traffic count maps, traffic data collection site maps, and documentation related to the maps were provided. Following this meeting, detailed interviews were conducted in Pierre, South Dakota, on June 24 and July 2, 1999. SDDOT personnel in the Office of Data Inventory who are directly involved in the collection of traffic data, traffic data reporting, and traffic forecasting were the primary interview subjects. Copies of various documents pertaining to traffic forecasting were obtained by the RESPEC project team, along with examples of actual traffic data and other relevant output products. Upon RESPEC's review of the meeting notes and the corresponding material that had been collected, the interviews were supplemented by various informal visits to the SDDOT as well as follow-up telephone interviews.

Identification of the traffic data derivations, event sequences, procedural components, and forecasting methodologies were the main considerations during the review of 20-year traffic forecasting at the SDDOT. Primary focal points during the procedural review were:

- Historical perspective; how SDDOT's procedure has evolved to its present state.
- Data collection; the derivation of traffic counts, statewide VMT, and the determination of traffic counting locations.
- Criteria involved in producing factors; what the input criteria are and how they are used to produce the traffic forecasting factors.
- Tools used; particularly, identification of the automated systems, software, and databases.
- Traffic forecasting factor use; after the forecasting factors are generated, what types of SDDOT operations employ them, and for what purposes.

The following sections overview the 20-year traffic forecasting procedure, software, and data at the SDDOT.

3.1 HOW SDDOT'S TRAFFIC FORECASTING HAS EVOLVED

The 20-year traffic forecasting procedure has been an ever-evolving process at the SDDOT that began in the late 1970s. After the traffic data are collected and statewide VMT is generated, the traffic forecasting procedure is essentially carried out by one person. Like most states, traffic analyses initially started with simple traffic counts to get a "snapshot-in-time" of highway use. Then, basic planning functions began to take shape whereby projections of future traffic became desirable and ways to predict future traffic growth were instituted. Transportation planning began to take more precedence, higher order planning functions began to emerge, and increasingly sophisticated scientific means began to creep into planning processes over this time.

Today, traffic forecasts are the primary input criteria for many DOT operations. Many of these operations are guided by federal policies where conditions have created the impetus to project traffic growth for yearly statewide transportation plans and also support traffic analysis for individual highway projects. The rural nature of the state (with few and scattered urban/ urbanized areas), limited resources (compared to other, larger state DOTs), and the bridge state conditions (defined earlier) are conditions that have made the SDDOT traffic forecasting procedure unique and incomparable to most all other states.

3.2 TRAFFIC DATA COLLECTION

Complete information on SDDOT traffic data collection is available in the *South Dakota Traffic Monitoring Documentation* prepared by the Office of Data Inventory [South Dakota Department of Transportation, 1998]. This document contains a thorough overview of traffic count operations, procedures, equipment, vehicle classifications, and other information pertinent to traffic monitoring at the SDDOT. The following information provides a brief description of the traffic counting schema at the Department and includes a historical overview of the evolution of traffic data collection in the state.

Maps obtained from the Office of Data Inventory at the SDDOT show the locations of permanent traffic counters as well as locations used to set up temporary traffic counters. There are approximately 6,251 traffic count locations throughout the state. Fifty-one continuous, permanent automated traffic recorder (ATR) sites are used for both volume and classification counts. Approximately 6,200 temporary, short-term portable count sites are used for volume counts. Locations identified for siting portable counters have generally remained constant, but these locations are only used on a temporary basis and in cyclical patterns relative to traffic counting needs for inventory purposes. A sampling plan for traffic counts is developed each year whereby portable counters are set up at specified locations once a year, generally early spring to early fall. Average daily traffic (ADT) is then calculated from the volume counts by applying seasonal and axle correction factors. Weather, construction activities in the immediate area, and other assigned activities for the maintenance crews installing the counters are the main influences that determine utilization of a temporary traffic counting site.

Determination of traffic counting locations was initiated several years ago when the SDDOT followed nationwide trends for instituting traffic counts as a type of survey data to supplement the decision-making processes involved in transportation planning, project prioritization, operations, and maintenance. Ongoing highway construction projects that would accommodate permanent installation of inpavement traffic counting loop/probe sensors were primary considerations for locating counters. Several other criteria have been used over the years to locate both permanent and temporary traffic counting sites. These criteria include:

- Locations that were deemed to be logical and relevant based on the professional judgments of authoritative SDDOT personnel involved at the time.
- FHWA recommendations, policies, and input whereby nationwide interests have been an inducement either directly or indirectly affecting traffic counting operations at state DOTs [Federal Highway Administration, 1992].
- The selection and placement of HPMS sample segments.
- Requests from local authorities.

Although the criteria for the selection and placement of traffic count locations have relevant basis, the criteria have been used disparately and are generally nonconjunctive. In other words, the process has evolved from early practices where little consideration was given to a statewide plan for locating traffic count sites. Today, the SDDOT has basic guidelines provided in the *South Dakota Traffic Monitoring Documentation* and the TMG.

Information gathered during interviews for this project coupled with the SDDOT's own *Documentation of ATR Groupings & Sample Size* stated that ATR placements and ATR groupings are still based on professional judgements. Essentially, most FHWA policies/guides provide basic guidelines that are considered minimum requirements to perform an operation or activity effectively. The TMG is no different. Guidelines are considered as foundations and there are often FHWA expectations that state DOTs will want to build or improve upon such foundational guidelines.

3.3 INPUT CRITERIA USED TO PRODUCE TRAFFIC FORECASTING FACTORS

From a historical perspective, the input criteria used to produce traffic forecasting factors have been fairly narrow in scope and without much deviation in regard to their type or use. The main criteria are generally derived through sources internal to the SDDOT. However, one or two externally derived criteria have been used on occasions where they were deemed relevant either to the input process or as benchmarks to verify factors already produced.

Internally derived input criteria are statewide VMT broken down into regular and commercial vehicle types, the total mileage for each highway functional class (interstate, arterials/collectors, and local roads) across each of the six regions around the state, and the historical growth trends of statewide VMT. External criteria introduced at the discretion of SDDOT traffic forecasting personnel have included population growth trends from census data and economic growth trends.

Prior to further discussions on the traffic forecasting procedure used at the SDDOT, a few primary details need to be noted concerning input criteria. These notes are as follows:

- Actual VMT totals for the six regions must be extracted from the statewide VMT data and then recomputed and distributed proportionally.
- Twenty-year traffic forecasts are only performed for regular (passenger car) vehicles and commercial (truck) vehicles and are not distributed across any categorical truck types with assigned axle designations (as are readily available in VMT reports).
- The six regions appear to be autonomous to SDDOT traffic forecasting and do not have coincidental boundaries with any other bureaucratic function that can be readily discerned, including the state's six planning districts.
- Growth trends based on historical data assume a straight-line projection.
- Population and economic growth data are nominally used in final comparisons with the 20-year traffic growth projections and are only used as lightly weighted input at the end of the traffic forecasting procedure if there are significant discrepancies.

The primary details as itemized above will be important considerations when reviewing the documentation of SDDOT's 20-year traffic forecasting procedure in Section 3.6 of this report.

3.4 AUTOMATED PROCESSES IN TRAFFIC FORECASTING PROCEDURES

Traffic data collection and traffic data management are the primary operations utilizing automation or information system technology for traffic forecasting at the SDDOT. Data collection makes use of traffic counting loop/probe sensors inlaid in the highway pavement at permanent traffic count locations, and tube/inductive loop sensors laid on the pavement surface at nonpermanent locations, both of which will produce traffic count readings in digital form. These readings are held in electronic format in the counter units at each site. The ATRs are connected to telemetry so they can be monitored daily, and there is also a dial-up modem at each site whereby readings can be collected on demand. All modems are connected via telephone lines to SDDOT headquarters in Pierre which allow for simultaneous retrieval and collection of traffic count data at the centralized location of the Office of Data Inventory. Data from the boxes of the portable counters are normally retrieved by a field technician. Once collected, the traffic data are reviewed and edited as necessary, then stored in ADABAS databases on the state's IBM mainframe. State trunk highway traffic data are stored in the RES file, and nonstate trunk traffic data are stored in the Non-State Trunk Roadway Inventory (NSTRI) file. Complete information on the automated processes of traffic operations is contained in the *South Dakota Traffic Monitoring Documentation* [South Dakota Department of Transportation, 1998].

There are no commercially developed software programs in use at the SDDOT to produce traffic forecasting factors. Quattro Pro spreadsheets were developed "in-house" several years ago on a personal computer (PC) platform to perform simple reductions of the VMT data, calculate the miles of each functional roadway class per region, and develop the "straight-line" historical growth trends to produce traffic forecasting factors. The spreadsheet output has never been considered the final traffic forecasting product because these factors have traditionally served as intermediate output for subsequent review and analysis. The factors have always been subject to adjustment based on human judgments about factor "believability" and comparison to other numbers used for planning purposes such as economic and/or population growth indicators.

During reviews of the SDDOT procedure, it was learned that the 20-year traffic forecasting spreadsheet programs were recently lost and/or deleted and are now nonretrievable. Additionally, the documentation for these programs includes only a few scant notes recorded before the original program developer retired and left the SDDOT. Since the programs were not extremely sophisticated, the logic could probably be replicated fairly closely in newer and more suitable programming software. Ultimately, the past practices and supporting automated processes have essentially been precluded by the primary objective of this research project, which is the development of a *new* procedure to produce traffic forecasting factors at the SDDOT.

Another finding during procedural reviews was the apparent lack of any archived records of historical VMT data prepared for traffic forecasting. Similar to the traditional 20-year traffic forecasting procedure, "raw" traffic count data are extracted from the ADABAS files on the mainframe and VMT numbers are then generated from PC applications and manual processes. The final VMT data from past years have simply been copied onto 3½-inch floppy disks since 1991 and most of these disks have become corrupted or lost. The annual VMT data have never been archived on any tape, optical storage, or other media, and paper records of as-computed VMT are essentially the only historical reference to past years' VMT. In 1991, calculations performed for VMT production were changed to correlate with HPMS reporting, and procedures used to produce VMT records prior to this time are difficult to replicate. Therefore, the loss of spreadsheets and expertise to produce 20-year traffic forecasting factors, coupled with the inability to easily validate original derivations of VMT (important start-up data to traffic forecasting procedure) prior to 1991, make it extremely difficult to verify the historical performance of 20-year traffic forecasting factors. Without any past reference, the Department has essentially never been able to assess the integrity of the factors, however used.

3.5 DEPARTMENTAL USE OF 20-YEAR TRAFFIC FORECASTING FACTORS

Departmental requests for 20-year traffic forecasts occur on an “as-needed” basis and in an ad hoc fashion. This section describes these types of requests as opposed to the transportation activities/systems that are described in other sections of this report where traffic forecasting factors are required input. The primary systems/activities that require traffic forecasting factors, as described in more detail elsewhere, are:

- HPMS
- RES
- Pavement design
- Activities of specific highway projects.

Internal use of traffic forecasting factors is driven by the data input requirements of a particular DOT activity and requests depend on whether the forecasting factors are deemed to improve the confidence and integrity of the activity’s outcome. Since the 20-year traffic forecasting factors have always been subject to postprocessing manipulation based on subjective judgments of the traffic forecasting personnel, past years’ factorial values have to be considered as variable on a year-to-year basis.

Requests for traffic forecasts span all SDDOT divisions and offices, as well as external agencies. A general overview of request origination and the corresponding incentives for employing traffic forecasting factors in departmental activities are as follows:

- *Planning functions* – traffic forecast data are requested as decision-making criteria for highway infrastructure needs analysis, project prioritization, project scheduling, and other DOT planning activities where projections of future traffic are considered relevant to the particular planning process.
- *Engineering functions* – traffic forecast data are requested as decision-making criteria for designing highway geometry/alignments, pavement types/thickness, shoulder types/widths, and other engineering aspects where future traffic loads might influence highway designs.
- *Operations functions* – traffic forecast data are requested as decision-making criteria for the Division of Operations, region offices, and area offices to schedule pavement maintenance activities, in efforts to instill better highway traffic engineering/safety control, to improve roadway environmental conditions, and for other operations and maintenance activities that might be impacted by the changes in future traffic loads.
- *External agency needs* – traffic forecast data are requested by other state agencies when they feel that their planned activities may impact or be impacted by DOT functions, when traffic forecasts may provide criteria for political and/or budgetary considerations,

when regulatory issues (commercial licensing/permitting in particular) may need traffic forecast data as input, and when offices involving tourism and /or economic development perceive long-term planning benefits, etc.

It should be noted that all the activities utilizing 20-year traffic forecasts have factors available for passenger cars and commercial trucks, but not for commercial trucks distinguished by the number of axles. The availability of forecasting factors for commercial vehicles classified by axle configurations could be considered as highly desirable input criteria for many departmental activities, particularly in the design, construction, performance assessment, management, and maintenance of highway pavements.

3.6 SDDOT'S CURRENT 20-YEAR TRAFFIC FORECASTING PROCEDURE

The procedure to produce 20-year traffic forecasting factors has been performed every 4 years at the SDDOT. The procedure was last performed in 1994 to produce traffic forecasting factors for the years 1995–2015.

The following sections detail the sequence of procedural steps that are currently followed by SDDOT personnel to develop 20-year traffic forecasting factors. Each section describes a successive step of the process.

3.6.1 Preparation of VMT Data

Annual VMT reports are compiled and published each year by the Office of Data Inventory at the SDDOT. Statewide VMT numbers have been critical start-up data in the traditional production of 20-year traffic forecasting factors. A brief synopsis of the event sequence to produce yearly VMT totals is as follows:

- ATRs are assigned to and located on roadway segments that have predetermined lengths.
- Various ATR groups are distributed proportionately across the state highway system classified roadways (Interstate, Principal Arterial, Minor Arterial, Major Collector, and others) to gain representative counts for each roadway classification.
- Representative counts are also collected on both rural and urban roadways.
- Thirteen vehicle classifications (recommended by the FHWA) can be distinguished and counted separately because ordered ATR groups are capable of recording the number of axles on each vehicle; axle correction factors can then be applied to segregate the various vehicle class counts.
- Daily traffic counts are recorded over a 1-year reporting cycle for each vehicle classification at a counting site that has a specific roadway functional classification.

(The sum of the daily traffic counts on a segment for a given reporting year divided by 365 days gives the Average Annual Daily Traffic (AADT)).

- The total annual traffic multiplied by the roadway segment length gives the yearly VMT over that roadway class segment for each vehicle type.
- Within a particular area such as a county, total VMT for a particular roadway classification can be estimated using the following ratio:

$$\frac{\text{Total VMT on All Sample Segments}}{\text{Total Mileage of All Sample Segments}} = \frac{\textit{Total VMT}}{\text{Total Mileage}}$$

- The VMT numbers produced for counties according to functional road category, vehicle type, and rural/urban designation are combined to give the statewide VMT.

The traditional SDDOT procedure to produce 20-year traffic forecasting factors begins with these statewide VMT totals.

3.6.2 SDDOT's Current 20-Year Traffic Forecasting Methodology

Step 1: Extraction of Statewide VMT

The total VMT for each of the six traffic analysis regions defined specifically for use in 20-year traffic forecasting is arrived at by summing the VMT numbers for all the counties making up each particular region. The sum of the six region VMT totals produces the statewide total annual VMT. Table 3-1 shows the counties that make up each region.

Step 2: Statewide VMT Growth Projection From Historical Data

Quattro Pro spreadsheets have been used since the late 1980s to project traffic growth on a statewide basis. Although the spreadsheets are no longer available for use, the programs' logic and algorithms are fairly easy to explicate from the last hardcopy output produced in 1994. The primary processes that have been involved in projecting traffic growth are as follows:

- A base year is identified to begin the analysis. This base year is the same year the 20-year traffic forecasting procedure is performed.
  - 1994 was both the base year and the last time the 20-year traffic forecasting procedure was performed.
- Historical statewide VMT data are used to project future VMT growth.
  - In 1994, projections were based on VMT growth that occurred from 1981 to 1994.

Table 3-1. Counties by Traffic Analysis Region

Region 1 (R1)	Region 2 (R2)		Region 3 (R3)
Brookings	Clay		Aurora
Clark	Lincoln		Bon Homme
Codington	Minnehaha		Brule
Deuel	McCook		Charles Mix
Grant	Turner		Davison
Hamlin	Union		Douglas
Kingsbury			Gregory
Lake			Hanson
Miner			Hutchinson
Moody			Jerauld
			Sanborn
			Yankton
Region 4 (R4)	**Region 5 (R5)**		**Region 6 (R6)**
Beadle	Buffalo	Perkins	Bennett
Brown	Campbell	Potter	Butte
Day	Corson	Stanley	Custer
Edmunds	Dewey	Sully	Fall River
Faulk	Haakon	Todd	Harding
Hand	Hughes	Tripp	Jackson
Marshall	Hyde	Walworth	Lawrence
McPherson	Jones	Ziebach	Meade
Roberts	Lyman		Pennington
Spink	Mellette		Shannon

- The historical trend shows that statewide VMT has been generally increasing and the spreadsheet logic is based on the assumption that statewide yearly VMT will continue to increase.
  - Review of historical VMT data in 1994 showed up-and-down fluctuations in statewide VMT over the years from 1981 to 1994, but the general trend was a rising growth pattern.
- A regression analysis equation in the Quattro Pro spreadsheets is used to establish a straight-line growth projection of VMT based on historical data.
  - In 1994, overall VMT projections were based on a 1.7 percent yearly compound growth rate.
- The VMT totals in the urbanized areas of Rapid City and Sioux Falls (in Pennington, Minnehaha, and Lincoln Counties) are excluded from the traffic analysis regions because these are treated separately in the current statewide forecasting procedure.
  - In 1994, urbanized areas represented 14.88 percent of the state's population. Therefore, the statewide VMT was reduced by 14.88 percent.

- The separate treatment of traffic forecasting in Rapid City and Sioux Falls occurred because, population-wise, the state's urbanized areas have tended to show greater population growth than rural areas. This is taken into account in the future VMT growth projections.
  - In 1994, growth rates for the urbanized areas were estimated at 2.5 percent, compounded annually, resulting in projected VMT totals for those regions containing the urbanized areas to be upwardly increasing curves as projections move further into the future.

The above processes yield an overall, statewide projection of traffic growth for all vehicle classifications and over all roadway functional classifications, but is not yet broken down into regions. The succeeding steps of the procedure are where these breakouts occur and the corresponding traffic forecasting factors are then produced.

Step 3: Functional Roadway Systems VMT Growth Projections From Historical Data

In addition to the availability of historical statewide VMT data critical to step 2, historical data are also maintained for the total VMT on each functional roadway class system in the state. Based on the historical VMT data for the roadway classifications of interstate and arterial, a linear regression analysis similar to that performed in step 2 is used to project VMT growth on these highway systems. The combined total of the interstate and arterial VMT projections is then subtracted from the statewide VMT projection to get a growth projection for the "other" functional roadway system. Statewide 20-year traffic forecasting factors are produced by dividing the VMT growth projections for all functional roadway classifications at each forecast year by the base year (1994) VMT.

Step 4: Regional VMT Growth Projections From Historical Data

A linear regression analysis of the historical traffic data for each of the six regions is performed to project VMT growth within each of the six regions. Again, verification is attained by summing the regional VMT growth projections and comparing the accumulation to the statewide total. However, the primary output of this step is the total percentage VMT growth projection at the end of 20 years within each region.

Step 5: VMT Growth Projections by Functional Class Within Regions

When regional VMT growth has been determined, it becomes fairly simple to distribute the growth projections across the various functional roadway classifications within each region. Total mileage is maintained for each functional roadway class within a region, as well as total statewide mileage for each functional classification. Therefore, each region contains a specific percentage of the statewide functionally classified roadway mileage. The percentages are used as an adjustment factor to calculate each region's proportionate share out of the statewide traffic growth projection for each roadway classification.

Step 6: Segregating Commercial and Regular Traffic in VMT Growth Projections

The 20-year traffic forecasting procedure at the SDDOT only forecasts passenger vehicles and commercial vehicles without consideration of the need to develop factors for commercial vehicles classified according to axle distributions. As stated earlier in this report, however, traffic counting procedures actually distinguish between 13 vehicle classifications in the annual VMT reports. Vehicle types can be determined because the ATRs record the frequency and time interval between each axle that runs over the loop/tube of the ATR. Postprocessing software captures the vehicle types and groups them accordingly. Data on commercial vehicle types are maintained according to the percentage distributions of annual VMT for all 13 vehicle classifications in each of the six forecasting regions. An example of the percentage distributions of commercial vehicles traveling the state's highway system for 1995 is found in Table 3-2.

Table 3-2. Percentage of Vehicles by Type Traveling the State's Highway System for 1995

Vehicle Type	Urban Interstate
Autos	78.0
Pickups – Other 4-Tire	15.2
Subtotal	***93.2***
Single-Unit Trucks	
Buses	0.2
2-Axle, 6-Tire	1.4
3-Axle	0.9
4-Axle	0.3
Single-Trailer Trucks	
4-Axle or Less	0.9
5-Axle	2.4
6-Axle or More	0.3
Multi-Trailer Trucks	
5-Axle or Less	—
6-Axle	—
7-Axle or More	0.4
Subtotal	***6.8***
Total	***100.0***

The percentages of all truck categories other than 'Pickups–Other 4-Tire' from Table 3-2 are summed to give a total percent truck distribution. The statewide VMT is multiplied by the total percentage of trucks to give a statewide total truck VMT. Truck forecasting then becomes very similar to previous steps of the traffic forecasting procedure whereby the VMT for trucks is apportioned into the six traffic regions based on the representative functional roadway class mileage in each region. Regression analyses are performed on the historical truck VMT going back to 1984 (the first year of available truck data) for the various functional roadway classifications in each region. The truck forecasts then become a separate array designation in the 20-year traffic forecasting factors tables.

Step 7: 20–Year Traffic Forecasting Factors Array Table

The 20-year traffic forecasting factors are obtained directly from the 20-year projected VMT coming out of the regression analyses. The 20-year projections are merely divided by the actual VMT data recorded for the most recent available year (called the base year). To put it simply, the traffic forecasting factors are just the ratios of the 20-year projections over the most recent year of recorded VMT. If the last year of data deviates significantly from the mean of previous years' data for some reason, an inherent bias is thrown into the factors. An example would be the flooded road conditions that occurred a few years ago in the northeast part of the state. Traffic rerouting and detours to alternate roadways over the time it took to raise roadway grades of flooded roads is an exceptional year that affected traffic patterns significantly. To use these actual VMT numbers for such an irregular traffic year tends to bias the ratios that are used to derive the traffic forecasting factors. In any event, traffic forecasting over large regions mitigates this bias somewhat but would probably not be acceptable for traffic forecasting using geographically smaller TAZs.

The 20-year traffic forecasting factors array table is the final result of the traditional 20-year traffic forecasting procedure at the Office of Data Inventory. The 20-year traffic forecasting factors are produced and organized in the table by region according to the roadway classifications of interstate, arterials and collectors, and local roads. The factors are further distinguished in the table by regular and commercial vehicle categories. The most recent "Twenty-Year Factor Array" produced by the Office of Data Inventory in 1994 is given in Table 3-3.

Table 3-3. Twenty-Year Factor Array, 1995–2015

Region	Interstate		Arts & Colls		Local Roads	
	Reg	Comm	Reg	Comm	Reg	Comm
One (R1)	1.268	1.750	1.359	1.325	1.143	1.143
Two (R2)	1.325	1.716	1.226	1.256	1.533	1.533
Three (R3)	1.263	1.744	1.346	1.358	1.159	1.159
Four (R4)	1.164	1.689	1.251	1.356	1.099	1.099
Five (R5)	1.350	2.012	1.370	1.417	1.276	1.276
Six (R6)	1.284	1.831	1.368	1.468	1.135	1.135

4.0 REVIEWS OF TRAFFIC FORECASTING PROCEDURES AND COORDINATION OF MPOS

Task 4: Summarize each MPOs present traffic forecasting procedure as well as its forecasting coordination with DOT.

There are three urbanized areas in the state of South Dakota; namely, North Sioux City, Rapid City, and Sioux Falls. North Sioux City, South Dakota, is an outlying portion of Sioux City, Iowa, but only has a population of about 2,000 people and does not have an associated, full-time planning office Therefore, the only two MPOs represented in the state are at Rapid City and Sioux Falls.

Information was gathered on individual traffic forecasting procedures and coordination with the SDDOT through on-site visits to the Rapid City and Sioux Falls public works offices. Interviews were conducted in Rapid City on June 11, 1999, and in Sioux Falls on July 28, 1999. The situation at North Sioux City was reviewed and analyzed through available literature during the research efforts for this project task, and a phone interview was also conducted with Mr. Chad Lingenfelter, Transportation Planning/MPO Director at SIMPCO. The following sections present the results of the findings through the literature reviews, interview processes, and other information gathering activities.

4.1 TRAFFIC FORECASTING AND COORDINATION AT NORTH SIOUX CITY, SOUTH DAKOTA

North Sioux City, South Dakota, is situated in the extreme southeastern tip of the state and is located on the Big Sioux River near its convergence with the Missouri River. There are only two points of entry via roadways from Sioux City, Iowa, represented by the Interstate Highway 29 and State Highway 105 bridges across the Big Sioux River. Rapid and expansive development around the North Sioux City area in the late 1980s and early 1990s created immediate upgrade needs, including highway improvements, interstate interchange expansion, and better access to the area overall. Primary real estate developments driving the expansion have been the Dakota Dunes Golf Course and supporting facilities, influx of the Gateway 2000 complex, and commercial/residential subdivisions planned around these developments. Although growth has tapered off from the original developmental “boom” that occurred during this time frame, the needs still exist to perform long-range planning functions and traffic forecasting in particular for the North Sioux City area.

In discussions with Mr. Chad Lingenfelter of SIMPCO, he reported that the TRANPLAN software in use at SIMPCO is based almost entirely on socioeconomic input to generate passenger trips. He does not feel that the software currently models traffic well for the “funneling” effect of bridge scenarios such as those present at the I29 and Highway 105 bridges into North Sioux City. SIMPCO is working on improving this aspect of their traffic forecasting model.

Since North Sioux City only has a population of just over 2,000 people and does not have a full-time municipal planning office, SIMPCO is not able to fully coordinate transportation planning activities. Currently, such activities are only coordinated through SIMPCO for the urbanized areas in Iowa and Nebraska with significantly larger populations. SIMPCO does request a traffic count map on occasion from the Office of Data Inventory at the SDDOT, or else traffic count data from the Yankton Area office of the SDDOT. For verification purposes, however, SIMPCO will often send personnel to North Sioux City to conduct traffic counts following these requests. This is a potential source of traffic count data that the SDDOT may want to consider to enhance traffic forecasting activities in this area. Otherwise, in-state traffic data collection for planning purposes and subsequent traffic forecasting will only be performed from a SDDOT perspective since there is not a full-time office to perform traffic monitoring functions in North Sioux City.

Fortunately, North Sioux City represents a state port-of-entry (POE) whereby inbound highway traffic has only two access points and is essentially “funneled” in via the two bridges mentioned previously. These conditions are good for traffic data collection, and the potential exists for supplementary data provided by a commercial vehicle weigh station currently located at North Sioux City on Interstate 29. The existing POE weigh station is planned for replacement by a new facility in the Year 2001. Weigh-in-motion (WIM) technology and automatic vehicle identification (AVI) are being considered at the North Sioux City POE as part of the Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) business plan recently developed by Cambridge Systematics, Inc. for the SDDOT [Erickson and Markert, 1998]. As they become available, these installations would provide the means to enhance and supplement traffic data collection and corresponding traffic forecasting procedures greatly for this area.

4.2 TRAFFIC FORECASTING AND COORDINATION AT RAPID CITY, SOUTH DAKOTA

A meeting was conducted on June 11, 1999, between the RESPEC project team and the Rapid City MPO [Horton, 1999]. The purpose of the meeting was to overview traffic data collection and traffic forecasting procedures at the city of Rapid City, review the city’s traffic forecasting coordination with the SDDOT, and examine the interfaces of city/state procedures.

The Rapid City MPO recognizes the significant role that good traffic forecasting can play and is also aware of the importance of employing a sound forecasting procedure based on logical criteria and relevant data input. Over 2 years, spanning 1995 to 1997, a team consisting of city, MPO, and state personnel worked on the development of a *Rapid City Transportation Model – A Traffic Forecasting Model* [Rapid City Metropolitan Planning Organization, 1997]. The theory of the model is based on three main components: (1) network characteristics, (2) travel and land use characteristics, and (3) simulation runs. The model's procedures are based on the utilization of Tmodel 2 software [Tmodel 2 Corporation, 1997] where 145 TAZs have been defined within Rapid City's jurisdictional boundaries.

Although there is a good awareness of the importance of sound traffic forecasting procedures at the city of Rapid City, implementation of the model has been put on hold for an indefinite period of time. There are several factors contributing to delays in model implementation, which include:

- All relevant input criteria cannot be fully actuated at this time; in particular, defined land use areas have not been wholly accepted by all of the parties involved in the city's planning processes.
- Similar to the SDDOT, dedicated personnel and resources for performing traffic forecasting functions have been diminished and are currently very limited.
- Loss of experienced personnel, coupled with internal reorganization and reassignment of planning duties, have created gaps where traffic forecasting expertise would normally be required.

These restrictions to implementation of the Rapid City traffic forecasting model have compelled the MPO office to rely on a simplified and straightforward approach to projecting traffic growth factors.

The report entitled *Rapid City MPO – 1998 Traffic Counts and Factors* [Rapid City Traffic Engineering and Operations, 1999] overviews the city's basic traffic forecasting methodology. The essential traffic counting and forecasting operations as identified in the report are outlined as follows:

- Annual traffic is based on data collected at five SDDOT permanent traffic count stations in Rapid City (the city also maintains five permanent traffic counting stations with plans to add more in the future, but data from the city stations were not used in 1998).
- Average weekday traffic counts were compared to the same period of previous years (1991 to 1998) to produce week-by-week comparisons of traffic volumes from one year to the next.
- The annual traffic growth rate is produced based on the average weekly traffic totals over each particular year.
- The final product is a table showing the historical traffic growth trends, which can be used to project future traffic growth.

It should be noted that there are no actual traffic forecasting factors produced for this report with the means for projecting traffic growth left to the discretion of table users. As stated in the report, "Annual traffic growth factors represent past trends in traffic; but, are useful in estimating short range traffic projections. While this capability exists by having this data, caution should be exercised by those using it to perform traffic forecasts."

Exclusive use of the SDDOT's 5 permanent counting stations in the Rapid City environs essentially means that traffic forecasting performed by either the SDDOT or the city is based on the same data. Methodologies differ primarily in the straightforward approach used by the MPO in applying historical trends strictly within the city limits versus the regional approach used by the SDDOT. The SDDOT takes the data from the five SDDOT counting stations in Rapid City and combines it with all other traffic data from that region to produce VMT start-up data for the traditional procedure described in Section 3.6 of this report. Essentially due to the lack of resources, available data, and dedicated personnel at this point in time, the city desires as much coordination as possible with the SDDOT on traffic forecasting activities.

4.3 TRAFFIC FORECASTING AND COORDINATION AT SIOUX FALLS, SOUTH DAKOTA

A meeting was conducted by RESPEC on July 28, 1999, with the city of Sioux Falls Public Works Department [Ausen and Smith, 1999]. The purpose of the meeting was to overview traffic data collection and traffic forecasting procedures employed by the city and to review the associated city/SDDOT coordination and procedural interfaces.

Sioux Falls is the largest urban area in South Dakota and has been experiencing rapid growth over the past several years. These circumstances bear important planning considerations, which include traffic forecasting as a vital tool for helping define the long-term needs of the city's transportation system infrastructure. The Sioux Falls Public Works Department is acutely aware of the role traffic forecasting can play in transportation planning activities and has taken appropriate steps to integrate relevant and logical traffic forecasting procedures with the city's ongoing planning functions. This includes the utilization of Tmodel 2 software for traffic forecasting operations whereby socioeconomic and land use data are the primary input variables.

The city of Sioux Falls is well prepared to support many MPO planning functions, including traffic forecasting, by dedicating the appropriate resources and tools to supplement data input requirements and supporting criteria. The primary mechanisms in place to support transportation planning activities include the following:

- A *Residential Land Use Report* [Sioux Falls Planning Office, 1998] prepared, updated, and published annually which defines 254 TAZs within the study area of the city and includes rural areas of Minnehaha and Lincoln Counties as well.

- A 20-year managed plan for the city entitled *Sioux Falls – Year 2015 Comprehensive Development Plan* [Sioux Falls Planning and Building Services, 1996], which includes various socioeconomic data, growth area analyses, development strategies, decision maps, and proportional material included that is relevant to the strategic interests of good transportation planning.
- A *Minnehaha County Comprehensive Development Plan* [Minnehaha County Planning Department, 1998] with a presentation, format, ideological strategy, and planning concepts that closely parallel the Sioux Falls comprehensive plan as described above.
- A comprehensive plan document for Lincoln County very similar to the one developed for Minnehaha County.
- A citywide traffic counting scheme newly developed and instituted in 1995 which includes publication of *Traffic Volume Counts for the City of Sioux Falls, 1994 – 1998* [Sioux Falls Engineering Department, 1998].
- A Geographic Information System that is structured to support various planning/public works activities (including transportation planning), to provide base maps as a broad set of graphical interface tools, and to produce decision maps useful to many of the city's analytical processes.

In addition to these dedicated tools and resources, the city of Sioux Falls makes use of outside data as available and applicable from the local Chamber of Commerce, the U.S. Bureau of the Census, and local surveys performed for special needs, among other sources.

Finally, the city is looking to refine traffic forecasting procedures of the future by implementing planned improvements. These improvements include the procurement of new traffic modeling software within the next year. Also, the city began to share the responsibilities for Sioux Falls' traffic data collection with the SDDOT in 1997. However, the city understands that even better traffic forecasting coordination with the SDDOT is possible, and alludes to this in the city's document *Traffic Volume Counts for the City of Sioux Falls 1994 – 1998* [Sioux Falls Engineering Department, 1998]. Quoting from introductory information to this report, "At this time (1997), the City Engineering Department also began to use the AADT factors calculated by the SDDOT. The switch to the SDDOT factors is accountable for some change in traffic volumes in 1997 as compared to previous years." In fact, the city's 'traffic adjustment factor' prior to 1997 was around 0.97 to 0.98, which was felt to be more realistic than the SDDOT's 0.91 adjustment factor assumed in 1997. When applied to transportation routes such as 41st Street, which carries up to 60,000 vehicles/day, such a fluctuation to the adjustment factor can reflect significant transportation planning impacts. Again, better coordination and verification are desired, particularly at the Sioux Falls MPO and SDDOT boundary interfaces, as well as on state routes through the city.

5.0 REVIEWS OF OTHER STATES' TRAFFIC FORECASTING PROCEDURES AND DATA COLLECTION METHODS

Task 5: Summarize the traffic forecasting procedures and data collection methods of other states. (At a minimum, survey a representative sample of other rural Midwest states.)

The reviews of literature performed on a broad, national scale, as described in Chapter 2.0 were followed by direct contact with states having traffic forecasting methodologies with practicable characteristics that might be adopted by the SDDOT. For particular state DOT reviews, telephone interviews became the primary method to determine which states might be able to contribute information on traffic forecasting procedures with relevant and congruous qualities in relation to SDDOT needs. Detailed telephone interviews were conducted with those states deemed to have information directly relevant to the research efforts for this project, and requests for supporting documentation felt to be directly applicable were forwarded simultaneously.

The contributing information is primarily representative of the states in the Upper Midwest because of the similarities in geographic, demographic, and state transportation agency characteristics relative to South Dakota. States with dissimilar interests in statewide traffic forecasting were briefly reviewed to discern if any *portion* of their traffic forecasting methodologies might have relevancy to this SDDOT research project. State traffic forecasting procedures briefly reviewed under these criteria included: Florida [Shimpeler, Corridino Associates, 1990], Michigan [KJS Associates, Inc., 1996], New Jersey [URS Consultants, Inc., 1995] and Connecticut [Connecticut Department of Transportation, 1997]. The primary reason for noninclusion of traffic forecasting information from those states in this report was a common, underlying theme of applying urban modeling techniques on a statewide level. When the number of metropolitan areas and the denser population of those states is considered, this technique can be understood to have more direct applicability. Florida and Michigan are working to apply distinct traffic forecasting models based on travel trip generation between nearby cities/urban areas (a concept that was overviewed earlier). New Jersey and Connecticut, being geographically smaller states with more condensed populations, are basically merging metropolitan areas and applying an urban model on a statewide basis. Unfortunately, urban-oriented models with these types of characteristics would not be practical for the SDDOT's statewide traffic forecasting needs.

It was apparent early in the information gathering efforts that no state is currently performing traffic forecasting that entirely matches the SDDOT needs. However, it should be noted that some states did not reply to requests for information or simply did not have enough supporting information for a definitive review. Of those procedures assessed, many could not be substantively ascertained because they are theoretical, are currently under development, have only been partially implemented, or have been implemented as pilot projects under fully controlled conditions. It was presupposed that there are states that have traffic forecasting components applicable to this research effort, but the current traffic forecasting climate for states with rural characteristics similar to South Dakota is one of ongoing analysis and development. Therefore, there are no current or past perspectives on which to base evaluations of forecasting procedures in states that have similar needs.

5.1 SUMMARIZATION OF OTHER STATES' TRAFFIC FORECASTING PROCEDURES

To be included in this study, material from other states had to meet at least one or more of the following research criteria:

1. Geographic/demographic similarities to South Dakota.
2. Statewide forecasting procedures that have merit according to peers.
3. The particular DOT's willingness to be interviewed and/or forward information.
4. The feasibility of applying any procedural components to the SDDOT's unique set of conditions.

States that were able to offer information satisfying the research criteria are detailed in the following sections.

5.1.1 Idaho

Research Means – Electronic database searches and reviews of available literature. Two telephone interviews were conducted with the Transportation Systems Engineer at the Idaho Transportation Department's Planning Division [Manubay, 1999].

Status of Statewide Traffic Forecasting – A research report entitled *Statewide and Sub-Area Transportation Model Feasibility Study* [Khatib et al., 1997] was completed by the National Institute for Advanced Transportation Technology (NIATT), University of Idaho, for the Idaho DOT. This report is being followed by an effort currently in progress entitled *Idaho Statewide Transportation Planning Model* [Khatib et al., 1999a].

Overview – A statewide transportation planning model is envisioned as the eventual outcome of the aforementioned study. According to some of the other state transportation agencies contacted, including Chief of the Research Bureau at the New Mexico State Highway and Transportation Department (NMSHTD) [Albright, 1999], the Idaho research project appears to be the best in terms of cost and progress. In interviews with the Planning Division's Transportation Systems Engineer at the Idaho DOT, there is apparently an impetus behind the study involving legal proceedings whereby real estate developments in Idaho were negatively impacted by inadequate transportation planning. Extensive literature on the research effort was forwarded to the RESPEC project team by the Idaho Transportation Department's Planning Division.

Analysis Findings – As yet, none of the research findings have been put into practice. A progress report on the research efforts was delivered in January 1999 by the NIATT, along with a draft final report of a *Statewide Household Travel Survey Pilot Study* [Khatib et al., 1999b], which is a critical component of the project. The household survey pilot project turned up some unforeseen problems in that the number of survey responses was much lower than anticipated, and for those participants responding, return times were "surprising slow." Probably the most important aspect of the pilot survey is best summed up in a direct quote from the report: "Above all, the greatest lesson learned by the research team is that a travel survey, especially on a statewide level, requires extensive manpower and work." There is more work to be accomplished on the project, and the research theories need to be put into actual practice before the results of the Idaho efforts can be seriously evaluated.

5.1.2 Iowa

Research Means – Electronic database searches and reviews of available literature.

Status of Statewide Traffic Forecasting – No research studies or ongoing analysis of traffic forecasting procedures could be identified. The only information received related to existing procedures that have been in practice for some time.

Overview – Iowa has similar Midwestern geographic and demographic characteristics to South Dakota, but departmental traffic forecasting procedures are based on decentralized analyses performed at district offices.

Analysis Findings – The traffic forecasting concepts in Iowa were felt to be too dissimilar to the centralized/administrative needs of the SDDOT, so further research of Iowa's process was discontinued.

5.1.3 Minnesota

Research Means – Electronic database searches and reviews of available literature. A telephone interview with the Director of the Traffic Forecast & Analysis Section, Minnesota DOT [Cepress, 1999] was conducted.

Status of Statewide Traffic Forecasting – There have been some ongoing research efforts on traffic analysis, but there have been no recent efforts to implement any traffic forecasting procedures other than those currently in place. The *Procedures Manual for Forecasting Traffic on the Rural Trunk Highway System* [Minnesota Department of Transportation,

Transportation Forecasting Unit, 1985] details the primary traffic forecasting methodology that is most relative to South Dakota conditions.

Overview – Minnesota has a concept that segregates statewide rural and urban traffic forecasting into two distinct procedures. Rural traffic forecasting procedures are streamlined and straightforward, but according to the Director of the Traffic Forecast & Analysis Section, Minnesota DOT, have proven fairly accurate over time. Applying growth trends to historical traffic is a primary component of Minnesota's traffic forecasting schema, much like South Dakota.

Analysis Findings – Acceptable degrees of accuracy are reported for the rural traffic forecasting procedure in Minnesota based on historical reviews of past forecasting factor production. South Dakota does not have a good historical perspective to judge the effectiveness of past practices, but similarities in the two neighboring states' geographic and demographic characteristics would tend to lend support to maintaining a straightforward, rural traffic forecasting approach. One significant difference in the approach maintained by Minnesota is an increased focus on commercial truck types and truck-type distribution on rural routes. From the review of the traffic forecasting procedures manual, it is apparent the Minnesota DOT recognizes that traffic forecasting factors for commercial vehicles play a key role in pavement management and pavement design processes.

5.1.4 Montana

Research Means – Electronic database searches and reviews of available literature. Efforts to contact Ms. Patricia Saindon of the Montana DOT, Transportation Planning – Rail, Planning, & Transit Division, were referred to other offices, but these referrals were not able to forward any information that directly pertained to the SDDOT study.

Status of Statewide Traffic Forecasting – No research studies or ongoing analysis of traffic forecasting procedures could be identified. The only information available for review was contained in the *1997 Annual Report – System Characteristics Overview, Policy Goals and Action Status* [Montana Department of Transportation, 1997] encompassed by the *Montana TranPlan 21 – Transportation Planning for the 21st Century*. The review indicated sparse material on any statewide traffic forecasting methodologies that might be employed.

Overview – The limited material reviewed contained nothing of direct relevance.

Analysis Findings – Further review of the Montana traffic forecasting environment was discontinued.

5.1.5 Nebraska

Disclosed findings were very similar to Montana. Further reviews were discontinued.

5.1.6 New Mexico

Research Means – Electronic database searches and reviews of available literature. A telephone interview with the Chief of the Research Bureau, NMSHTD [Albright, 1999], and two telephone interviews with a consultant to the NMSHTD who is recently retired from Barton-Aschman Associates, Inc. [Hamburg, 1999] were conducted.

Status of Statewide Traffic Forecasting – New Mexico initiated research to address statewide traffic forecasting needs in 1986. At that time, it was determined that three primary conditions would need to be met before the initiative could continue. These were data quality control, database consolidation, and development of a Geographic Information System (GIS). The process has been ongoing as the conditions continue to be addressed, and the initiatives have been modified as traffic forecasting developments and philosophical changes have occurred over time.

Overview – Much like South Dakota, New Mexico is considered a "bridge" state, has the same number of MPOs as South Dakota, and also has other similar geographic/demographic characteristics. A study report entitled *A Research Process for Developing a Statewide Multimodal Transport Forecasting Model* [Barton-Aschman Associates, 1991] was issued and the basic premises in the report's defined needs are apparently still supported at the NMSHTD. However, actual development and implementation has yet to be initiated. The primary basis of the proposed procedure for NMSHTD traffic forecasting include treatment of multimodal transportation and travel demand estimations. Extensive information and material were forwarded to the RESPEC project team by the NMSHTD Bureau of Research and Mr. John R. Hamburg.

Analysis Findings – Like statewide traffic forecasting procedures at other states, a model is being researched and formulated but is too premature to put into practical application. Questions then arise as to the practicality (i.e., Will staffing, time, money, and resources be available to perform such comprehensive planning processes as multimodal analysis and travel demand forecasting?). In preparation for multimodal analysis, NMSHTD has dedicated resources to obtain better truck data and to determine equivalent single-axle load (ESAL) movements on state highway routes. ESAL forecasting through the multimodal procedure might indeed be relevant, but there is no indication in the material reviewed of the expected returns and possible uses for such data.

5.1.7 North Dakota

Findings were similar to Montana and Nebraska without any material available that appeared to have direct relevance to this project. Beyond the initial searches, no follow-up research was performed.

5.1.8 Oregon

Research Means – Electronic database searches and reviews of available literature.

Status of Statewide Traffic Forecasting – Studies have been performed through the *Transportation and Land Use Model Integration Program* under the guidance of the Transportation Development Branch of the Oregon DOT. A research report entitled *Consultant Recommendations for the Development of Phase II Databases, Models, and Forecasting Methods* [Parsons Brinckerhoff Quade & Douglas, Inc., and Urban Analytics, Inc., ECONorthwest, KJS Associates, Inc., 1996] was reviewed by the RESPEC project team to gain a sense of traffic forecasting direction at Oregon for the comparative purposes of this study.

Overview – There were three primary characteristics of traffic the forecasting development in Oregon that stood out during reviews: (1) concepts are again based on urban modeling techniques and their application is based on intercity travel, (2) external TAZs have been defined as necessary to enhance the model's integrity which will require cooperative agreements and coordination with states surrounding Oregon, and (3) GIS has been defined to play a critical role by acting as a data repository for traffic modeling software. Although there is not a lot of correlation to traffic forecasting needs at the SDDOT, there were a few concepts that bore further review.

Analysis Findings – In its entirety, the traffic forecasting direction that Oregon is pursuing does not have a lot of direct relevance to South Dakota. The information on GIS as a data repository for traffic modeling software concluded that both input and output capabilities would exist. However, there was not enough discussion on the technical aspects to evaluate the essential mechanics of this functionality. Specifically, there was no indication whether the database was expected to be internal to the GIS software or if there was to be a separate relational database. Also, the data input and output mechanisms were not identified. If there is any indication that GIS might play a role in the traffic forecasting development efforts for this SDDOT research project, follow-up discussions with the Oregon DOT might be strongly warranted.

5.1.9 Utah

Research Means – Electronic database searches and reviews of available literature. Contact was attempted with the Traffic Analysis Office at the Utah DOT, but the only information reported to be available at this time is a "Traffic Book" at a cost of $30. Since it was reported that this document contains no information on traffic forecasting methodologies and simply provides current traffic count statistics for the state, the information was not ordered.

Status of Statewide Traffic Forecasting – No research studies or ongoing analysis of traffic forecasting procedures could be identified. The Utah DOT did host a conference on traffic forecasting in December 1998 with several state DOTs in attendance. Conference material reviewed indicated only information specific to traffic forecasting interests in states like Idaho, New Mexico, and others was available. The states identified had already been contacted relative to this study.

Overview – Utah was contacted primarily in light of reports from other sources that the traffic forecasting environment has similarities to South Dakota's research project needs. However, there was no information that could be made available relative to traffic forecasting that might be applied to this SDDOT study.

Analysis Findings – Without review material, no analysis could be performed.

5.1.10 Vermont

Research Means – Electronic database searches and reviews of available literature. Telephone contact with Ms. Amy Gamble, Vermont Agency of Transportation.

Status of Statewide Traffic Forecasting – Vermont has done a significant amount of work on a statewide traffic forecasting model [Vanasse, Hangen Brustlin, Inc., 1996]. It is one of the few states reviewed under this study that has progressed beyond theoretical development and/or staged implementation phases to an actual statewide traffic forecasting model that is in place and operational.

Overview – The Vermont approach is based on a typical urban model with the inherent travel demand analysis theme. Extensive household and roadside surveys were used to generate estimates of travel trips and trip lengths. The process applies a traffic modeling process to regional subareas which are then aggregated to produce a statewide level forecast.

Analysis Findings – The procedural reviews indicated that situational differences between South Dakota tend to preclude employment of any concepts that are currently in practice in Vermont. The two primary differences that are felt to be difficult to overcome are: (1) the state is very small geographically as compared to South Dakota and can be treated rather cost effectively when statewide procedures are employed, and (2) statewide traffic forecasting data are heavily based on the use of survey questionnaires sent out to the general public and the performance of roadside surveys would be time and cost prohibitive for the SDDOT.

5.1.11 Wisconsin

Research Means – Electronic database searches and reviews of available literature. A telephone interview with the Travel Forecasting Section Chief, Division of Transportation Investment Management at the Wisconsin DOT [Uelmen, 1999] was conducted.

Status of Statewide Traffic Forecasting – A statewide traffic forecasting model based on time-series techniques and multimodal concepts is under development. The model is outlined in the document *Improving Traffic Forecasting With Time Series Models* [Harmatuck, 1997]. The model puts a heavy emphasis on the movements of freight, including railroad, trucking, and even waterway modes.

Overview – Wisconsin, like many other states, has been performing traffic forecasting based on historical trends in traffic growth. The reasons for considering the development of a new traffic forecasting model are founded on the belief that past practices have produced inaccurate forecasts and also that a model based on socioeconomic trends will produce much better results. These concepts include recognition that transportation mode shifts over time will reflect impacts on the traffic flows of the various components of the transportation system infrastructure, particularly in the ways goods/freight are transported.

Analysis Findings – South Dakota does not have the variety and extent of transportation modal coverage as Wisconsin, nor do socioeconomic conditions change quite as rapidly in South Dakota as they do in certain geographic locations in the state of Wisconsin. To be more specific, a state with primarily rural agricultural conditions has a much different set of socioeconomic conditions than a state with more industrial/commercial interests. For these reasons, most of the premises in the Wisconsin traffic forecasting development cannot be highly considered at the SDDOT. However, recent developments in railroad restructuring in South Dakota and the current impetus to implement ITS/CVO technological components in the state are facets that might bear future considerations.

5.1.12 Wyoming

Research Means – Electronic database searches and reviews of available literature. A telephone interview with the Transportation Planning Office, Wyoming DOT [Delaplaine, 1999] was conducted.

Status of Statewide Traffic Forecasting – Guidebooks were forwarded describing procedures that have been used for the past several years to forecast travel demands and travel patterns in the urbanized areas of Wyoming [Delaplaine, 1979a; 1979b]. A new statewide traffic forecasting procedure that would replace existing methods has essentially been developed but has not yet been practically applied at the Wyoming DOT. The *Interactive Statewide*

Transportation Planning Modeling Process [Wang and Wilson, 1995] describes the procedural concepts.

Overview – Again, like South Dakota, Wyoming is considered a "bridge" state with similar geographic/demographic characteristics. Socioeconomic data and traffic counts are the primary data sources for input to the Wyoming model. These are complemented with interactive input based on professional judgments of the planner-user. Traffic data are "modeled" based on peak summer weekend counts for cars and trucks while socioeconomic inputs are based on the movement of goods, tourist trips, and work commutes across the Wyoming highway network. An interesting aspect of the procedure is a computer software suite involving a Windows-based General Network Editor (GNE), Excel spreadsheets, and Visual Basic programs that allow for user interaction during traffic forecasting activities.

Analysis Findings – The geographic/demographic similarities to South Dakota, the concepts of modeling car and truck vehicle modes only, and the user-interactive procedure are all statewide traffic forecasting concepts deemed comparatively relevant to SDDOT needs. However, the model has not been practically applied on a statewide basis. The only evaluation of the technique involves a case study performed in the southeast corner of Wyoming encompassing the relatively urbanized areas in and around Laramie and Cheyenne.

5.1.13 Alberta, Canada

Research Means – Electronic database searches and reviews of available literature.

Status of Statewide Traffic Forecasting – This Canadian province was not reviewed from a traffic forecasting standpoint, so a status overview of that venue is not applicable in this report. Inclusion for this study was determined because of an approach to traffic data collection that has apparent worthiness to these SDDOT research efforts. In particular, an article entitled *Improved Method of Grouping Provincewide Permanent Traffic Counters* [Sharma and Werner, 1981], presents an approach to traffic counting operations that bears careful scrutiny.

Overview – In an effort to improve the method of grouping traffic counters in Alberta, Canada, a technique was developed which, according to the article, "…is simple, objective, computer-oriented, and statistically credible." The method is based on seasonal variations in traffic flows which is an important consideration in South Dakota. In essence, the technique involves the application of hierarchical groupings of ATRs and statistical, comparative testing of multiple groups.

Analysis Findings – Since good, reliable data are primary key in obtaining relevant, accurate output from any analytical process, data collection techniques play highly important roles that are often underestimated. Although initial reviews of SDDOT traffic data collection did not reveal any serious flaws and the SDDOT adheres to guidelines provided in the TMG, the criteria have been used disparately and are generally nonconjunctive. In other words, the process has evolved from early practices where little consideration was given to a statewide plan for locating traffic count sites. It should be noted that relocation of SDDOT ATRs does not necessarily need to be a consideration under a hierarchical grouping plan and such a technique might be a fairly low cost alternative in efforts to improve data integrity.

5.2 KEY OBSERVATIONS NOTED IN THE REVIEWS OF OTHER STATES' TRAFFIC FORECASTING PROCEDURES

Several points of interest became apparent during literature reviews of other states' traffic forecasting methodologies. These points will be noteworthy in succeeding project tasks where the direction of SDDOT traffic forecasting development will be determined. The following sections describe these key observations.

5.2.1 Efficiencies to be Gained From Improved Traffic Forecasting Procedures

One study criteria was significantly lacking throughout the reviews of other states' traffic forecasting procedural developments. Specifically, there was very little material on the gains to be expected from adopting new traffic forecasting procedures. There were some generalized comments in a few of the documents alluding to increased efficiencies for particular DOT operational areas. However, there was no specific information of any analysis undertaken whereby overall increases in efficiencies could be identified, costs versus benefits could be compared, or redistributed resources could be charted. As an example, the particular DOT operational area of pavement design might generate several questions to be answered, such as:

- Are current traffic forecasting factors supported by pavement design engineers?
- If so, how *important* are current traffic forecasting factors, including factors for commercial vehicles, to pavement design processes?
- Would traffic forecasting factors be utilized more fully if designers' confidence levels in the factors were increased?
- If usage levels and confidence were increased, could estimates then be formulated for the pavement design process improvements?

Many other DOT operational areas could also be assessed to determine the possible gains that might be realized through improved traffic forecasting procedures. If specific operational areas do not consider planning statistics like traffic forecasting factors to bear enough significance, then well meaning efforts to improve traffic forecasting procedures may not be justified.

5.2.2 Urban Traffic Modeling Techniques Applied to Statewide Traffic Forecasting

Modified urban modeling techniques are evidently being applied quite successfully to statewide traffic forecasting procedures at many state highway agencies. There are many factors driving this movement, but most of these are not readily applicable to states that are primarily rural like South Dakota. As an example, mandates to maintain better "clean air" corridors through better forecasting of traffic growth on major routes in urbanized areas, or even between urban/urbanized areas, is not as great a concern in South Dakota. As another example, valuable commercial real estate that might be negatively impacted by error-prone transportation planning activities affects relatively minute portions of states that are predominately rural and agricultural. Beyond the influences driving the advent of urban models applied on statewide basis, most of the modified urban modeling techniques would be difficult to implement given South Dakota conditions.

5.2.3 Traffic Forecasting Procedures and Information Systems Architectures

Most of today's traffic modeling software is PC based. The automated processes currently utilized in traffic forecasting at the SDDOT includes mainly spreadsheet programs on a PC system platform. However, traffic data must be extracted from RES and NSTRI files on the mainframe, and then prepared for PC-based processing. This is not a situation that lends itself well to good planner-user interaction throughout the forecasting procedure, especially when compared to Wyoming's development of well-defined processes where data, data editing functions, and software are more user-accessible in a PC systems environment.

5.2.4 The Role of Geographic Information System in Forecasting Processes

It was obvious through literature reviews and DOT interviews that a GIS can play an active role in traffic forecasting. As examples, a GIS can provide a source for transportation network data or jurisdictional boundary/TAZ data. However, traffic forecasting procedures cannot be performed by GIS software. According to the *Guidebook on Statewide Travel Forecasting* [Horowitz, 1999], "There are substantial incompatibilities between GIS data structures and those necessary for travel forecasting… Coding errors that can be minor for typical GIS applications (maps, statistical summaries, etc.) can be catastrophic to a travel forecast."

5.2.5 Data Integrity in Forecasting Processes

The old adage about "garbage in, garbage out" holds very true when producing traffic forecasting factors. As a primary example, ATRs generate the primary data utilized in traffic forecasting procedures, but the quality of this data is dependent upon many variables. Just a few of these dependencies include:

- Technological capabilities of the counters.
- Calibration of the counters.

- Placement of the counters.
- Definitions for counter groupings and coverage areas of TAZs/land use zones at counter locations.

There are many other potential data sources that have been defined for traffic forecasting procedures, depending on the software, procedural logic, and defined use. External census data, surveys, transportation network definitions, and programming algorithms are just a few of the potential sources where flawed data can be introduced, and thereby, weaken the output.

6.0 PRELIMINARY RECOMMENDATIONS

Task 6: Submit a technical memorandum that summarizes the findings of the literature review, survey procedures, required data, and software that improve South Dakota's present forecasting procedure.

As identified above, Task 6 of this research project to "Prepare and Submit a Technical Memorandum" requested summaries prepared for the SDDOT Technical Panel at that interim point of the project. Preliminary recommendations were included in the summaries for the procedures, required data, and software that would improve South Dakota's present traffic forecasting procedure. Prior to submitting the preliminary recommendations, it was presupposed that there would be two sets of conditions posing restrictions to the development of a new traffic forecasting procedure at the SDDOT. In essence, these were:

1. The state's rural, agricultural, and socioeconomic makeup is not conducive to the implementation of a statewide traffic forecasting model in light of today's modeling trends and directions.
2. There are currently limited personnel, personnel time, and resources available at the SDDOT to fully dedicate to traffic forecasting.

It was also assumed that these conditions would not preclude the department from taking initial development steps that would allow traffic forecasting improvements to be easier to implement over time.

The following list summarizes the preliminary recommendations provided by RESPEC and approved by the SDDOT Technical Panel. Where appropriate, commentaries are provided on recommendation actions that occurred as the study neared completion.

- RESPEC recommended that the SDDOT develop an overall plan with inherent policies for the designation and placement of ATRs.
- RESPEC also recommended consideration to a hierarchical grouping of existing ATRs.
  - Both of these recommendations were qualified with supporting proposals calling for the review of the designation, placement, and grouping of ATRs to aid in decision making on these recommendations. The SDDOT Technical Panel concluded that the recommendations needed to be taken under advisement.
- RESPEC recommended improving SDDOT/MPO coordination.
  - Recommendations for improving SDDOT/MPO coordination were essentially expanded and finalized in the final recommendations under Task 9 of this project. Chapter 8.0 of this report, "Recommended Coordination Between the SDDOT and MPOs" contains the full recommendations for coordinated efforts.

- *RESPEC recommended restructuring the six large traffic forecasting regions in the SDDOT's current traffic forecasting scheme to county TAZs.*
  - The large traffic regions were discontinued and counties were chosen to be the traffic forecasting analysis units in the development of the new procedure.
- *RESPEC recommended incorporation of more commercial vehicle classifications in the production of traffic forecasting factors.*
  - The SDDOT Technical Panel approved splitting the single "Truck" vehicle classification into two categories of "Class 5-9 Commercial" and "Class 10-13 Commercial."
- *RESPEC recommended direct incorporation of socioeconomic data in the traffic forecasting procedure.*
  - Data from the "County Business Patterns for South Dakota" [U.S. Census Bureau – Register Analysis Branch, 1998] were incorporated directly in the development of the new traffic forecasting procedure. South Dakota county population statistics and the number of building permits issued by county in South Dakota [U.S. Census Bureau, 1999a] were incorporated as subjective criteria in the development of the new procedure.
- *RESPEC recommended performance of the traffic forecasting procedure every 2 years versus the current 4-year cycle.*
  - The SDDOT Technical Panel has taken this recommendation under advisement.
- *RESPEC recommends automating the newly developed procedure through a software programming effort.*
  - Preliminary recommendations for SDDOT traffic forecasting software/programs were essentially expanded and finalized in the final recommendations under Task 10 of this project. Chapter 9.0 of this report, "Recommended Software for 20-Year Traffic Forecasting at the SDDOT," contains the full set of recommendations for software implementation and/or programming efforts.

7.0 DEVELOPMENT OF A NEW STATEWIDE SDDOT TRAFFIC FORECASTING PROCEDURE

Task 7: Based on the tasks above and approval of the preliminary recommendations from the technical panel, develop and document a practical 20-year traffic forecasting procedure for SDDOT which will improve the accuracy of the computed forecasting factors.

The following sections (Section 7.1–7.3) detail the research findings related to past forecasting practices, current constraints or procedural development, enhancement feasibility, and data needed to define a revised 20-year traffic forecasting procedure for the SDDOT. The resulting revised procedure is documented in Section 7.4.

7.1 REVIEW OF CURRENT SDDOT 20-YEAR TRAFFIC FORECASTING METHODOLOGY

An outline of the SDDOT's current 20-year traffic forecasting procedure was provided in Chapter 2.0 of this report. However, a review of the current forecasting methodology is essential to establish a basis for revision of the procedure and to provide a basis for comparison with the newly developed procedure.

7.1.1 General Overview of Current 20-Year Traffic Forecasting Methodology

In the past, the sole source of data input for the production of 20-year traffic forecasting factors at the SDDOT has been historic, statewide VMT totals. The traffic forecasting technique has involved only two basic processes occurring in a repetitive fashion to arrive at the statewide 20-year traffic forecasting factors. A cyclical procedure involving apportionment of VMT followed by a regression analysis each time the VMT is apportioned are the two basic processes. The following is a concise overview of the basic steps that have been involved in the procedure:

1. The total VMT for each of the six traffic analysis regions is summed to produce the statewide total annual VMT.
2. Statewide VMT growth is projected over 20 years based on a linear regression analysis of historical VMT, excluding the urbanized areas of Rapid City and Sioux Falls.
3. The statewide VMT growth projection from the linear regression analysis is apportioned across the various functional roadway classifications of the state highway system.
4. A linear regression analysis of the historical traffic data for each of the six regions is performed to project VMT growth within each of the six regions.

5. VMT growth projections within each region are apportioned to the various functional roadway classifications based on the number of miles of functionally classified roadways within each region.
6. Linear regression analyses of historical VMT for all truck categories other than ‘Pickups–Other 4-tire’ to project ‘commercial’ vehicle VMT forecasts.
7. The VMT growth projections for the functionally classified roadways, within the six traffic forecasting regions, and for ‘commercial’ and ‘passenger’ vehicle types are reduced to factorial form and put into a 20-year factor array table.

This procedure of “backing into” a 20-year factor array table from a statewide VMT total has been performed every 4 years at the SDDOT. Clearly, the procedure has involved very little start-up data and a straightforward approach.

7.1.2 Identified Constraints on 20-Year Forecasting Procedure Development

Several constraints to the development of a 20-year traffic forecasting procedure were identified in the RFP for this project and in previous sections of this report. The constraints can be categorized in two distinct areas follows:

1. A set of statewide conditions that present unique circumstances to address in a statewide traffic forecasting procedure:
   - A “bridge state” situation whereby the state’s transportation network carries significant passenger vehicle traffic and commercial freight movements across the state to east-west coastal destinations or other distant metropolitan destinations.
   - A rather large geographic area with low population density.
   - Primarily rural/agricultural characteristics.
   - A highway network that is fairly diverse across the state.
   - Only two MPOs and one nonrepresented, out-of-state MPO that are all widely scattered.
2. Constraints imposed through the SDDOT operational environment:
   - Limited DOT funding, personnel, and resources for performing traffic forecasting.
   - Low SDDOT confidence levels with current traffic forecasting factors.
   - Combined operational, administrative, and political environment unique to SDDOT.
   - Limitations to traffic data collection schemes.

Despite these constraints, there is an inherent recognition that traffic forecasting can play an important role by enhancing many DOT operations. The initiation of this research effort to develop better traffic forecasting techniques indicates the department's desire to maximize improvements to traffic forecasting while still understanding that there are limiting conditions.

7.1.3 Procedural Enhancements Considered in Current Investigation

The current investigation carries the assignment of enhancing SDDOT traffic forecasting given the constraints. The existing procedure lacks several facets that would instill departmental confidence and allow expanded use of the traffic forecasting factors. A few of the primary limitations in the existing procedure are:

- Forecasting factor integrity cannot be verified.
- Data input is minimal, yet the iterative process to produce forecasting factors is quite time consuming.
- Older spreadsheets that have been heavily relied upon have become outmoded and/or lost.
- There is no way to upgrade the current procedure and take advantage of ongoing advancements in traffic forecasting techniques.

Therefore, the important considerations of the current investigation are to overcome the limitations of the existing procedure while maximizing the immediate and future performance of the traffic forecasting procedure. Investigations of the advancing traffic forecasting techniques at other state DOTs become most relevant, but must be tempered by the constraints imposed by the prevailing SDDOT conditions.

7.1.3.1 Established Traffic Forecasting Models

Computer software 'models' represent the primary advancement in traffic forecasting techniques. Traffic forecasting models were originally conceived for urban applications but larger, more densely populated states have initiated development whereby urban models are modified to meet statewide forecasting needs. Less populated rural states are encountering more difficulties in adapting traffic modeling techniques to address their particular statewide traffic forecasting needs. There are some ongoing research and development efforts at select states with characteristics similar to South Dakota, but none could be identified where a reliable statewide traffic forecasting model has been fully and successfully implemented.

7.1.3.2 Modifications to Current Forecasting Practices

As traffic forecasting research and development efforts continue at states with rural, sparsely populated characteristics, there are techniques being tried that eventually prove to be impractical. Travel trip surveys of the general public seem to be very difficult to adapt and institute. Other types of data collection activities that would be critical for "trip" generation in a true traffic forecasting model also seem to be very difficult to identify and accomplish for a state with sparsely populated demographics. Regrettably, these types of data are critical to modeling and forecasting traffic.

It is apparent that the SDDOT needs to utilize data that are feasible to collect and maintain for traffic forecasting activities given the resource constraints and the state's characteristics. The approach will obviously need to be modified extensively from urban modeling theory, primarily because of the data availability. SDDOT traffic forecasting needs to start with a straightforward approach that represents an improved methodology over past practices and also provides a foundation that readily accommodates continuous enhancements and refinements to the procedure. Monitoring the progress in performance of the SDDOT procedure, as well as monitoring the advancements of traffic forecasting at other states will be critical components. The ultimate objective is to define and build a tailored model providing reliable factor output, maximizing the use of available data, and making the most efficient use of limited SDDOT resources.

7.2 DATA REJECTED FOR IMMEDIATE USE IN 20-YEAR TRAFFIC FORECASTING

There were several types of data analyzed for possible augmentation of traffic forecasting activities at the SDDOT during this research effort. Each type of data was thoroughly reviewed to assess the applicability level within a sound traffic forecasting procedure. Many data sources had to be disqualified based on review and analysis findings. Following are the primary data types removed from further consideration in this study based on review findings:

- Vehicle registrations by county in South Dakota
- Revenues from taxes collected on the sales of petroleum products in South Dakota
- Tourist visitation counts by attraction sites
- Transportation statistics from the U.S. Census Bureau
- Commercial vehicle routings from major national carriers.

Other generalized categories of data were briefly reviewed but quickly eliminated from consideration for being inapplicable to statewide traffic forecasting at the SDDOT. The excluded data categories included economic indicators, national travel trip estimates, and demographic trends. Some of the primary disqualifying factors included nonapplicability to conditions such as those found in South Dakota, utilization in procedures attempted elsewhere had already proven faulty, data were not to a desirable level of detail, and/or the quality of the data was highly questionable.

The following sections provide a discussion of the research findings for each of the data types that were studied in the list above and eliminated from further consideration.

7.2.1 Vehicle Registrations

Review and analysis of vehicle registrations across the state as a possible correlative data source for traffic forecasting did not prove to be reliable for the SDDOT's needs. Examination of representative vehicle registration data compared to VMT data revealed trends that were widely divergent in many instances. In particular, vehicle registrations showed trends that were often proportional to traffic, but not across all demographic conditions. An accounting of vehicle registrations does provide the number of vehicles that are capable of being on roadways, but not when or how often those occurrences will be. Again, urban areas with their dense resident populations and higher traffic volumes appeared to provide a better scenario for applying a forecasting analysis that compares trends between traffic and the number of vehicle registrations. These observations were based solely on a few relative samplings because the project definition of a statewide traffic forecasting procedure precluded the detailed analysis and treatment of data within sub-areas of the state under this project, and also precludes the SDDOT from performing a statewide traffic forecasting procedure that de-fragments to sub-area analysis.

In random testing of South Dakota counties, trends in traffic compared to the number of vehicle registrations using data from the South Dakota Department of Motor Vehicles had indeterminate results. Assumptions are that several unique circumstances make South Dakota unreceptive to statewide traffic forecasting analyses involving county vehicle registrations. In particular, areas with depressed conditions and/or fluctuating farm economies do not seem to follow any trends when vehicle registrations are directly compared to traffic volumes. It is possible that the number of *newer* vehicles registered by county might have possible connotations in a statewide traffic forecasting procedure at the SDDOT. However, the difficulties in finding, sorting, extracting, and preparing this type of data for indistinct results did not seem feasible, particularly given the project time and budget constraints. Therefore, vehicle registration data could not be considered at this time for implementation into the 20-year traffic forecasting procedure at the SDDOT.

7.2.2 Revenues From Sales Taxes on Petroleum Products

Initial reviews of the revenues generated as a result of the sales of petroleum products in the state of South Dakota disclosed that relevant data were unavailable. Data that were forwarded in electronic report form from Mr. Richard Ray of the South Dakota Department of Revenue merely reflected a statewide total of revenue generated. Subsequent telephone conversations with Mr. Ray and other Department of Revenue personnel revealed that taxes are simply collected from distributors (often with corporate headquarters out of state) and not at the retail level.

Closer scrutiny of using tax revenues from petroleum products required a look at "backing into" county level statistics by first determining the number and locations of service stations, convenience stores, and other retail outlets for petroleum products by county. The South Dakota Retailers Association had information of this type available but there was no other correlative data inherent to determine the amount of sales tax, or even gross sales per petroleum retail establishment. It was felt that applying some type of secondary factor to attempt to break out and estimate revenues would be contrary to the intent of applying direct, relevant data to the traffic forecasting procedure. Although utilization of this potential data source had to be finally abandoned under the procedural development efforts for this project, RESPEC feels that petroleum product sales tax revenues would be excellent supplementary data to the SDDOT traffic forecasting procedure. If this information ever becomes available whereby the information is broken down by retail outlet at the county level, incorporation of this data should definitely be considered once again.

7.2.3 Tourist Visitations

Incorporation of tourist visitation counts broken down by state tourism attraction sites were also considered for this project. The data originate at major tourist attractions in the state whereby each visitation to a particular site is counted and the data are ultimately forwarded to the South Dakota Department of Tourism on a yearly basis.

The data overview provided concerning tourist visitations revealed there would be direct implications for the seasonal traffic flows occurring on highway routes in and around tourism areas. In a statewide 20-year traffic forecasting procedure for South Dakota, the data would provide an excellent analysis tool in traffic modeling software of the truest sense. Unfortunately, the SDDOT personnel and budget constraints identified in the RFP for this project restrict the implementation of such full-scale modeling capabilities at this time. Procedural development for this project is felt to significantly improve forecasting techniques over past practices, and is also being contemporaneously structured to allow the SDDOT to phase into true traffic modeling capabilities if resources and budgets so allow in the future. (A full description of these capabilities is provided in Section 10 of this report.) Future incorporation of modeling capabilities will allow many potential data sources, such as tourist visitations, to be considered in the SDDOT traffic forecasting procedure. The available tourist visitation data should definitely be revisited at that time.

7.2.4 U.S. Census Bureau Transportation Statistics

For this study, the U.S. Census Bureau's publication of transportation statistics were the primary focus of data reviews [U.S. Census Bureau, 1999b]. Several categories of data out of the transportation statistics were immediately discerned to merit investigation with the main sources identified as: "Transportation Statistics Annual Report, 1998," "Historical Time Series – Journey to Work," "Travel to Work Characteristics for the United States by State," and several sections of commodity flow surveys. Other transportation statistics report sections were immediately discounted because of the lack of South Dakota data, irrelevance to the conceptual development of a statewide traffic forecasting procedure for the SDDOT, or lack of ability to directly correlate inherent data to said development.

Reviews of the U.S. Census Bureau's publication of transportation statistics, which is collected and maintained from national perspectives, revealed several characteristics with both positive and negative advantages for possible incorporation in a statewide traffic forecasting procedure for South Dakota. Two noticeable disadvantages are:

1. Much of the data are not collected from direct sources such as traffic counters, but instead, come from survey questionnaires which tend to represent archetypes.
2. Most all of the above tend to fit better in true traffic modeling concepts.

Some of the main advantages are that there is an abundance of data readily available, well prepared for presentation, and with broad categorization.

"Journey" and "travel" are terms from the studied transportation statistics that are synonymous with the exercise of trip generation in preparatory work for a traffic model. "Flow" has connotations of a data variable that has already been prepared for direct inclusion in a modeling concept. Again, South Dakota conditions tend to preclude the incorporation of a fully integrated traffic forecasting model at this time. Also, it should be noted that much of the U.S. Census Bureau's transportation data are *already* prepared for planning functions, often based on estimations or assumptions of some type, and are not data directly collected for a specific planning purpose. Due to all of these characteristics, it is felt that inclusion at the present time is not feasible. Also, any future consideration of incorporating these data items will need to be carefully weighed against the type of model that *might* eventually be developed at the SDDOT.

7.2.5 Commercial Vehicle Route Data

Databases of travel routes taken by commercial vehicles on scheduled and/or unscheduled trips are available for access on Internet Web pages and other electronic means. Reviews of several of these databases were performed to determine applicability to this research effort. There is clearly some good, relevant information available in a select few databases, but immediate questions arose during the analysis about the extents and integrity of the data represented. More precisely, major carriers provide data for their own particular company, but it is unknown how representative this data might be for the trucking industry as a whole. Even an effort to assimilate data from all such available databases would not totally alleviate such concerns. In particular, data from smaller companies with less extensive national routing and more localized routes are not universally available, and this condition would appear to inject some bias into the disposition of the commercial vehicle data intended for usage in a statewide traffic forecasting scheme. Therefore, the rather large-scale efforts necessary to collect such data cannot be advised when it is clear that subjective assumptions will need to be made anyway, thus introducing data validity issues.

Probably the closest approximation to a database clearinghouse for commercial vehicle operations on a national scale is the commodity flow data maintained by the U.S. Census Bureau [U.S. Census Bureau, 1999b]. Again, to consider using this commodity flow information will require questions that might arise from discussions in the preceding paragraph. Namely, what trucking industry sectors and/or data might be missing from the U.S. Census Bureau's numbers and what assumptions were made to gain numbers for national representation?

7.3 DATA SELECTED FOR USE IN NEW TRAFFIC FORECASTING PROCEDURE

The previous section contained information on several potential data sources that could not be incorporated into the new procedure for various reasons. The data sources that were ultimately chosen met the criteria imposed by the SDDOT needs and/or limitations defined during the course of the research efforts for this project. Following are the data sources that accommodated SDDOT traffic forecasting criteria and were subsequently selected:

- SDDOT historical traffic data
- Population growth trends by county in South Dakota
- Business growth trends by county in South Dakota
- Building permits issued by county in South Dakota.

The following sections detail the data chosen for use in the new procedure, the techniques employed for data extraction from resident sources, and the preparation that occurred to ready the data for use in traffic forecasting.

7.3.1 SDDOT Historical Traffic Data

When the task to develop a new traffic forecasting procedure was initiated, it was recognized that a database of historical traffic data would be fundamental to 20-year traffic forecasting factors. Historical growth patterns provide the primary basis for analyzing future traffic trends and are critical aspects in any forecasting procedure. Also, this data have been essential to traffic forecasting at the SDDOT from the very inception of such procedures. Upon extraction of traffic counts and preparation of VMT data, subsequent reviews proved that historical VMT data have to serve as the foundational analysis criteria on which to base traffic forecasting at the SDDOT.

7.3.1.1 Overview of SDDOT Historical VMT Data

An annual publication entitled *South Dakota Vehicle Miles of Travel Report* has been produced by the SDDOT since 1981. (A sample of the report from 1998 can be found in Appendix A.) The statewide VMT totals presented in this publication originate from "raw" traffic counts collected at the permanent and nonpermanent ATR sites around the state. The report is generated by software that meets federal reporting requirements whereby total VMT for each county in South Dakota is output and categorized by Functional Highway Classification, Federal Aid Designation, and Urban/Rural Traffic. Over the years, the software has undergone revisions to keep up with changing policies regarding the classification of state highway routes and the subsequent presentation of annual statewide VMT. Each year, however, the original traffic data that are used to generate the VMT reports have been saved and stored on the state's mainframe computer.

7.3.1.2 Preparation and Use of Historical VMT Data

The *South Dakota Vehicle Miles of Travel Report* represents a series of historical VMT data files that are very amenable and well contrived for projecting future traffic trends. As previously mentioned, the traffic files that generate VMT data have been archived annually on the state's mainframe computer system every year since 1981. To date, however, these files have never been directly used as input for the SDDOT 20-year traffic forecasting procedure. The statewide VMT totals as input for the procedure have been residing on a PC platform in spreadsheet formats. The original data sources are the "raw" traffic counts collected at ATR sites around the state which are the same for both the mainframe and PC platforms.

Since the spreadsheet programs were essentially lost in a system failure of some sort, the all-important VMT data had to be recovered and prepared for functional development of the new procedure. Software to prepare the data for reporting has changed over the years since 1981, so a mainframe extraction method whereby the yearly data would be standardized and commensurate became an issue to overcome. Basically, the redesignations of functional highway classifications and other similar changes over time are what caused the irregularities of the data output year-by-year.

To extract the mainframe data files in an acceptable and standardized format, Mr. Dennis Winters of BIT was contacted for his knowledge and expertise on the subject data. Upon gaining an understanding from RESPEC on the extraction specifications and intended use of the data, Mr. Winters was able to recreate all the VMT files for both passenger vehicles and commercial vehicles from the mainframe and into a PC-ready format. The format was an ASCII file representation of the reports as previously output to printers connected to the mainframe.

Upon receipt of the files, RESPEC needed to perform several preparatory functions to ready the data for use in the 20-year traffic forecasting process. The first activity was a comparison of the data files to published VMT reports from previous years. There *were* some widespread discrepancies noted between the extracted data files and the finalized reports as published. It is not known whether these discrepancies are due to adjustments made for paper reporting purposes or whether data were manipulated on the mainframe at some time after reports were published. In either event, the inconsistencies did not appear great enough to disqualify any of the mainframe data from inclusion in the new traffic forecasting procedure for the SDDOT.

Ensuing data preparations were performed to ready the data for incorporation in the SDDOT 20-year traffic forecasting procedure in its entirety. Following is an overview of the associated activities to prepare the VMT data:

- Yearly passenger vehicle VMT from 1981 to the present was extracted from each ASCII file and imported into columns in a spreadsheet with designations as 'Interstate,' 'Arterial,' and 'Other' functional highway classifications, and by 'Urban' and 'Rural' roadway designations.
  - 'Interstate' VMT for passenger vehicles was imported directly
  - 'Arterial' was imported as the sum of Federal Aid Principal Arterial and Minor Arterial designations.
  - 'Other' was the sum of State Trunk System/Federal Aid Major Collectors, State Trunk/Non-Federal Aid Other, Non-State Trunk/Federal Aid Major Collectors, Non-State Trunk/Non-Federal Aid Minor Collectors, and Non-State Trunk/Non-Federal Aid Local Roads.
- Yearly commercial vehicle VMT from 1985 to the present was extracted from each ASCII file and imported into columns in a spreadsheet with designations as 'Interstate' and 'Arterial' functional highway classifications, and by 'Urban' and 'Rural' roadway designations.
  - 1992 commercial vehicle data were excluded because a computer system crash during this year rendered this data unavailable.
  - 'Interstate' VMT for commercial vehicles was imported directly.
  - 'Arterial' was imported as the sum of Federal Aid Principal Arterial and Minor Arterial designations.
  - The 'Other' functional highway classification was excluded as inappropriate at this time for commercial vehicles.
- Commercial vehicle data were further distributed into two categories of "Class 5-9 Commercial" (all single unit and/or single trailer trucks) and "Class 10-13 Commercial" (all multi-trailer trucks) by applying appropriate percentage factors to the commercial vehicle VMT.
  - The factors were available in yearly reports of "South Dakota Comparative Vehicle Classification Report – Percentage of Vehicles by Type Traveling the States Highway System" furnished by the Office of Data Inventory at the SDDOT.

– The distributions for "Class 5-9 Commercial" and "Class 10-13 Commercial" were arrived at by:

  - Computing the sum of the percentage factors for all single-unit/single-trailer truck types.
  - Computing the sum of the percentage factors for all multitrailer truck types.
  - Multiplying the total commercial vehicle VMT of the mainframe ASCII files by the ratios of the percentage factor summations to the total percentages for all commercial vehicles.

Once all VMT data had been imported, the spreadsheet was thoroughly reviewed. Imported data were referenced against original data sources to ensure translations had been performed correctly, and calculations performed during translations were verified by cross checks involving manual calculations.

7.3.2 Population Growth Trends

Reviews of population growth trends for South Dakota counties from the U.S. Census Bureau's *USA Counties – General Profiles* [U.S. Census Bureau, 1999a] and subsequent investigations of their potential use in a statewide traffic forecasting procedure for the SDDOT indicate relevance for counties containing urban/urbanized areas but are more unpredictable when applied to counties that are rural in nature. There is a discernable correlation between the traffic and population patterns around an urbanized area like Sioux Falls with both trends showing increases at about the same rate. Correlative investigations of population and traffic in rural areas showed erratic tendencies due to several influencing factors. Although not all of the influences are readily apparent, obvious relationships to traffic patterns can be noted between the population trend of a county, the county population trend compared to neighboring counties, county proximity to urban/urbanized areas, and the county's regional location.

Tables of population growth trends by county in South Dakota have been included in the newly developed 20-year traffic forecasting procedure for the SDDOT. Unlike other data used, however, population growth trends are not directly applied to the statewide procedural analysis for the reasons stated above. The population growth trends can be employed as traffic forecasting factor verification criteria under many circumstances but cannot be directly relied upon at this time to provide more than that function. Conditions in South Dakota whereby only three metropolitan areas are scattered over a large extent of sparsely populated rural counties present unique circumstances to overcome when comparing traffic and population trends. However, it is felt that another compelling reason to include this data is that monitoring the rural tendencies over a few years' time may lead to recognition of perceptible patterns that could then be utilized logically in the traffic forecasting process.

7.3.2.1 Overview of Population Data From the U.S. Census Bureau

Although population data are not directly used as a criteria in the revised SDDOT 20-year traffic forecasting procedure, it was determined that population trends could be used as data for subjective analysis by SDDOT Data Inventory staff. This will especially hold true on infrequent occasions when traffic forecasting factor demarcation is not clearly defined by other criteria and additional verification may be needed. The data are also being included at this time because the monitoring of population as compared to traffic trends over a few years' time may lead to recognition of perceptible patterns that could then be used logically in the traffic forecasting process. The SDDOT may well determine that population trends will have implications for evolving traffic forecasting operations, including possible statewide traffic modeling.

7.3.2.2 Preparation and Use of Population Data

The process to prepare and export population trend data for South Dakota counties from the U.S. Census Bureau's *USA Counties – General Profiles* [U.S. Census Bureau, 1999a] was very straightforward. Following is a step-by-step sequence of the process:

1. The data files were downloaded from the U.S. Census Bureau's Internet Web pages in an ASCII file format.

2. The population trend data consist of two population percentage factors: a percentage increase or decrease for each South Dakota county from 1980 to 1990, and a percentage increase or decrease for each South Dakota county from 1990 to 1997.

3. The two population percentages were exported from the ASCII files to an Excel spreadsheet that included county business trend data and building permit data.

4. A spreadsheet algorithm has been included to combine the two population percentage figures into one percentage increase/decrease for all years from 1980 to 1997. (This was done so that VMT from 1981 to present could be correlated more directly to the population trends.)

5. Excel spreadsheet graphing utilities were used to generate graphs of the historical population trends for each county giving traffic forecasting personnel the ability to quickly compare population trends with other traffic forecasting criteria.

The merits of the population trend data need to be evaluated more thoroughly by SDDOT traffic forecasting under conditions where full production of forecasting factors occurs over a longer time frame. During this initial procedural development, there were two tendencies that were readily apparent. Urban/urbanized area population growth appears to have a direct correlation with traffic growth across all functional highway classifications and all vehicle categories. Conversely, population decreases in depressed counties, such as those shown occasionally on Indian reservation lands, had erratic relationships with traffic patterns across functional highway classifications and vehicle categories with the causes being nearly imperceptible given the time constraints of this project.

7.3.3 Business Growth Trends

When business growth trends from the county business patterns for counties in South Dakota [U.S. Census Bureau – Register Analysis Branch, 1998] were applied in the development of the SDDOT traffic forecasting procedure, direct correlation to traffic across all vehicle types and functional highway classes around the state could be seen. However, the extraction and preparation of pertinent information from this source were highly important to the success of incorporating the data. Distribution in tables reflecting the types and sizes of business enterprises, followed by the processes of breaking out the commercial versus passenger traffic and reducing these numbers to factorials across the distributions, were the primary considerations.

7.3.3.1 Overview of U.S. Census Bureau "County Business Patterns"

The incorporation of data extracted from the "County Business Patterns for South Dakota" indicated direct, immediate relevance to a new statewide traffic forecasting procedure at the SDDOT. Once the data were downloaded in ASCII format from the U.S. Census Bureau's Internet Web pages, it was immediately recognized that assumptions relative to South Dakota conditions and SDDOT needs would need to be made. These assumptions would be necessary to maximize the utility and functional integrity of the data as applied within the traffic forecasting procedure. Once assumptions were determined, guidelines were formulated for the use of county business data and the data was then prepared accordingly.

7.3.3.2 Preparation and Use of U.S. Census Bureau "County Business Patterns"

Following are the precepts whereby guidelines were established to incorporate the data from the *County Business Patterns for South Dakota* into the new traffic forecasting procedure for the SDDOT and the data preparation that occurred so that guidelines could be followed:

1. The county business data came under the general categories of Agricultural Services/Forestry/Fishing, Construction, Finance/Insurance/Real Estate, Manufacturing, Mining, Services, Transportation/Public Utilities, Wholesale Trade, Retail Trade, and Unclassified Establishments. These categories needed to be apportioned into two categorical groups for direct correlation with the vehicle-type traffic data categories of passenger vehicles and commercial vehicles.

   Guideline: Assumptions based on the study of vehicle-categorized rates of traffic attraction by business type was related to South Dakota through reviews of similar data from the South Dakota Retailers Association. These reviews led to the formulation of two business groupings: Group I included the business categories of Agricultural Services/Forestry/ Fishing, Retail Trade, Finance/Insurance/Real Estate, Services, and

Unclassified Establishments. Group II included Construction, Manufacturing, Mining, Transportation/Public Utilities, and Wholesale Trade.

Guideline: Assumptions based on the identical study performed above concerning national data and South Dakota Retailers Association data led to the formulation of two types of passenger/commercial vehicle traffic attraction splits by business group. Group I should have attraction rates of 80 percent cars and 20 percent trucks, and Group II should have attraction rates of 80 percent trucks and 20 percent cars.

2. Next, "County Business Pattern" data groups businesses "size-wise" by the number of employees per establishment. According to the number of employees per business, the groupings are 1–19 employees, 20–99 employees, 100–499 employees, and >499 employees.

   Guideline: Business size groupings of the U.S. Census Bureau were adopted directly for the traffic forecasting procedure, with the exception that the category >499 was combined with the 100–499 category to give a >100 categorical grouping. This was an assumption based on the exceedingly small number of businesses in South Dakota that have greater than 499 employees.

   Guideline: South Dakota businesses were grouped according to the number of employees per business based on samplings relative to South Dakota to establish "traffic" multipliers that can then be applied to each group (i.e., a business with 8 employees will generate traffic that is less than a similar, but larger business with 28 employees by some given multiple). The multipliers were assumed as 1 for the 1–19 employee grouping, 5 for the 20–99 employee grouping, and 10 for the employee grouping identified as >100. It needs to be noted that multipliers are meant to develop trends only and are not an effort to establish actual relative numbers. Again, the multipliers were established based on reviews of data from the South Dakota Retailers Association.

3. The "County Business Pattern" data contains the total number of businesses by size and type for each county in South Dakota, but does not have exact totals for the numbers of employees by business type due to the business groupings by general size only.

   Guideline: The multipliers established in item 2 above were applied to the total number of businesses by size and type to give a means to directly correlate business data with the projected traffic trends for each county.

   – It needs to be noted here that this rule cannot be confused with the process of trip generation as might be performed in a traffic forecasting model. Trip generation requires a significant amount of specific data input that can be used to estimate actual travel trips, while the business size multipliers are merely used to relate overall county "business-generated" traffic more realistically. The concept again goes back to implementation of a statewide traffic forecasting procedure meant for rural conditions over a widespread area versus a traffic forecasting model applied in an urban<u>ized</u> environment with increased data availability and denser demographic conditions.

The guidelines established to incorporate county business trends and the corresponding data preparations were a concentrated effort because of the vital role this data assumes in the development of a new SDDOT 20-year traffic forecasting procedure.

7.3.4 Building Permits

The *USA Counties – General Profiles* [U.S. Census Bureau, 1999a] which provides the population trend data also contained the number of building permits issued yearly for South Dakota counties. Reviews of the building permit data, when applied under a statewide concept at the SDDOT, did not reveal any discernable trends related to traffic patterns. Reviews of other traffic forecasting procedures, particularly involving traffic forecasting models, indicated that a correlation could often be found when building and/or development activities were associated with traffic trends. The general assumption that is made in these models is that subdivisions cropping up around cities/towns, urban sprawl situations, and large developments in any rural/nonrural area reflect noticeable similarities when compared to traffic trends of the same area. Again, however, South Dakota's rural conditions and unique lack of any real estate developments on a broad basis have to be considered as the primary reasons that this type of data cannot be correlated well for SDDOT purposes. Except for the areas around Rapid City, Sioux Falls, and North Sioux City, most of the state is exemplified by exceedingly low numbers of yearly building permits being issued.

The building permit data were incorporated into the spreadsheet procedures for statewide traffic forecasting at the SDDOT, but are currently recommended only as a data item to be monitored. Over time, there may be evidence that such data will contribute to traffic forecasting around urban/urbanized areas, but may need to be coupled with city planning data, such as replats, for proposed subdivisions and other planned development.

7.3.4.1 Overview of Building Permit Data From the U.S. Census Bureau

The number of building permits issued for new private housing units by county in South Dakota on a yearly basis is not data that have been actively used in this initial development of the SDDOT 20-year traffic forecasting procedure. Instead, the data are being provided as a criteria to help determine certain long-term corrections that might be necessary to the traffic forecasting factors should particular urban/urbanized growth scenarios crop up. As an example, if traffic numbers show a sudden increase in and around an outlying development zone of an urban/urbanized area, then the building permit data should be reviewed to determine if there is any correlation. Evidence of correlative growth means that preexisting conditions probably led to these sudden increases. Namely, prior planning, surveying, replatting, and/or rezoning for a subdivision(s) or other major real estate development had to occur within the area in question. Review and analysis of these scenarios over time could well lead the SDDOT to seek better coordination and more data sharing with urban/urbanized planning offices relative to these situations. In other words, "predevelopment" data sources provided by activities such as those cited above, combined with historical traffic data and building permits authorized for new private housing, could provide the keys to a more efficient traffic forecasting procedure in these situations.

7.3.4.2 Preparation and Use of Building Permit Data From the U.S. Census Bureau

The building permit data for new private housing included in the newly developed 20-year traffic forecasting procedure were extracted directly from the *USA Counties – General Profiles* data. There was not any manipulation, reformatting, or computations performed on the data.

7.3.5 Preservation of Traffic Forecasting Data

All of the efforts to prepare and incorporate data from the sources as detailed in the previous sections have essentially generated an unrefined database. It is highly recommended that all of the data be securely stored and maintained by the SDDOT in order to preserve the important facilitation this data will provide as a primary foundation for ongoing statewide traffic forecasting processes. Although database development was beyond the scope of this project, the data extractions and the accompanying data preparations represent important groundwork that should not be lost. If the ensuing incorporation of traffic forecasting software at the SDDOT is distinctly possible in the near future, the data generated for this project are readily structured to migrate to the supporting database.

7.4 DOCUMENTATION OF A REVISED STATEWIDE 20-YEAR TRAFFIC FORECASTING PROCEDURE FOR THE SDDOT

In the development of a revised statewide 20-year traffic forecasting procedure for the SDDOT, it was felt that three basic, essential requirements had to be fully satisfied. Fulfillment of these requirements would provide the SDDOT with a statewide traffic forecasting procedure that would be more than capable of serving current, as well as long-term, needs. The requirements were defined as:

1. Finding data that provides a good base of criteria for procedural analysis and applying this data in a more direct, straightforward manner during procedural operations.
2. Including a procedural methodology that instills confidence in the traffic forecasting factors that are eventually produced.
3. Implementing a procedure that lends itself well to being continually refined over time by readily accommodating enhanced and expended capabilities.

It was understood throughout the procedural development how imperative it was to meet these requirements. In regard to the actual working structure of the procedure, it was recognized that several other parameters would act as developmental guidelines. These parameters included:

- Good data management capabilities, yet uncomplicated to utilize
- Logical and well understood guidelines that the user can follow to apply the criteria
- Allowances for user interaction so that the procedure would not be totally inflexible
- Processes that are verifiable by the user and also adaptable to changing needs
- Inherent capabilities to check the integrity and/or validity of the traffic forecasting factors.

With the requirements and parameters in mind, development of the procedure progressed in a very manageable fashion.

It should be noted that the procedure relies heavily on Microsoft Excel spreadsheets to automate computations and processing as much as possible for this project. By definition in the RFP for this project, there were no intentions to begin or facilitate programming of a statewide 20-year traffic forecasting procedure for the SDDOT. The spreadsheet programs are not meant to be long-term software tools for the SDDOT, but merely a means to automate and expedite implementation of the operations necessary to satisfy the procedural rationale. The implications are that a formal programming effort may be undertaken at some time in the near future when the SDDOT is satisfied that all “fine tuning” for the procedure has been accomplished and software development can be fully specified.

The following sections provide the detailed documentation of each step involved in the revised procedure to produce statewide 20-year traffic forecasting factors for the SDDOT. Since data input is essentially an integral part of the procedure, occasional reference to the data sources and preparations sections (Sections 7.3.1 through 7.3.4) may be necessary to complement the succeeding documentation.

7.4.1 Revised SDDOT Traffic Forecasting Procedure: Development of Factors

The historical VMT data for each county in South Dakota have been imported into a “development of factors worksheet.” The data have been distributed into appropriate categories of ‘Passenger,’ ‘Class 5-9 Commercial,’ and ‘Class 10-13 Commercial’ vehicle types within appropriate Functional Roadway Classifications and in either Rural or Urban designations. An example of the data distribution for ‘Rural’ ‘Interstate’ ‘Passenger’ VMT in Brookings County can be found at **A** on Figure 7-1. This approach represents a method of applying historical VMT directly versus the past procedure where statewide VMT was apportioned into six traffic analysis regions. Other changes to note in comparison to the past procedure are:

- The six traffic analysis regions have been eliminated and traffic forecasting factors will now be produced for each South Dakota county (which closely approximate TAZs in a traffic forecasting model).

Brookings County Example, From "SDDOT Traffic Forecasting Worksheets: Development of Factors"

A

Brookings	Rural: Interstate (Passenger)	Rural: Class 5-9 Commercial	Rural: Class 10-13 Commercial	Rural: Arterials (Passenger)	Rural: Class 5-9 Commercial	Rural: Class 10-13 Commercial	Rural: Other (Passenger)	Urban: Urban Inter-state (Pass.)	Urban: Class 5-9 Commercial	Urban: Class 10-13 Commercial	Urban: Urban Arter-ials (Pass.)	Urban: Class 5-9 Commercial	Urban: Class 10-13 Commercial	Urban: Urban Other (Passenger)
1981	31,172,679							983,719						
1982	31,915,028			35,969,469			37,208,049	1,411,836			39,772,262			1,334,889
1983	37,212,357			29,279,613			37,101,711	1,664,279			38,912,460			1,427,437
1984	35,225,461			35,577,607			36,776,798	1,966,021			38,187,790			1,415,441
1985	38,309,866			39,137,560			36,761,723	1,967,035			41,218,964			1,322,722
1986	38,876,158	7,355,520	108,702	36,796,195	4,646,194	53,123	36,871,736	1,967,035	121,956		42,796,660	1,706,812	35,574	1,332,858
1987	42,200,903	7,837,783	264,790	34,988,730	4,407,726	25,155	40,401,132	2,138,325	129,419	3,157	40,565,499	1,719,491	15,457	2,259,834
1988	41,538,990	7,810,476	165,010	43,181,213	5,545,969	110,326	40,155,049	2,139,718	128,088	4,575	43,521,381	1,875,165	56,823	2,273,985
1989	46,251,531	8,619,109	261,186	41,816,315	5,211,161	125,825	42,091,889	2,391,173	145,972	2,281	40,005,877	1,575,878	45,678	2,312,412
1990	47,754,668	8,887,642	281,254	30,544,702	3,887,002	103,351	44,580,152	2,469,739	146,466	6,658	30,057,874	1,390,580	26,237	7,883,061
1991	39,428,943	7,352,506	217,852	28,717,998	3,664,945	81,182	45,421,074	1,236,936	76,690	1,212	33,907,248	1,542,634	39,555	7,885,048
1992	46,388,259	8,640,679	265,867	32,198,866	4,053,293	135,829	46,730,607	1,529,297	91,169	3,647	34,686,536	1,644,574	54,312	8,108,146
1993	50,083,966			31,341,453			46,866,675	1,651,271			37,675,325	-	-	8,151,823
1994	53,771,086	9,890,871	433,177	32,564,149	4,047,799	183,761	46,906,830	4,192,102	249,717	10,193	38,080,446	1,320,941	32,841	8,139,409
1995	56,220,246	9,888,960	905,327	35,326,412	4,337,812	232,925	46,852,120	4,350,113	253,842	15,865	39,376,262	1,348,488	41,252	8,155,921
1996	64,246,147	11,141,526	1,193,736	39,086,674	4,544,671	502,402	46,960,834	4,875,961	280,081	22,229	41,793,156	1,206,702	286,956	8,177,829
1997	67,736,683	11,312,009	1,693,415	37,884,337	4,227,472	684,217	46,944,975	5,207,686	308,832	20,179	41,898,403	1,187,686	337,232	8,180,968
1998	69,374,269	11,724,252	1,595,608	40,535,709	4,514,659	720,500	47,330,198	5,318,700	286,613	43,146	41,785,041	1,132,267	399,092	8,209,540
Forecasts:														
Base Year (98)	64,108,125	B [illegible],376,494	1,382,694	36,289,406	4,180,781	666,604	49,318,514	4,486,382	290,194	27,672	39,032,203	990,389	259,447	9,777,828
1999	66,175,047	[illegible],733,434	1,508,693	36,377,367	4,140,790	619,100	50,145,443	4,702,872	307,902	30,480	39,027,764	929,156	286,112	10,363,690
2003 C	74,442,736	13,161,192	2,013,088	36,729,216	3,980,827	829,481	53,453,160	5,672,833	376,734	41,709	39,010,008	684,226	387,769	12,706,937
2008	84,777,347	14,945,891	2,643,582	37,169,028	3,780,872	1,092,458	57,587,807	6,660,285	463,274	55,747	38,987,812	378,063	516,090	15,636,046
2013	95,111,958	16,730,589	3,274,076	37,608,839	3,580,918	1,355,434	61,722,453	7,747,737	549,814	69,784	38,965,616	71,900	644,411	18,565,155
2018	**105,446,570**	**18,515,288**	**3,904,570**	**38,048,651**	**3,380,964**	**1,618,411**	**65,857,100**	**8,835,189**	**636,354**	**83,821**	**38,943,420**	**(234,263)**	**772,732**	**21,494,264**
Annual Growth Factor= D	**1.8668%**	**1.8360%**	**3.0757%**	**0.2202%**	**-0.9110%**	**3.0951%**	**1.1958%**	**2.3444%**	**2.5904%**	**3.1898%**	**-0.0108%**	**-3.8510%**	**3.1631%**	**2.5957%**
		1.6371%	0.3333%	1.9703%	-0.8023%	0.3693%	-0.4329%		2.3648%	0.2777%	2.6425%	-3.0516%	0.6566%	-2.3950%

E

Figure 7-1. SDDOT Traffic Forecasting Worksheets: Adjustment of Factors.

- Forecasting factors will now be produced for two commercial vehicle types which are essentially Class 5-9 Commercial and Class 10-13 Commercial.
- Removal of urbanized VMT in Minnehaha and Pennington Counties is no longer necessary since the refined procedure will analyze historical rural/urban VMT at the county level.
- Iterative linear regression analyses in attempts to apportion statewide VMT into the six traffic analysis regions, across functional roadway designations, and by vehicle type will no longer be necessary since the revised procedure begins with VMT data that are already prepared and directly applicable at those levels.

One series of linear regression analyses is now the only iteration that needs to be effected in the revised procedure. Linear regression analyses to determine 'Base Year' VMT projections and VMT projections at 5-year intervals are performed for each category of historical VMT data. Sample 'Base Year' and 5-year interval projections for 'Rural' 'Interstate' 'Passenger' VMT can be found at **B** and **C** on Figure 7-1.

7.4.2 Revised SDDOT Traffic Forecasting Procedure: Nonadjusted Growth Factors

The VMT growth projections from the linear regression analyses need to be redesignated as annual percentage growth factors so that comparative analysis to county business and population growth trends in subsequent operations of the revised procedure will be more accurate and direct. Annual growth factors based on historical VMT are computed as a compound percentage annual growth, begin at the base year, are projected 20 years into the future, and also represent nonadjusted numbers at this point in the revised procedure. A sample 'Annual Growth Factor' projection for 'Rural' 'Interstate' 'Passenger' VMT in Brookings County can be found at **D** on Figure 7-1.

The 'Annual Growth Factors' for 'Class 5-9 Commercial' and 'Class 10-13 Commercial' vehicle types are reapportioned to reflect rates representative of their proportionate share out of the combined growth for all commercial vehicles. This again needs to be performed so that comparative analysis to county business and population growth trends will be more accurate and direct. Sample 'Annual Growth Factors' reapportioned for 'Rural' 'Interstate' commercial vehicle designations in Brookings County can be found at **E** on Figure 7-1.

7.4.3 Revised SDDOT Traffic Forecasting Procedure: Adjustment

Three important criteria have been established to supplement the analysis and adjustment of historical VMT projections in the revised traffic forecasting procedure. The criteria to supplement VMT growth projections are derived from county business data, number of new private housing building permits by county, and county population data. In essence, these criteria preparations lend the desired integrity to the production of statewide 20-year traffic forecasting factors. The traditional SDDOT traffic forecasting procedure was only based on historical VMT analysis without the direct use of any other external data sources to supplement analysis and adjustment of VMT growth projections. The following sections address the three data types chosen as criteria to supplement the revised procedure.

7.4.3.1 County Business Data

The previous data preparations for the revised traffic forecasting procedure established two distinct categories of business types to be directly related to two comparative vehicle traffic types (passenger and commercial). The ability to compare *trends* in the growth of county business activity to the VMT growth by county was the ultimate objective in these preparations. County business data for each county in South Dakota have been imported into a worksheet for "establishing supplemental criteria." An example from the worksheet of the two categories of business data prepared for Brookings County can be found at **A** on Figure 7-2.

In order to ready the business data for comparative analysis with VMT data, the following processes occur:

- Linear regression analyses to determine base year business growth (1998 Growth) projections and 20-year business growth (2018 Growth) projections are performed for each of the two business categories (Sample '1998 Growth' and '2018 Growth' projections can be found at **B** and **C** on Figure 7-2).
  - Please note there are 5 years of available business data to compare with 20 years of historical VMT for passenger vehicles or 8 years of historical VMT for commercial vehicles, but comparative *trends* are the primary concern in this revised procedure.
- The two categories of business types need to have 20-year growth projections from the regression analyses computed as annual compound percentage growth factors for ensuing direct comparisons with VMT growth trends (a sample 'Annual Growth Factor' projection for Brookings County can be found at **D** on Figure 7-2).
  - Please note there are a select few South Dakota counties where projected '2018 Growth' decreases by more than 50 percent of the total number of businesses of the last year data were recorded. For these situations, '2018 Growth' became one-half of the number of businesses for the last year data were recorded. This assumption was made based on county examples where examinations revealed there were very few businesses to begin with (three total in one county), or a major catastrophe was responsible (like the tornado of recent years that wiped out so much of Spencer, South Dakota). The judgments are that the loss of one business occurring in a county with sparse business activity cannot impact traffic by a third, countywide, and business activity over time generally recovers to some degree after a catastrophic event.

Brookings	Construction, Manufacturing, Mining Transportation, Wholesale Trade					Agricultural Services, Retail Trade, Finance, Services, Other					Building Permits	Population (% Change)	
# Employees	1-19	20-99	>100	Total	Wtd Total	1-19	20-99	>100	Total	Wtd Total			Year
1993	157	19	7	183	322	404	45	7	456	699			
1994	150	18	7	175	310	411	45	7	463	706			
1995	149	20	6	175	309	416	45	7	468	711			1980
1996	164	19	7	190	329	436	42	8	486	726	54	3.6	1990
1997	162	21	7	190	337	474	45	9	528	789	93	3.9	1997
1998 Growth:					336.1 (B)					786.2		7.3596	
2018 Growth:				(C)	434.1					1186.2			
Annual Growth Factor:					1.13% (D)					1.69%			
20%-80% Car/Commercial Traffic Split				(E)	*1.24%*		*80%-20% Traffic Split*			*1.57%*			

A F G

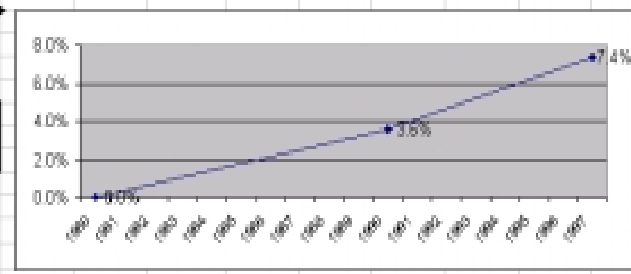

Figure 7-2. SDDOT Traffic Forecasting Worksheets: Establishing Supplemental Criteria.

- The two categories of business types need to have the 'Annual Growth Factor' adjusted to reflect the appropriate passenger/commercial traffic split that the categorical types of businesses are expected to generate.
  - The adjustment needs to be accomplished so that the business data relate directly in comparative analyses with the commercial and/or passenger VMT projections (a sample ' 20 percent–80 percent Car/Commercial Traffic Split' for Brookings County can be found at **E** on Figure 7-2).

The process to prepare county business data and establish this data as criteria for ensuing comparison with VMT growth trends is a critical step in the revised 20-year traffic forecasting procedure.

7.4.3.2 Number of Building Permits by County

The number of building permits issued for new private housing in each South Dakota county will merely be used for review of unique situations in the revised traffic forecasting procedure. The data are being provided to aid in monitoring certain urban/urbanized growth scenarios and to determine if long-term corrections to traffic forecasting factors might be necessary under those scenarios. Building permits data from 1996 and 1997 have been translated directly into the worksheet for "establishing supplemental criteria" from the *USA Counties – General Profiles* data [U.S. Census Bureau, 1999a]. Since there will not be any straight comparison of building permits data to VMT projections in the revised procedure, no regression analysis or percentage growth projections are performed on this data. A sample entry of 'Building Permits' data for Brookings County can be found at **F** on Figure 7-2.

7.4.3.3 County Population Data

There will not be any straight comparisons of county population data to VMT projections in the revised 20-year traffic forecasting procedure. The data may be used, however, for subjective analysis in an interactive process to verify and/or adjust traffic forecasting factors as necessary. The population data are presented for each South Dakota county in the revised procedure as an overall percentage population trend from 1980 to the present in graphical form whereby direct comparisons can be made to VMT and business trends. An example of a 1980 to 1997 population trend graph for Brookings County can be found at **G** on Figure 7-2.

7.4.4 Revised SDDOT Traffic Forecasting Procedure: Graphical Analysis of Criteria

The graphical analysis of criteria represents the final steps of comparing, analyzing, and adjusting the VMT growth projections that ultimately produce the adjusted SDDOT statewide traffic forecasting factors. This research project was defined to develop a statewide traffic forecasting procedure, but programming efforts to automate the procedure were beyond the scope of the study. For the purposes of this project, worksheet graphs were used to facilitate rapid and direct comparison of traffic and business growth projections. The graphs contain the projected business growth trends and traffic growth trends, each expressed as percent annual compound growth. The graphs have been organized to relate the appropriate business trends with the corresponding traffic trends as follows:

- Arterials & Other/Passenger vehicle growth compared to the growth trend for businesses defined by 80 percent passenger vehicle/20 percent commercial vehicle traffic attraction rate.
- Arterials & Other/Commercial vehicle growth compared to the growth trend for businesses defined by an 80 percent commercial vehicle/20 percent passenger vehicle traffic attraction rate.
- Interstate/Passenger vehicle growth compared to the growth trend for businesses defined by an 80 percent passenger vehicle/20 percent commercial vehicle traffic attraction rate.
- Interstate/Commercial vehicle growth compared to the growth trend for businesses defined by an 80 percent commercial vehicle/20 percent passenger vehicle traffic attraction rate.
- For counties that have urban/urbanized areas, corresponding traffic growth trends appear on the graphs.

Included as an example is Figure 7-3, which is a graph of Brookings County showing passenger vehicle growth projections on Arterial & Other routes compared to the business growth projection for businesses defined to have an 80 percent passenger vehicle/20 percent commercial vehicle traffic attraction rate. Traffic projections are identified as **A** on the example graph, and the projected business growth is identified with a **B**.

For the graphical analysis concept to work as intended, guidelines were developed to successfully merge the criteria with the graphs.

- Any traffic trend line showing a slope opposite the business trend line will require closer analysis of the actual data and *probable* adjustment of the annual percentage growth projection for traffic.
- Any traffic trend line having a differential greater than 1 percent when compared to the business trend line will require closer analysis of the actual data and *possible* adjustment of the annual percentage growth projection for traffic.
- If a traffic trend line has the same slope as the business trend and is within 1 percent above or below the business trend percentage, then there will *probably not* be any adjustment required to the annual percentage growth projection for traffic.

Arterials & Other
Passenger Vehicles

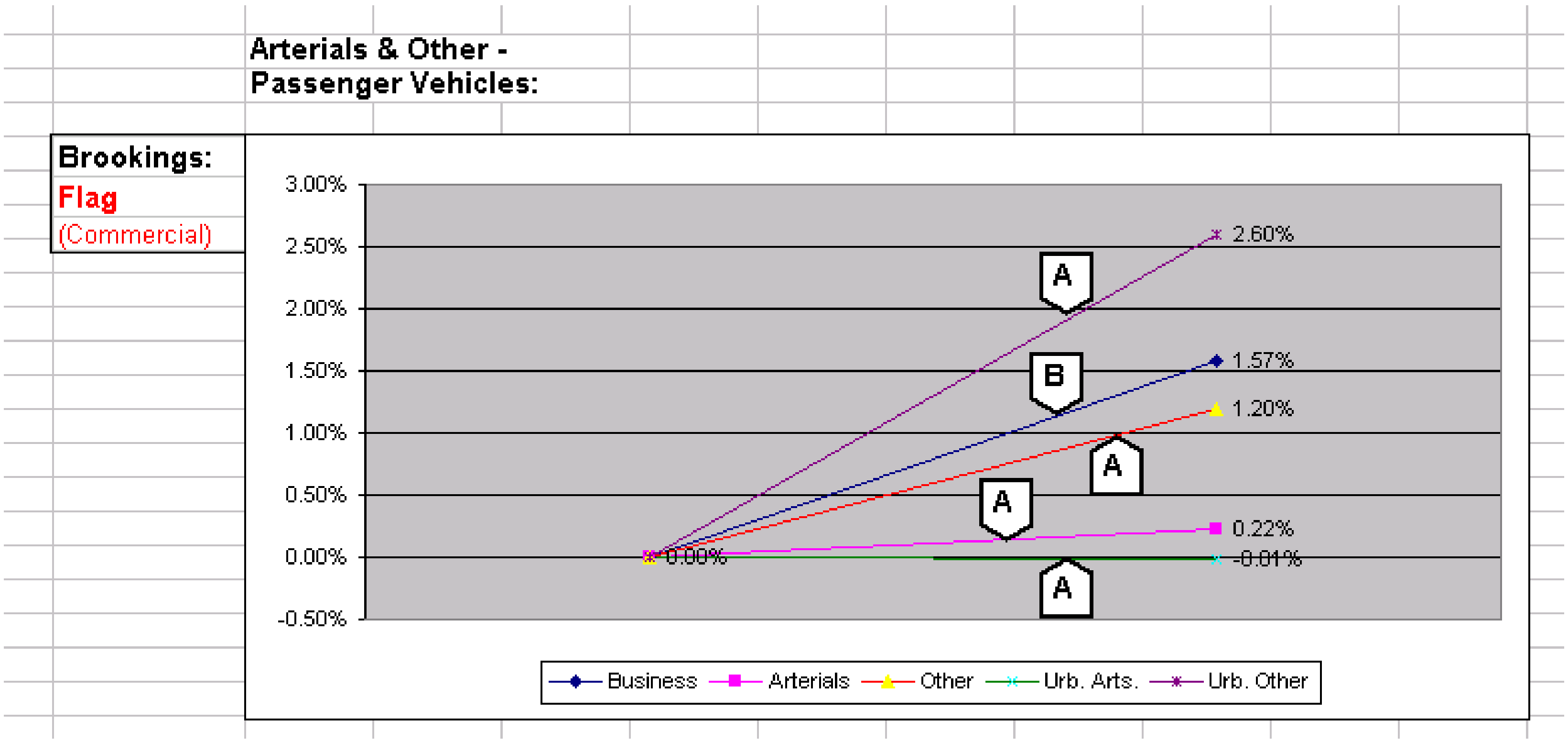

Figure 7-3. SDDOT Traffic Forecasting Worksheets: Graphical Analysis of Criteria.

7.4.5 Revised SDDOT Traffic Forecasting Procedure: Growth Factor Adjustments

Adjustments to the percentage growth projections for traffic are interactive processes based on review of the criteria provided by all the data used in the revised traffic forecasting procedure. When guidelines used in the graphical analysis indicate a possible or probable adjustment, review of the historical VMT data on the "nonadjusted factors worksheet" will provide a useful insight on adjustment suitability. In a trial performance of the procedure, the assumed guidelines used in the graphical analysis proved to work as intended. When a possible or probable adjustment was indicated through application of the graphical analysis guidelines, subsequent reviews of historical VMT almost always verified that the adjustment condition was indeed warranted.

The actual adjustments that were assumed in the trial performance of the revised traffic forecasting procedure were very standardized. Nearly all of the percentage traffic growth projections that indicated necessary adjustment were increased 20 percent to 25 percent when the business growth trend was greater or else decreased 20 percent to 25 percent when the business growth trend was less. The adjustments were normally accomplished by performing a regression analysis on the most recent 5 years of VMT data and comparing the output to a regression analysis performed on the 5 years of available business data. This process tended to adjust the projected traffic growth by 20–25 percent because the 5-year analysis outlooks represent approximately this percentage when compared to the 20 (±) years of available traffic data. On some occasions, subjective analysis of data trends and/or patterns by the traffic forecaster will influence the final adjustment amounts.

On limited occasions when the graphical analysis guidelines do not indicate a clear-cut adjustment solution, subjective analysis will be required. This analysis will be based upon review of the population and building permits data provided as supplemental criteria for the revised traffic forecasting procedure and/or also based on the professional judgment of the traffic forecaster. Knowledge of South Dakota conditions would also provide valuable insights. Following are some of the primary subjective analysis criteria that could be used for those limited occasions when an adjustment condition requires further scrutiny:

- Review of the county attributes for the traffic trend being reviewed (i.e., a sparsely populated county versus a county with a large urban area).
- Knowledge of conditions that may be contributing to discrepancies (i.e., a high growth business trend in a county might relate directly to a high growth trend of interstate traffic, yet traffic is shown to be steadily decreasing for the 'Other' functional classification. The assumption is that the opening of a new business like Cabela's along Interstate 90 in Mitchell, South Dakota, would generate more interstate traffic and the trend for 'Other' might be legitimate, thus reflecting that the projected growth factor for 'Other' should remain unadjusted).

- Reviews of regional trends (as in a group of South Dakota counties) that may be occurring to inject a discrepancy (i.e., vast flooding that occurred in the northeast part of South Dakota a few years ago that actually closed several major transportation routes and caused traffic patterns to adjust accordingly over quite a long period of time).

Experienced traffic forecasting personnel may augment the criteria defined above by conceptualizing other analytical techniques as the procedure becomes more familiar over time and tendencies become more apparent. The discovery and introduction of additional data would open up even more possibilities for developing criteria, gaining supplemental analysis tools, and augmenting the revised procedure.

7.4.6 Revised SDDOT Traffic Forecasting Procedure: Production of Forecasting Factors

In performing the revised traffic forecasting procedure, many of the projected traffic growth percentages need to be adjusted. It is highly advisable to "flag" the adjustments as soon as they are made. There are three primary reasons to follow this regimen:

1. Since no software has been developed for the revised procedure, processing is essentially manual, leaving no "audit trail" to readily retrieve the adjustments (as would be available in an automated process).
2. Adjustments made to projected traffic growth percentages will need to be tracked so that the corresponding adjustments can be reflected in the final 20-year traffic forecasting factors.
3. Adjustments are also then historically catalogued for future reference, act as matters of record, and are readily available in case any reanalysis or rework is necessary.

The final 20-year traffic forecasting factors are easily produced by dividing the 20-year VMT projections by the 'base year' VMT projections. In situations where the projected traffic growth percentages are adjusted, the forecasting factors are calculated by multiplying the initial unadjusted forecasting factor by the ratio of the adjusted growth percentage and dividing by the initial unadjusted growth percentage.

The Excel spreadsheets used to perform computations and retain data during the development of the procedure for this project are extremely basic and provide little automation. There are no data, spreadsheet, or worksheet links provided because the project intents called for development of a procedure only, without initiation of a software development effort. Therefore, any additional data can be added to the worksheets by simply inserting appropriate rows without any adverse effects to spreadsheet cell equations. Also, it is recommended that only 20 years of historical data be maintained for the newly developed procedure. Although there were only eighteen years or less of historical data available for this project, any data that is currently not desired as part of the analyses' can be excluded quite easily.

8.0 DEVELOPMENT AND VALIDATION OF 20-YEAR TRAFFIC FORECASTING FACTORS

Task 8 In conjunction with DOT's Data Inventory and Planning & Programs personnel, use the recommended procedure to develop and validate 20-year traffic forecasting factors using DOT's most recent data.

8.1 SDDOT 20-YEAR TRAFFIC FORECASTING FACTOR ARRAY

Documentation of the new 20-year traffic forecasting procedure was structured in a way that presented the chronological process leading to the traffic forecasting factors. The final factors are transferred to the "SDDOT 20-Year Traffic Forecasting Factors" spreadsheet, as found in Appendix B. The spreadsheet acts as the final report for printing/publication purposes and also serves as a means of electronic storage for the final traffic forecasting factors.

The 20-year traffic forecasting factors in the array table can be applied to 'Base Year' traffic counts and/or VMT data to project 20-year traffic/VMT. The factors would be applied to the functional route designation (or any portion thereof), with the corresponding vehicle classification, and county identification as cross-referenced in the array table. Base year data is recommended because applying the factors to the most recent year's actual traffic/VMT numbers could result in forecasts that are misrepresentative. In other words, the actual data of the most recent year might be significantly higher or lower than the average growth that occurred over previous years.

8.2 VALIDATION OF 20-YEAR TRAFFIC FORECASTING FACTORS

Development of the revised traffic forecasting procedure required careful attention to testing and verification processes to ensure the integrity of the factors produced. This was accomplished by applying the procedure to historical data and projecting traffic forecasts to a recent year where actual VMT is already known. This process was somewhat restricted because there is not historical VMT data that goes back far enough to perform analyses *and* project 20-year forecasts within the same range of data. Therefore, factor validation had to be performed using the procedural analyses on shorter spans of historical data (usually 10 years) and projecting forecasts over periods less than 20 years (normally 5, 10, or 15 years). Also, the county business patterns only reflect a 5-year history, so projected business trends were assumed to be relative to the trends occurring prior to 1992. In light of these restrictions, forecasting factors did project traffic growth that was generally within 1 percent to 2 percent of actual VMT. Representative test results are found in Table 8-1, which shows the actual 1998 VMT by vehicle class on particular roadways in counties from each of the traffic analysis regions as compared to VMT projections from the new procedure.

Table 8-1. Representative Test Results: Actual VMT Compared to VMT Projections From the New Procedure

Region	County/Roadway/ Vehicle Class Sample)	Actual 1998 VMT	1998 Forecast VMT (New Procedure)	Difference (In Percent)
1	Lake/Urban Other/ Passenger	3,709,444	3,767,953	1.6
2	Union/Rural Interstate/ Passenger	157,920,058	152,546,131	–3.4
3	Davison/Urban Arts/ Class 5-9 Commercial	2,009,738	2,018,158	0.4
4	Faulk/Rural Other/ Passenger	12,944,276	13,231,284	2.1
5	Hyde/Rural Arterials/ Class 5-9 Commercial	20,739,159	20,418,824	–1.5
6	Lawrence/Rural Arts/ Passenger	97,960,866	97,123,592	–0.8

The true test of validation will be direct comparisons of forecasts to actual traffic 5, 10, and 20 years hence. Close attention to factor performance as iterations of the procedure are accomplished will allow for more careful scrutiny, as well as continuous refinement of the procedure over time.

In addition to validation processes, performance comparisons between the old and new procedures were tested to gain perspectives on relative improvements. Again, certain assumptions had to be made to compare two procedures that have divergent approaches to traffic forecasting. Direct relative comparisons of the factors produced in the new procedure for various vehicle types and functional roadway classes by counties to the broader, more generalized regional factors of the old procedure produced expected results. The new procedure produced county factors that varied significantly when compared to the regional factors produced by the old procedure.

Since the older procedure is based on the large traffic analysis regions, factors produced by the smaller county TAZs of the new procedure needed to be compared by their regional cumulative averages against factor output of the older procedure. Also, the wider variety of forecasting factors produced across vehicle types and functional roadway classifications in the new procedure required additional factor merging to gain perspectives of the cumulative average against the more generalized output of the old procedure. The reviews were performed in the context of the assumptions made that county, vehicle, and roadway class averages could be compared to forecasting factors of a regional nature. Again, comparative results were mixed but on a general statewide basis; factors produced by the new procedure tended to be slightly higher.

Other processes to verify and validate primarily the integrity of historical VMT data were conducted during the development of the new 20-year traffic forecasting procedure. These were explained as appropriate in the respective sections of this report concerning treatment of data.

9.0 RECOMMENDED COORDINATION BETWEEN THE SDDOT AND MPOS

Task 9: Recommend coordination between the DOT and MPOs for determining the forecasting factors.

The following sections provide the recommendations to enhance SDDOT/MPO coordination based on the reviews of current SDDOT and MPO environments and the inherent restrictions that were discovered through the course of this project.

9.1 RECOMMENDED COORDINATION AT NORTH SIOUX CITY, SOUTH DAKOTA

There is no controlling transportation planning authority for coordinated efforts in North Sioux City, South Dakota to fully relate with an out-of-state SIMPCO. This essentially means that the SDDOT will be solely responsible for traffic forecasting around this urbanized area.

It is recommended that the SDDOT incorporate any relevant data for the statewide traffic forecasting procedure out of the proposed WIM and AVI technologies when these capabilities are implemented at the new Jefferson, South Dakota POE. Also, any traffic forecasting collaboration or add-on capabilities that can be accomplished should be considered and planned for as the time approaches to carry out the WIM and AVI implementation. Finally, it is felt that the recently added data of the new procedure will help considerably in this area with more data and increased analysis capabilities expected over time.

9.2 RECOMMENDED COORDINATION AT RAPID CITY, SOUTH DAKOTA

There are presently several conditions limiting traffic forecasting efforts at Rapid City, South Dakota:

- Lack of resources
- Limited data available
- Restricted in the ability to dedicate personnel
- Defined land use for traffic modeling has not been wholly accepted by all parties involved in planning functions.

Because of these restrictions, statewide traffic forecasting factors produced by the SDDOT have been heavily relied upon as a primary source for transportation planning in Rapid City, South Dakota.

Two recent developments have transpired at Rapid City Public Works offices during the course of this project. A new traffic engineer has been added to Rapid City's staff, and there has been a solicitation for proposals to formulate an overall long-range transportation plan for the city. It is assumed that traffic forecasting needs will be strongly considered as these developments continue.

Recommendations

The SDDOT will need to continue in a lead role instead of a coordinating partner for traffic forecasting in the Rapid City area, at least into the near future. In this capacity, the SDDOT should keep in close communication with the city for the following reasons:

- To assist as needed with the city's ongoing transportation planning endeavors.
- To provide more feedback to the Rapid City MPO concerning statewide traffic forecasting now performed at the county level and including business, population, and building permits data instead of across broad regions with less readily applicable data.
- To gain feedback from the city when circumspect conditions arise during the performance of the new statewide traffic forecasting procedure (such as planning documents revealing the nature and location of proposed new developments, areas planned for annexation, land use zoning revisions, etc.).

Effective two-way communication will be key at this juncture, particularly when the above initiatives are considered in the background. As the city moves forward with transportation planning objectives, coupling this type of communication can only lead to the eventual implementation of fully coordinated traffic forecasting activities.

9.3 RECOMMENDED COORDINATION AT SIOUX FALLS, SOUTH DAKOTA

The city of Sioux Falls utilizes several data resources and planning tools to support MPO activities, as overviewed in Section 3.3 of this report. Additionally, the city anticipates improving traffic forecasting by implementing improved traffic modeling software to replace the current TModel 2 software system. Also, the city of Sioux Falls began using traffic forecasting factors from the SDDOT statewide procedure in 1997 to support MPO functions, but these factors are lower than those previously produced by the city, and actual growth trends of traffic in Sioux Falls has been ever-increasing. (Impacts can be rather significant when transportation routes such as 41st Street are considered.)

Recommendations

In light of the refined procedures employed by Sioux Falls and the newly developed traffic forecasting procedure for the SDDOT, there are several recommendations for improved coordination.

1. After developing statewide traffic forecasting factors, the SDDOT should request the forecasting factors produced by Sioux Falls.
2. Discrepancies should be noted and reviewed.
3. If reviews need to be supplemented with additional information, the SDDOT should request other updated city planning documents such as those accumulated during the research efforts of this project.
4. If there is no clear-cut evidence that Sioux Falls' factors have been arrived at through procedural inequities determined to be in conflict with the SDDOT procedure, the Department should adjust their 20-year traffic forecasting factors accordingly.
5. Adjustments to the SDDOT 20-year traffic forecasting factors would only be for routes classified as 'Urban' in Minnehaha and Lincoln Counties.

These recommendations are made with full consideration of the conditions that have evolved to support such action. The primary conditions are:

1. The new SDDOT procedure may well produce factors that are in close harmony with Sioux Falls' factors because traffic forecasting regions have been broken down to the county level and additional criteria are now employed.
2. If adjustments to the SDDOT factors are necessary because of discrepancies with Sioux Falls' factors, the impacts to the county level factors are not now as great as adjustments to the previously defined traffic forecasting regions would have been.
3. Any adjustments to the SDDOT factors can now be performed with less overall impact because only the Sioux Falls 'Urban' factors are adjusted and traffic forecasting is performed individually for Minnehaha and Lincoln Counties (instead of being encompassed in a large traffic forecasting region) providing smaller traffic analysis zones whereby the 'Rural' factors can better cushion such adjustments.
4. The Sioux Falls approach is at more of a microscopic level than the SDDOT's macroscopic, statewide outlook, and therefore, should be given stronger consideration than in the past.

A factor influencing the above recommendations will be the proposed move to a new traffic modeling software package at the city of Sioux Falls. The city and the SDDOT both need to be aware that careful scrutiny of factor output will need to be undertaken, and all inherent processes need to be fully verifiable before readily accepting forecasting factors from any newly defined source.

10.0 RECOMMENDED SOFTWARE FOR 20-YEAR TRAFFIC FORECASTING AT THE SDDOT

Task 10: Recommend software and its functional requirements that will automate the 20-Year Traffic Forecasting Factor computations.

The development of the statewide traffic forecasting procedure for the SDDOT precluded the incorporation of any software packages from the private sector. Nearly all of the traffic forecasting software available today is structured for urban modeling, and none seems well suited to statewide traffic forecasting in a state with unique rural conditions like those present in South Dakota. Also, very scattered software development at other state DOTs has been progressing slowly and is not really compatible with the statewide traffic forecasting needs of the SDDOT. For these reasons, the new procedure has been developed to specifically address the statewide needs of the SDDOT and is structured with a logical decision-making process that will lend itself well to an automated procedure.

RESPEC strongly recommends that the SDDOT proceed immediately with a software development effort to automate the new traffic forecasting procedure that is presented herein. The procedural documentation and associated Excel spreadsheets completed during the current research effort will provide significant design guidance during the development effort. Key objectives of this software development effort should include:

1. Automating the new traffic forecasting procedure to facilitate immediate cost-effective use of the new procedure and to enhance its reliability and effectiveness.
2. Developing software that is structured to easily accommodate program refinements needed to implement enhanced procedural capabilities as they evolve over time.

The following sections detail specific efforts that should be initiated to achieve these objectives.

10.1 SOFTWARE APPLICATION DEVELOPMENT FOR THE NEW TRAFFIC FORECASTING PROCEDURES

RESPEC recommends the initiation of a software application development effort as soon as possible to automate the new SDDOT traffic forecasting procedure detailed herein. There are several driving factors behind this recommendation; namely:

- Increase efficiencies and maximize time savings.
- Empower the procedure with a well-structured database and applications development software that is congruous with the procedural requirements.
- Minimize the possibilities for introducing errors during the procedure.

- Minimize subjective analysis to gain more objective output.
- Provide reliable integration and corresponding input paths for other important SDDOT systems, such as pavement/roadway design systems, pavement management systems, and transportation project planning and prioritization systems.
- Instill consistency and uniformity over time (as compared to recent losses of data, loss of personnel with procedural expertise, etc.).

The new traffic forecasting procedure is structured to translate smoothly into an effectual software application and provides a reliable means to realize the benefits of automating this procedure. Although the software development effort will include detailed planning and design efforts, the current research effort identified the following primary software requirements:

- All historical traffic, business patterns, population trends, and building permits data should be migrated to a well-designed database.
- The database should readily allow for the entry of new data and data updates with inherent tools for verification as needed.
- The software should have intrinsic algorithms to perform all procedural calculations automatically (e.g., the user must currently cut and paste formulaic cells in the spreadsheets whenever criteria dictates that a new iteration of a calculation needs to be performed).
- The software should include decision logic for matching procedural rules to criteria (e.g., reconcile all factor adjustment decisions where there is greater than 1 percent deviation between the traffic and business growth trends and/or reconcile all factor adjustment decisions for growth trends where projected traffic and business slopes are divergent).
- The software should include programmed logic that will automatically perform procedural operations based on criteria analysis (e.g., disallow any yearly VMT in a column that is excessively out of range with the standard deviation of all other data in that column).
- The programming of the software should allow for appropriate actions and desired production of output based on established procedural guidelines and analysis requirements (e.g., adjust all traffic forecasting factors and print a report for a given class of vehicles on a specific route designation that are either rural or urban, in specified counties, and that failed certain criteria and analysis routines).
- The software should include interfaces that will allow the user to make subjective adjustments when needed or desired.
- The software development should be modular to allow additional data items, new criteria, and procedural analysis to be integrated as needed over time.

Although the above requirements provide the general outline for developing a traffic forecasting software application, a formal software development plan and design process will be necessary to define the detailed specifications for the application.

10.2 FACILITATE CONTINUED ENHANCEMENT OF THE TRAFFIC FORECASTING SOFTWARE APPLICATION

RESPEC recommends that the new traffic forecasting procedure, and software development around the procedure, maintain a composition that can be readily improved and enhanced over time. There are several sound reasons to follow this strategy, including:

- Allowing for more flexibility and thereby better maintenance of the procedure and supporting system.
- Providing the necessary adaptability to fit into the long-range direction of information systems technology within South Dakota state government.
- Opening up more avenues to integrate traffic forecasting factors with other DOT operations, information systems, and software.
- Preparing traffic forecasting personnel and stakeholders at other departmental offices for future technology directions, such as with “modeling” software.

These concepts were key considerations throughout the development of the new traffic forecasting procedure. The new traffic forecasting procedure represents an improved process specific to today’s demands and also prepares a solid foundation that is well prepared to take advantage of the ongoing refinements in traffic forecasting.

The approach in this research project to develop a new traffic forecasting procedure has included a concentrated focus that anticipates eventual migration to significantly enhanced traffic forecasting software. The upcoming software specification, design, and development efforts should look to software development that is prepared to incorporate the following enhancements:

- Traffic forecasting regions, which are now represented by individual counties that relate intercounty traffic patterns more realistically, could eventually be considered as TAZs (as found in most urban traffic models).
- The business patterns incorporated as a primary criteria in the new procedure would provide a good data framework on which to base centroids for TAZs (such as the county seat, business center of the county, or lone urban area of the county).
- Counties are contiguous (no gaps), generally similar in their rural nature, transition smoothly from rural to urban in the rare instances where urban conditions exist, and would allow counties to be linked through centroids.

- Links could carry apportioned traffic forecasts according to defined sets of decision criteria (such as weighted combinations of historical ADT volumes, newly identified development areas, transportation route improvements such as a roadway widening, etc.).
- The current county base maps maintained in GIS format at the SDDOT could easily provide the transportation network substructure that would be an essential information system component.

Again, these are only a few of the possible enhancements that might be incorporated as the traffic forecasting procedure and supporting software evolve.

As stated earlier in this report, the primary reason an urban model could not be incorporated at the SDDOT is that there could be no trip generation due to the scarcity of metropolitan areas and the widespread rural conditions. Significantly enhanced software development *would* require additional data, criteria guidelines, and processing algorithms, but with a proper plan and preconceived implementation timeline, these conditions would be very manageable. Essentially, the 20-year traffic forecasting factors produced by the new procedure would be considered as the primary data in the migration to significantly enhanced traffic forecasting software.

There are existing types of data that could be used as analysis criteria in enhanced traffic forecasting software at the SDDOT. Three identified types of data with explanations of the roles these data might play in enhanced software are listed as follows:

1. *The state roadway network on county GIS maps maintained by the Office of Data Inventory at the SDDOT* — could be used to provide the software's roadway link/segment locations and carry apportioned traffic coming out of algorithms projecting various traffic growth.
2. *ADT data maintained on project-specific roadway segments by the Office of Data Inventory at the SDDOT* — could be used in conjunction with the county GIS maps 20-year traffic forecasting factors, and appropriate algorithms in the enhanced software to "fine tune" traffic growth projections.
3. *The number of businesses at specific trade center locations from the South Dakota Retailers Association* — could be used in the enhanced software to locate businesses more distinctly on the county roadway network provided by GIS maps versus simply inputting the number of businesses per county.

Figure 10-1 is being included to illustrate the concept of significantly enhanced SDDOT traffic forecasting software more clearly. It also shows some of the added capabilities that could be provided in the enhanced traffic forecasting software, even when just three refinements such as those cited above are all that are incorporated. Theoretical analysis capabilities of the enhanced software are described below in an example that is coupled with Figure 10-1. The

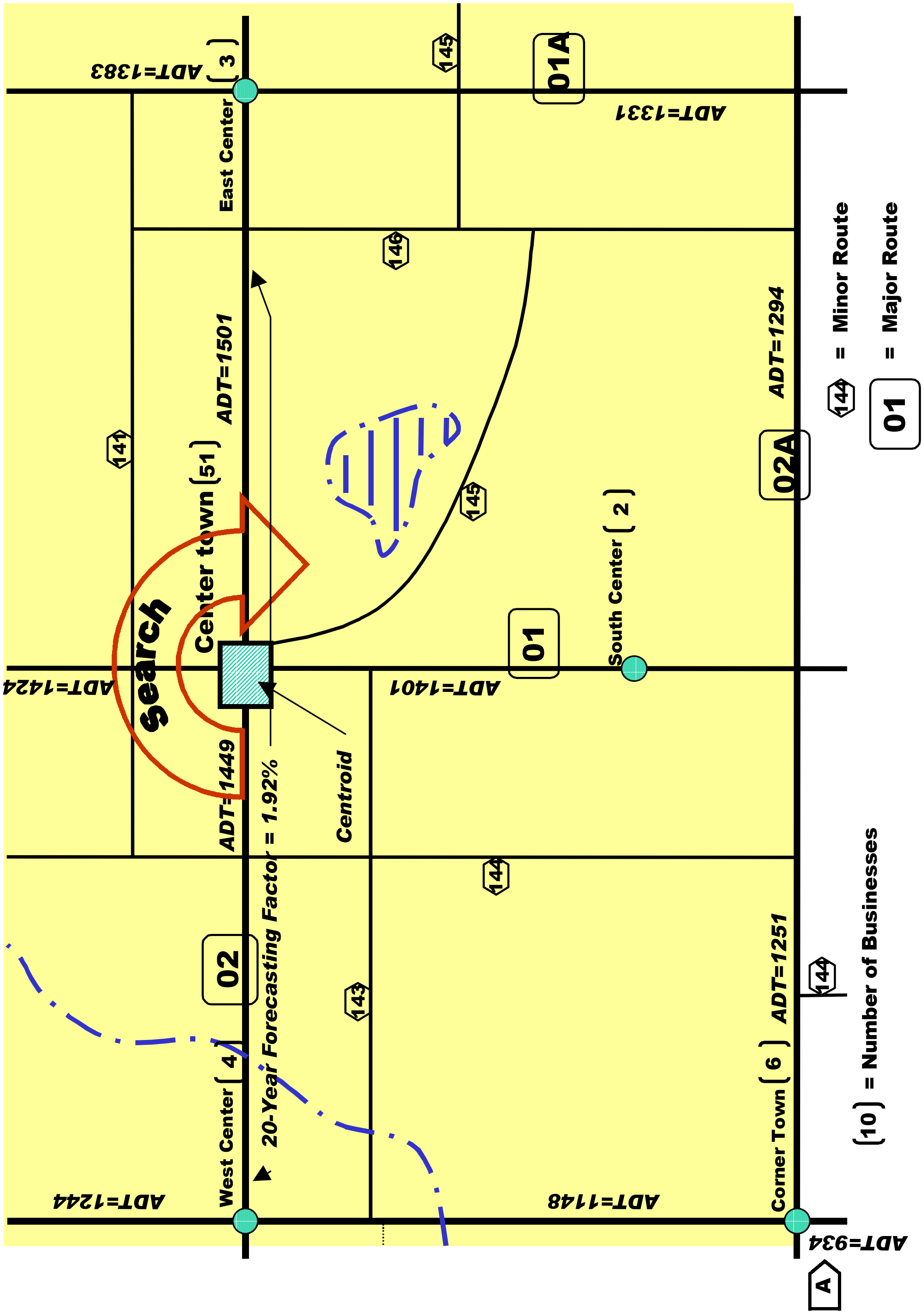

Figure 10-1. Center County.

example has also been simplified for conciseness and clarity and assumes that 20-year traffic forecasting factors have been produced by the revised procedure for use as base data in the enhanced software. The figure can be referred to as necessary for the example provided herein:

- Preprogrammed algorithms use the centroid (Center Town on the example), perform a circuitous 'Search' of all 'Major Route' highway links around the centroid, and apply an appropriate 20-year traffic forecasting factors to the ADT on all connected highway links of the 'Major Routes' only.
- Adjustments to traffic forecasts are made based on regression analysis of historical ADT on the connected highway links and/or based on business growth patterns at trade centers directly connected by highway links.
- Highway links in the same county but not directly connected to the centroid could also be adjusted by an ever-decreasing factor (based on software algorithm logic that would make the adjustment dependent on the link's removed distance from the centroid, the number of major intersections between the link and centroid, and/or the link's proximity to a viable trade center).
- Many other types of analysis logic could be applied using only these three criteria, such as: applying a factor with increased weight to a highway link that has been widened from two to four lanes or assigning a decreased weight factor to highway links that are in close proximity to each other.
- Because of the enhanced software's centroid/link concept, processes to refine traffic projections could also be performed interactively through adjoining counties, thereby reinforcing the concept of significantly enhanced traffic forecasting software (i.e., the ADT number on a roadway outside, but adjacent to 'Center County' as shown at A on Figure 10-1, could conceivably be influenced by projections coming out of the criteria and analysis based around 'Center County').

Although the example is theoretical to illustrate enhanced software potential, it is also presented to evidence the importance of the software planning, design, and development that considers long-term traffic forecasting goals. This particular example assumes traffic forecasting at the highway project level. The relational capabilities with other SDDOT information systems involving project planning/prioritization, pavement management, highway design, and others should be readily apparent, and therefore, appropriate software development becomes equally crucial to desired systems integration.

11.0 RECOMMENDATIONS AND CONCLUSIONS

The investigations performed for SDDOT Research Project SD1999-04 identified a number of specific recommendations and strategies that the SDDOT should strongly consider. Recommendations provided were formulated on objective analysis findings that define an improved 20-year traffic forecasting procedure for the SDDOT, allow better SDDOT/MPO traffic forecasting coordination, and satisfy the need to gain more procedural efficiency through software development.

11.1 RECOMMENDATIONS

Ten specific actions are recommended to improve the statewide 20-year traffic forecasting process at the SDDOT. The recommendations pertain to changes in traffic data collection and management, implementation of the new 20-year traffic forecasting procedure, actions to establish better SDDOT/MPO traffic forecasting coordination, and software design and development to automate the new procedure.

Changes in Traffic Data Collection and Management Practices

Project investigations resulted in two recommendations specific to SDDOT traffic data collection and associated data management practices. To support implementation of the new procedure, the Department should perform two essential activities:

1. *Review current policies for the designation and placement of ATRs.*

   – Current practices in traffic data collection should be the primary focus.

   – Hierarchical grouping of ATRs should be considered.

   – Historical traffic data are primary to statewide traffic forecasting at sparsely populated states with primarily rural conditions.

2. *Initiate efforts to establish a permanent database to support ongoing traffic forecasting activities and enhance ongoing management of related data.*

   – The data need to be securely stored and maintained by the SDDOT (as opposed to past practice).

   – Validation of forecasting factors will then be possible (as opposed to past practice).

   – Data development for this project represents important groundwork that should not be lost.

   – The data generated under this project is structured to readily migrate to a supporting database.

- Definition of database requirements should be included as an integral part of the software development plan to automate the new procedure.

Implementation of the New 20-Year Traffic Forecasting Procedure

In light of the current lack of an established 20-year traffic forecasting procedure, immediate implementation of a 20-year traffic forecasting procedure specific to the needs at the SDDOT is essential.

3. *Implement the new procedure as soon as possible.*

   Implementation of the new procedure will:

   - Replace processes and expertise that were recently lost.
   - Improve the quality and integrity of traffic forecasting at the SDDOT.
   - Improve the Department's confidence in, and use of, traffic forecasting factors.
   - Facilitate implementation of emerging, nationwide trends in traffic forecasting.

4. *Establish a 2-year traffic forecasting cycle versus the current 4-year cycle.*

   A shorter forecasting cycle will:

   - Make factors readily available, more current, and also more practicable for departmental needs.
   - Emphasize continued review and enhancement of the forecasting procedure.

Note that the new SDDOT procedure was developed using Microsoft Excel, primarily to facilitate storage and manipulation of data during the project. Although software development to automate the procedure was outside the project scope of work, documentation of the new procedure has been included so that SDDOT personnel can perform the procedure to produce the factors that are now through "manual operations" in lieu of an automated procedure.

Improvement of SDDOT/MPO Traffic Forecasting Coordination

Recommendations to improve SDDOT/MPO traffic forecasting coordination vary significantly for each of the MPOs in South Dakota. The following recommendations are specific to improved SDDOT coordination with each South Dakota MPO.

5. *Because there is no controlling planning authority for coordinated efforts in North Sioux City (e.g., there is no representation in SIMPCO), the SDDOT should take advantage of proposed weigh-in-motion/automatic vehicle identification (WIM/AVI) technology implementation at the new Jefferson, South Dakota, POE.*

– Traffic forecasting collaboration or add-on capabilities should be considered at the new POE.

– Relevant data provided by the proposed WIM and AVI technologies should be incorporated in the traffic forecasting process as it becomes available.

6. *In the near term, the SDDOT should maintain a lead role versus the role of a coordinating partner for traffic forecasting in the Rapid City, South Dakota, area.*

Since Rapid City is in a transition phase with regard to transportation planning and traffic forecasting activities, internal capabilities are currently restricted. The SDDOT can function as a lead in:

– Assisting as necessary with the Rapid City's ongoing endeavors to enhance transportation planning/traffic forecasting activities.

– Providing more feedback to the Rapid City MPO concerning factors produced by the new SDDOT procedure.

– Gaining feedback from the city when circumspect conditions arise.

– Maintaining open communications so that each entity can react accordingly to enhancements instituted at the city and to enhancements implemented by the SDDOT.

7. *The "microscopic" traffic analysis at Sioux Falls, South Dakota, should be given substantive consideration compared to the statewide "macroscopic" traffic forecasting approach of the SDDOT.*

The city of Sioux Falls utilizes several data resources and planning tools to support transportation planning activities and anticipates improving traffic forecasting by implementing improved traffic modeling software to replace the current TModel 2 software. Sioux Falls began using traffic forecasting factors from the SDDOT statewide procedure in 1997. In efforts to improve traffic forecasting coordination with the Sioux Falls MPO, the SDDOT should consider the following:

– After developing factors with the new statewide procedure, the SDDOT should request traffic forecasting factors produced by the city of Sioux Falls for comparison with the factors produced by the new procedure.

– Discrepancies should be rectified through a thorough SDDOT review of updated Sioux Falls planning documents and other available information. If warranted, statewide 20-year traffic forecasting factors should be adjusted for the Sioux Falls urbanized area.

– Implementation of new traffic modeling software at Sioux Falls will require careful acceptance but should be tempered with the realization that Sioux Falls' traffic forecasting factors are based on more detailed information.

– Both entities should collaborate to produce, agree upon, and use the same forecasting factors for the urbanized area of Sioux Falls, South Dakota.

Efforts to improve coordination with South Dakota MPOs should be afforded more suitably once the new SDDOT 20-year traffic forecasting procedure is implemented. Factors produced by the new procedure should prove to be in closer harmony with MPO factors because:

- Traffic forecasting regions are broken down to county levels.
- Urban/urbanized areas are treated more realistically.
- Analysis capabilities are increased with the incorporation of additional data.
- More criteria are now employed to add to factor integrity.

In general, the new SDDOT procedure includes additional data and provides improvements in traffic forecasting for urban conditions that will help considerably in each of these areas.

Software Design and Development to Automate the New Procedure

The remaining three recommendations address the critical need to automate the 20-year traffic forecasting process and emphasize the importance of planning to ensure that both current and future SDDOT traffic forecasting needs are met.

8. *Initiate a system planning effort to fully define the system requirements, specifications, and design.*

   – System developers and SDDOT personnel with interests in the traffic forecasting procedure will be those primarily involved.

   – The effort will ensure the desired implementation of a traffic forecasting software system specific to the needs of the SDDOT.

   – The approach will define the budget and resource considerations for the software development effort.

9. *Empower the procedure through software development.*

   – Increase efficiencies and maximize time savings.

   – Minimize the possibilities for introducing errors during the procedure.

   – Minimize subjective analysis to gain more objective output.

   – Instill consistency, uniformity, and better maintenance of the procedure over time.

   – Provide a reliable integration path to other important SDDOT systems that could utilize the forecasting factors.

For planning purposes, the level of effort to design, develop, and populate a database and subsequently structure, design, and develop software that automates data management and procedural calculations included in the working spreadsheets used for this project is roughly estimated to be $30,000. (This basically includes the first three primary software requirements identified in Section 10.1). Budget and resource requirements for the full software development effort will not be identified until Recommendation 8 is completed. Development costs can be expected to increase, however, with full automation of the forecasting process and incorporation of functions and calculations beyond those already included in the working spreadsheets.

10. *Anticipate eventual migration to significantly enhanced SDDOT traffic forecasting software.*

 - Include planning in the software development for a well-conceived migration path to the enhanced software.
 - Maintain project focus on the development of a new traffic forecasting procedure that is structured to accommodate ongoing software enhancements.
 - Prepare to facilitate continually refined enhancements to the traffic forecasting procedure over time.
 - Give careful consideration to components that would work well and that are already in place, supported, and maintained at the SDDOT for enhanced traffic forecasting software.

These recommendations have been provided to ensure that SDDOT traffic forecasting needs are met and to facilitate ongoing enhancement of SDDOT traffic forecasting capabilities. The procedure will need to be performed manually until the Department initiates a software development effort. System planning and design efforts will be crucial to the success of this software development effort.

11.2 CONCLUSIONS

Investigations of SDDOT traffic forecasting needs and traffic forecasting practices at the SDDOT and in other states with similar traffic forecasting conditions failed to identify a traffic forecasting model that was suitable for implementation by the SDDOT. Most traffic forecasting models that are being applied on a statewide basis are based on urban scenarios, a situation that presents significant problems for sparsely populated states, primarily rural in nature, and that have limited resources, personnel, and data to support these models.

Subsequent research efforts led to the development of a new SDDOT 20-year traffic forecasting procedure that is consistent with traffic forecasting conditions in South Dakota and is based on data that is readily available. The new procedure, which incorporates significant improvements in the traffic forecasting process, represents the first step toward future development of significantly enhanced traffic forecasting software at the SDDOT.

Significant essential improvements that are reflected in the new traffic forecasting procedure include the following:

- The six traffic analysis regions of the existing procedure have been eliminated, and traffic forecasting factors can now be produced for each South Dakota county (which closely approximate TAZs in a traffic forecasting model).
- The procedure begins with one regression analysis against VMT data to prepare it and make it directly applicable, so iterative linear regression analyses in attempts to apportion statewide VMT into the six traffic analysis regions, across functional roadway designations, and by vehicle type will no longer be necessary.
- The procedure is enhanced by using South Dakota "County Business Patterns" data to adjust VMT growth projections as necessary, and couples county population and building permits data with the assessments of the transportation planner to adjust traffic forecasts.
- Guidelines are included to allow criteria to be applied logically, verify processes, and make the procedure more adaptable to changing needs.
- Adjustments to traffic growth projections are now interactive processes based on reviews of the criteria provided by all the data prepared for the revised traffic forecasting procedure whereby useful insights are gained on adjustment suitability.
- Graphical analysis was conceived as the most expeditious means to allow rapid and direct comparative analysis of traffic growth projections and has been incorporated in the new procedure.
- Instead of one 'Commercial' vehicle category, forecasting factors are now produced for two commercial vehicle types that are essentially Class 5-9 Commercial and Class 10-13 Commercial.
- Removal of urbanized VMT in Minnehaha and Pennington Counties is no longer necessary since the new procedure analyzes historical rural/urban VMT at the county level.
- The final 20-year traffic forecasting factor array table is expanded greatly over the old factor array and can be utilized in more SDDOT operations by having extensive factors produced for counties, by various vehicle types, over broad functional roadway classifications, and by rural/urban designations.

The new traffic forecasting procedure has been developed to specifically address the statewide needs of the SDDOT and is structured with a logical decision-making process that will lend itself well to automation. The impelling reasons to proceed immediately with a software development effort to automate the new traffic forecasting procedure are to:

- Increase efficiencies and maximize time savings.
- Empower the procedure with a well-structured database and congruous applications development software.
- Minimize the possibilities for introducing errors during the procedure.
- Minimize subjective analysis to gain more objective output.
- Provide reliable integration and corresponding input paths for important SDDOT systems that include: pavement/roadway design systems, pavement management systems, and transportation project planning and prioritization systems.
- Instill consistency, uniformity, and better provisions to maintain the procedure over time (as compared to recent losses of data, loss of personnel with procedural expertise, etc.).
- Facilitate continued enhancement of the traffic forecasting procedure over time.

These concepts were key considerations throughout the development of the new traffic forecasting procedure. Further, the approach in this research project has included a concentrated focus that anticipates continual refinements to traffic forecasting practices and an eventual migration to significantly enhanced traffic forecasting software at the SDDOT.

Specific implementation recommendations that have been provided encompass all aspects of the forecasting process from initial forecasting data collection and management activities through system planning and software development activities that will be essential to implement the procedure. System planning and software design and development efforts included in these recommendations will be critical in defining a system architecture that will: (1) accommodate immediate automation of the procedure documented herein, (2) support future efforts to evaluate and potentially implement emerging traffic forecasting enhancements, and (3) facilitate future development of significantly enhanced traffic forecasting software. The conceptual enhanced SDDOT traffic forecasting software envisioned as a result of this study would take advantage of components that are already in place, supported, and maintained at the SDDOT.

SDDOT action on each of these recommendations will be essential to realize the full potential of the new forecasting procedure. Foresight to impending automation of the new procedure through software development efforts that includes careful planning for the eventual migration to significantly enhanced traffic forecasting software will ensure that the SDDOT will enjoy the benefits of a greatly improved statewide 20-year traffic forecasting procedure far into the future.

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APPENDIX A

SOUTH DAKOTA VEHICLE MILES OF TRAVEL REPORTS

SOUTH DAKOTA
VEHICLE MILES OF TRAVEL REPORT
BY COUNTY

APRIL - 1999

prepared by the

SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION
DIVISION OF PLANNING/ENGINEERING
Ph. (605)773-3278

in cooperation with the

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

URBAN MILES AND VEHICLE MILES OF TRAVEL BY COUNTY FOR HEAVY TRUCKS

STATE HIGHWAY AND LOCAL HIGHWAY SYSTEMS

--COUNTY---	FEDERAL-AID: INTERSTATE MILES	VMT	PRINCIPAL ARTERIAL MILES	VMT	MINOR ARTERIAL MILES	VMT	COLLECTOR MILES	VMT	NON-FEDERAL-AID: LOCAL CITY STREETS MILES	VMT	TOTAL URBAN MILES	VMT
AURORA												
BEADLE			12.3	1,875,801	15.1	332,058	8.3	155,444	89.4	269,642	125.1	2,632,945
BENNETT												
BON HOMME												
BROOKINGS	1.6	329,759	3.6	414,479	27.7	1,116,880	5.6	27,844	49.1	222,244	87.6	2,111,206
BROWN			12.4	4,162,240	22.6	559,271	15.1	360,215	85.1	377,905	135.2	5,459,631
BRULE												
BUFFALO												
BUTTE												
CAMPBELL												
CHARLES MIX												
CLARK												
CLAY			5.4	654,140	12.1	393,966	3.2	49,795	22.0	97,626	42.7	1,195,527
CODINGTON	0.5	65,359	6.7	2,103,440	29.7	1,138,176	8.7	181,901	92.4	358,631	138.0	3,847,507
CORSON												
CUSTER												
DAVISON	3.0	631,749	9.9	1,927,931	18.8	605,776	15.3	104,517	66.9	267,972	113.9	3,537,945
DAY												
DEUEL												
DEWEY												
DOUGLAS												
EDMUNDS												
FALL RIVER												
FAULK												
GRANT												
GREGORY												
HAAKON												
HAMLIN												
HAND												
HANSON												
HARDING												
HUGHES			8.5	1,898,939	17.3	576,275	5.0	103,644	53.3	241,197	84.1	2,820,055
HUTCHINSON												
HYDE												
JACKSON												
JERAULD												
JONES												
KINGSBURY												
LAKE			5.1	659,571	9.2	118,916	6.6	62,895	26.7	71,810	47.6	913,192
LAWRENCE	3.1	607,903	5.3	995,599	5.0	164,663	6.3	64,534	33.3	120,452	53.0	1,953,151
LINCOLN	4.0	1,816,969			9.6	332,025	10.0	83,203	8.1	6,166	31.7	2,238,363
LYMAN												
MCCOOK												
MCPHERSON												
MARSHALL												
MEADE	2.1	577,022	3.2	611,159	5.6	234,766	5.3	65,803	21.6	54,406	37.8	1,543,156
MELLETTE												
MINER												
MINNEHAHA	24.4	11,414,622	21.5	11,514,830	50.6	5,168,829	67.7	5,130,287	463.4	2,691,385	627.6	35,919,953
MOODY												
PENNINGTON	8.2	4,331,923	33.2	13,210,607	25.3	3,725,445	29.2	2,412,438	260.6	1,056,219	356.5	24,736,632
PERKINS												
POTTER												
ROBERTS												
SANBORN												
SHANNON												
SPINK												
STANLEY												
SULLY												
TODD												
TRIPP												
TURNER												
UNION	2.5	790,316			4.8	138,531	6.9	430,602	8.7	11,675	22.9	1,371,124
WALWORTH												
YANKTON			5.2	1,554,708	19.0	604,853	6.0	177,595	45.5	228,805	75.7	2,565,961
ZIEBACH												
TOTAL	49.4	20,565,622	132.3	41,583,444	272.4	15,210,430	199.2	9,410,717	1326.1	6,076,135	1979.4	92,846,348
ADT		1,141		861		153		129		13		129

05/26/99 HR156400 RURAL MILES AND VEHICLE MILES OF TRAVEL BY COUNTY FOR HEAVY TRUCKS

STATE HIGHWAY SYSTEM

	FEDERAL AID								NON-FEDERAL-AID			
COUNTY	INTERSTATE		PRINCIPAL ARTERIAL		MINOR ARTERIAL		MAJOR COLLECTOR		OTHER		TOTAL	
	MILES	VMT	MILES	VMT	MILES	VMT	MILES	VMT	MILES	VMT	MILES	VMT
AURORA	24	12,212,319			31	1,884,662	9	121,369			64	14,218,350
BEADLE			64	5,429,388	28	1,954,210					92	7,383,598
BENNETT			46	2,001,347	25	678,549					71	2,679,896
BON HOMME			39	2,612,476	59	2,628,489	12	404,685			110	5,645,650
BROOKINGS	22	13,319,860	34	3,735,800	27	1,499,359	10	322,742			93	18,877,761
BROWN			78	11,902,812	86	4,511,015					164	16,413,827
BRULE	30	14,358,252			63	3,302,743					93	17,660,995
BUFFALO					66	2,240,576					66	2,240,576
BUTTE			122	7,943,987	30	1,626,133	33	929,388			185	10,499,508
CAMPBELL			24	1,088,995	17	385,738	65	738,094			106	2,212,827
CHARLES MIX			28	2,401,900	104	5,657,385	12	90,211			144	8,149,496
CLARK			24	1,809,371	90	3,102,717					114	4,912,088
CLAY			19	3,471,090	41	3,900,176					60	7,371,266
CODINGTON	25	10,533,554	31	4,192,051	35	3,615,285	3	70,146			94	18,411,036
CORSON			87	2,590,018	79	1,914,652	26	385,805			192	4,890,475
CUSTER			90	8,824,320	91	3,541,221	28	363,308			209	12,728,849
DAVISON	15	8,797,497	19	2,368,497	2	192,766	2	86,735			38	11,445,495
DAY			39	5,618,656	49	2,462,742					88	8,081,398
DEUEL	16	6,612,502	24	1,749,959	70	4,738,274	3	67,281			113	13,168,016
DEWEY			66	2,165,229	80	2,544,924					146	4,710,153
DOUGLAS					53	3,308,459					53	3,308,459
EDMUNDS			48	4,399,489	35	1,268,699	31	398,834			114	6,067,022
FALL RIVER			95	8,866,479	4	271,009	57	712,598			156	9,850,086
FAULK			52	1,962,841	68	1,589,487					120	3,552,328
GRANT	10	3,400,467	30	2,601,548	45	2,952,370	16	317,133			101	9,271,518
GREGORY			59	3,384,632	40	1,600,949	45	601,068			144	5,586,649
HAAKON			85	2,132,732	37	1,254,391					122	3,387,123
HAMLIN	6	2,616,684	18	1,516,017	53	2,647,728	13	249,617			90	7,030,046
HAND			31	2,242,737	48	2,097,277	30	219,227			109	4,559,241
HANSON	19	11,298,722			28	1,021,879	39	1,244,165			86	13,564,766
HARDING			54	2,391,952	30	429,123	80	959,393			164	3,780,468
HUGHES			39	2,908,750	38	1,661,316	8	320,224			85	4,890,290
HUTCHINSON			47	3,767,170	77	4,426,538					124	8,193,708
HYDE			18	1,150,220	60	1,816,046	7	35,003			85	3,001,269
JACKSON	50	19,121,578	13	634,670	122	4,022,558	50	263,138			235	24,041,944
JERAULD					48	2,448,842	2	56,920			50	2,505,762
JONES	36	14,367,772	12	566,301		52,556	36	410,232			84	15,396,861
KINGSBURY			61	4,270,715	24	1,444,832					85	5,715,547
LAKE			35	3,758,887	10	729,323			1	6,079	46	4,494,289
LAWRENCE	25	16,210,517	74	9,515,646	31	2,951,582	3	142,704			133	28,820,449
LINCOLN	27	26,376,265	14	2,151,656	54	4,344,752	11	1,061,249			106	33,933,922
LYMAN	52	21,755,258	20	1,587,592	65	2,777,362	84	872,278			221	26,992,490
MCCOOK	24	14,848,702	25	943,579	25	993,979	31	1,379,845			105	18,166,105
MCPHERSON					82	2,412,643	32	277,760			114	2,690,403
MARSHALL					94	4,127,322					94	4,127,322
MEADE	23	24,589,202	143	4,684,933	31	1,794,291					197	31,068,426
MELLETTE			24	1,815,400	52	890,840	47	279,790			123	2,986,030
MINER			12	400,547	47	2,616,213					59	3,016,760
MINNEHAHA	45	37,275,851			94	12,983,841	27	2,442,343			166	52,702,035
MOODY	24	17,553,212	7	863,783	38	3,575,977					69	21,992,972
PENNINGTON	65	36,688,925	72	11,262,468	125	9,523,579	10	382,148			272	57,857,120
PERKINS			19	840,833	139	3,275,839					158	4,116,672
POTTER			61	2,532,794	23	956,831	12	68,768			96	3,558,393
ROBERTS	47	13,302,235	21	1,704,533	90	4,414,741	17	502,874			175	19,924,383
SANBORN			31	2,590,887	15	1,322,820	6	165,317			52	4,079,024
SHANNON			54	3,533,043	5	649,958		934			59	4,183,935
SPINK			79	6,068,707	104	3,791,409	12	201,986			195	10,062,102
STANLEY			66	4,217,039	29	980,131	60	387,522			155	5,584,692
SULLY			24	1,300,261			32	329,258			56	1,629,519
TODD			86	5,727,404			9	198,549			95	5,925,953
TRIPP			39	3,695,956	69	2,760,662	44	620,466			152	7,077,084
TURNER					84	5,321,766					84	5,321,766
UNION	45	30,320,651	1	150,336	64	4,034,361	1	57,004			111	34,562,352
WALWORTH			62	4,480,278	28	593,090	38	622,103			128	5,695,471
YANKTON			41	6,092,298	24	1,717,355	17	1,847,853			82	9,657,506
ZIEBACH			33	1,165,773	48	702,203	25	334,233			106	2,202,209
TOTAL	630	355,560,025	2,539	193,786,782	3,353	166,938,545	1,135	21,542,300	1	6,079	7,658	737,833,731
ADT		1,546		209		136		52		17		264

RURAL MILES AND VEHICLE MILES OF TRAVEL BY COUNTY FOR HEAVY TRUCKS

LOCAL HIGHWAY SYSTEM

--COUNTY---	--- FEDERAL AID ---- MAJOR ------COLLECTOR----- MILES	VMT	------- NON-FEDERAL-AID ------- MINOR ------COLLECTOR----- MILES	VMT	-----LOCAL ROADS----- MILES	VMT	-------TOTAL--------- MILES	VMT	TOTAL ------ALL RURAL------ MILES	VMT
AURORA	185	1,056,554	89	25,817	910	159,335	1,184	1,241,706	1,248	15,460,056
BEADLE	265	2,043,346	108	45,983	1,554	291,053	1,927	2,380,382	2,019	9,763,980
BENNETT	90	1,032,752	153	50,844	513	98,613	756	1,182,209	827	3,862,105
BON HOMME	115	1,166,169	51	27,262	825	295,582	991	1,489,013	1,101	7,134,663
BROOKINGS	195	3,434,970	108	83,780	1,064	383,520	1,367	3,902,270	1,460	22,780,031
BROWN	415	5,328,625	116	136,684	2,288	506,792	2,819	5,972,101	2,983	22,385,928
BRULE	130	1,398,039	111	56,495	875	286,976	1,116	1,741,510	1,209	19,402,505
BUFFALO	88	359,995			226	26,810	314	386,805	380	2,627,381
BUTTE	167	830,562	89	25,410	564	243,338	820	1,099,310	1,005	11,598,818
CAMPBELL	75	432,151	107	62,155	687	91,203	869	585,509	975	2,798,336
CHARLES MIX	215	2,071,773	114	57,625	1,404	268,258	1,733	2,397,656	1,877	10,547,152
CLARK	189	1,230,300	137	68,045	1,123	197,110	1,449	1,495,455	1,563	6,407,543
CLAY	133	1,964,198	61	73,086	550	184,175	744	2,221,459	804	9,592,725
CODINGTON	189	2,299,010	110	66,034	871	235,374	1,170	2,600,418	1,264	21,011,454
CORSON	226	707,740	134	44,519	1,379	147,517	1,739	899,776	1,931	5,790,251
CUSTER	161	642,692	110	45,797	405	131,832	676	820,321	885	13,549,170
DAVISON	155	2,135,564	37	19,641	579	185,742	771	2,340,947	809	13,786,442
DAY	197	2,025,194	242	160,943	1,241	321,985	1,680	2,508,122	1,768	10,589,520
DEUEL	150	1,660,309	58	37,581	766	203,995	974	1,901,885	1,087	15,069,901
DEWEY	192	899,766	92	52,690	840	100,809	1,124	1,053,265	1,270	5,763,418
DOUGLAS	124	1,352,074	46	35,687	642	153,674	812	1,541,435	865	4,849,894
EDMUNDS	214	1,051,536	76	26,700	1,052	150,272	1,342	1,228,508	1,456	7,295,530
FALL RIVER	94	544,762	133	64,482	513	177,119	740	786,363	896	10,636,449
FAULK	120	812,880	140	47,385	851	124,050	1,111	984,315	1,231	4,536,643
GRANT	193	2,196,488	77	45,196	937	361,789	1,207	2,603,473	1,308	11,874,991
GREGORY	142	749,647	82	28,600	913	186,381	1,137	964,628	1,281	6,551,277
HAAKON	145	360,284	148	56,997	616	108,471	909	525,752	1,031	3,912,875
HAMLIN	133	1,358,315	59	42,143	691	181,526	883	1,581,984	973	8,612,030
HAND	246	1,495,105	106	45,293	1,286	167,059	1,638	1,707,457	1,747	6,266,698
HANSON	90	885,364	54	28,733	609	162,675	753	1,076,772	839	14,641,538
HARDING	214	626,559	112	25,398	564	51,332	890	703,289	1,054	4,483,757
HUGHES	130	881,549	69	24,089	532	79,248	731	984,886	816	5,875,176
HUTCHINSON	222	4,424,495	79	57,402	1,181	330,249	1,482	4,812,146	1,606	13,005,854
HYDE	95	410,562	118	33,589	463	55,333	676	499,484	761	3,500,753
JACKSON	146	621,005	66	17,195	596	67,853	808	706,053	1,043	24,747,997
JERAULD	141	772,867	14	6,702	636	144,743	791	924,312	841	3,430,074
JONES	94	381,408	128	30,081	412	42,486	634	453,975	718	15,850,836
KINGSBURY	186	1,795,572	141	99,994	1,125	308,277	1,452	2,203,843	1,537	7,919,390
LAKE	187	2,464,105	58	57,095	784	270,930	1,029	2,792,130	1,075	7,286,419
LAWRENCE	102	1,481,852	89	82,399	368	242,971	559	1,807,222	692	30,627,671
LINCOLN	174	7,114,358	73	138,880	823	409,035	1,070	7,662,273	1,176	41,596,195
LYMAN	100	717,858	102	34,239	1,004	129,248	1,206	881,345	1,427	27,873,835
MCCOOK	138	2,304,312	74	35,765	851	255,631	1,063	2,595,708	1,168	20,761,813
MCPHERSON	162	599,977	152	66,427	793	216,479	1,107	882,883	1,221	3,573,286
MARSHALL	203	1,731,972	104	48,987	849	242,841	1,156	2,023,800	1,250	6,151,122
MEADE	373	1,752,972	265	98,581	868	125,170	1,506	1,976,723	1,703	33,045,149
MELLETTE	63	233,375	111	32,009	495	66,267	669	331,651	792	3,317,681
MINER	154	1,106,871	48	19,886	837	227,042	1,039	1,353,799	1,098	4,370,559
MINNEHAHA	236	7,521,459	114	167,309	1,068	637,034	1,418	8,325,802	1,584	61,027,837
MOODY	162	2,278,125	70	48,794	721	305,078	953	2,631,997	1,022	24,624,969
PENNINGTON	414	7,305,120	167	132,548	946	339,347	1,527	7,777,015	1,799	65,634,135
PERKINS	220	903,555	357	80,003	887	165,900	1,464	1,149,458	1,622	5,266,130
POTTER	133	700,490	36	12,982	790	164,437	959	877,909	1,055	4,436,302
ROBERTS	241	3,310,283	214	146,957	1,271	356,804	1,726	3,814,044	1,901	23,738,427
SANBORN	152	1,242,529	39	16,743	762	175,902	953	1,435,174	1,005	5,514,198
SHANNON	228	3,213,094	56	34,613	591	79,522	875	3,327,229	934	7,511,164
SPINK	245	1,893,658	216	68,678	2,090	350,607	2,551	2,312,943	2,746	12,375,045
STANLEY	128	256,550			434	79,405	562	335,955	717	5,920,647
SULLY	177	944,874	67	34,355	732	88,613	976	1,067,842	1,032	2,697,361
TODD	155	1,713,742	63	19,032	676	169,804	894	1,902,578	989	7,828,531
TRIPP	202	1,058,056	193	83,925	1,365	245,354	1,760	1,387,335	1,912	8,464,419
TURNER	158	3,453,574	47	37,764	971	477,008	1,176	3,968,346	1,260	9,290,112
UNION	123	3,568,030	38	113,007	655	325,421	816	4,006,458	927	38,568,810
WALWORTH	97	532,280	68	25,984	657	214,302	822	772,566	950	6,468,037
YANKTON	159	2,189,334	37	38,770	643	251,144	839	2,479,248	921	12,136,754
ZIEBACH	184	1,176,110	76	20,189	622	58,065	882	1,254,364	988	3,456,573
TOTAL	11,331	116,208,696	6,609	3,551,978	55,836	13,881,917	73,776	133,642,591	81,434	871,476,322
ADT		28		1		1		5		29

HEAVY TRUCKS ARE 2-AXLE, 6-TIRE TRUCKS OR LARGER

URBAN MILES AND VEHICLE MILES OF TRAVEL BY COUNTY FOR HEAVY TRUCKS

LOCAL HIGHWAY SYSTEM

--COUNTY---	FEDERAL-AID ----INTERSTATE---- MILES	VMT	PRINCIPAL -----ARTERIAL----- MILES	VMT	MINOR -----ARTERIAL----- MILES	VMT	----COLLECTOR----- MILES	VMT	--NON-FEDERAL-AID-- LOCAL CITY STREETS MILES	VMT	----TOTAL URBAN----- MILES	VMT
AURORA												
BEADLE			5.3	599,465	13.1	231,192	8.3	155,444	89.4	269,642	116.1	1,255,743
BENNETT												
BON HOMME												
BROOKINGS					23.9	727,296	5.6	27,844	49.1	222,244	78.6	977,384
BROWN			5.0	784,733	22.6	559,271	15.1	360,215	85.1	377,905	127.8	2,082,124
BRULE												
BUFFALO												
BUTTE												
CAMPBELL												
CHARLES MIX												
CLARK												
CLAY			4.3	569,181	9.0	153,818	3.2	49,795	22.0	97,626	38.5	870,420
CODINGTON			0.8	107,795	24.7	598,910	3.3	73,097	92.4	358,631	121.2	1,138,433
CORSON												
CUSTER												
DAVISON			1.9	675,090	17.7	551,012	15.3	104,517	66.9	267,972	101.8	1,598,591
DAY												
DEUEL												
DEWEY												
DOUGLAS												
EDMUNDS												
FALL RIVER												
FAULK												
GRANT												
GREGORY												
HAAKON												
HAMLIN												
HAND												
HANSON												
HARDING												
HUGHES					15.5	492,524	5.0	103,644	53.3	241,197	73.8	837,365
HUTCHINSON												
HYDE												
JACKSON												
JERAULD												
JONES												
KINGSBURY												
LAKE			2.1	177,373	9.2	118,916	6.6	62,895	26.7	71,810	44.6	430,994
LAWRENCE			2.8	590,333	5.0	164,663	6.3	64,534	33.3	120,452	47.4	939,982
LINCOLN					7.0	219,602	10.0	83,203	8.1	6,166	25.1	308,971
LYMAN												
MCCOOK												
MCPHERSON												
MARSHALL												
MEADE					4.4	86,328	5.3	65,803	21.6	54,406	31.3	206,537
MELLETTE												
MINER												
MINNEHAHA			5.1	3,577,860	45.8	4,946,719	67.7	5,130,287	463.4	2,691,385	582.0	16,346,251
MOODY												
PENNINGTON			6.2	2,626,408	19.7	3,011,511	27.2	2,312,238	260.6	1,056,219	313.7	9,006,376
PERKINS												
POTTER												
ROBERTS												
SANBORN												
SHANNON												
SPINK												
STANLEY												
SULLY												
TODD												
TRIPP												
TURNER												
UNION					4.8	138,531	6.9	430,602	8.7	11,675	20.4	580,808
WALWORTH												
YANKTON			0.2	8,671	17.7	495,045	6.0	177,595	45.5	228,805	69.4	910,116
ZIEBACH												
TOTAL			33.7	9,716,909	240.1	12,495,338	191.8	9,201,713	1326.1	6,076,135	1791.7	37,490,095
ADT				790		143		131		13		57

05/26/99 HR156400 URBAN MILES AND VEHICLE MILES OF TRAVEL BY COUNTY FOR HEAVY TRUCKS

STATE HIGHWAY SYSTEM

--COUNTY---	FEDERAL-AID ----INTERSTATE---- MILES	VMT	PRINCIPAL -----ARTERIAL----- MILES	VMT	MINOR -----ARTERIAL----- MILES	VMT	----COLLECTOR----- MILES	VMT	--NON-FEDERAL-AID-- LOCAL CITY STREETS MILES	VMT	----TOTAL URBAN----- MILES	VMT
AURORA												
BEADLE			7.0	1,276,336	2.0	100,866					9.0	1,377,202
BENNETT												
BON HOMME												
BROOKINGS	1.6	329,759	3.6	414,479	3.9	389,584					9.1	1,133,822
BROWN			7.4	3,377,507							7.4	3,377,507
BRULE												
BUFFALO												
BUTTE												
CAMPBELL												
CHARLES MIX												
CLARK												
CLAY			1.1	84,959	3.1	240,148					4.2	325,107
CODINGTON	0.5	65,359	5.9	1,995,645	5.0	539,266	5.4	108,804			16.8	2,709,074
CORSON												
CUSTER												
DAVISON	3.0	631,749	8.0	1,252,841	1.1	54,764					12.1	1,939,354
DAY												
DEUEL												
DEWEY												
DOUGLAS												
EDMUNDS												
FALL RIVER												
FAULK												
GRANT												
GREGORY												
HAAKON												
HAMLIN												
HAND												
HANSON												
HARDING												
HUGHES			8.5	1,898,939	1.8	83,752					10.3	1,982,691
HUTCHINSON												
HYDE												
JACKSON												
JERAULD												
JONES												
KINGSBURY												
LAKE			3.0	482,198							3.0	482,198
LAWRENCE	3.1	607,903	2.5	405,266							5.6	1,013,169
LINCOLN	4.0	1,816,969			2.6	112,422					6.6	1,929,391
LYMAN												
MCCOOK												
MCPHERSON												
MARSHALL												
MEADE	2.1	577,022	3.2	611,159	1.2	148,438					6.5	1,336,619
MELLETTE												
MINER												
MINNEHAHA	24.4	11,414,622	16.4	7,936,970	4.8	222,109					45.6	19,573,701
MOODY												
PENNINGTON	8.2	4,331,923	27.0	10,584,199	5.6	713,934	2.0	100,200			42.8	15,730,256
PERKINS												
POTTER												
ROBERTS												
SANBORN												
SHANNON												
SPINK												
STANLEY												
SULLY												
TODD												
TRIPP												
TURNER												
UNION	2.5	790,316									2.5	790,316
WALWORTH												
YANKTON			5.0	1,546,037	1.3	109,808					6.3	1,655,845
ZIEBACH												
TOTAL	49.4	20,565,622	98.6	31,866,535	32.4	2,715,091	7.4	209,004			187.8	55,356,252

APPENDIX B

SDDOT 20-YEAR TRAFFIC FORECASTING FACTORS: ARRAY TABLE

SDDOT 20-YEAR TRAFFIC FORECASTING FACTORS: ARRAY TABLE
1998-2018

	Interstate	Class 5-9 Commercial	Class 10-13 Commercial	Arterials	Class 5-9 Commercial	Class 10-13 Commercial	Other	Urban Interstate	Class 5-9 Commercial	Class 10-13 Commercial	Urban Arterials	Class 5-9 Commercial	Class 10-13 Commercial	Urban Other
Aurora:	1.467	1.400	2.754	1.328	1.374	2.980	0.854							
Beadle:				0.934	0.561	2.800	1.068				1.277	1.018	3.004	0.640
Bennett:				1.060	1.000	2.845	1.009							
Bon Homme:				1.289	1.215	2.900	1.114							
Brookings:	1.645	1.576	2.824	1.117	0.899	2.857	1.335	1.004	2.040	3.029	1.075	0.210	2.978	2.073
Brown:				1.231	1.175	2.876	1.391				1.437	1.436	3.044	1.030
Brule:	1.345	1.284	2.754	1.363	1.583	2.996	1.571							
Buffalo:				1.267	1.457	2.983	0.613							
Butte:				1.169	1.076	2.847	1.561							
Campbell:				0.903	0.959	2.855	1.280							
Charles Mix:				1.493	1.501	2.949	1.294							
Clark:				1.102	1.112	2.895	0.932							
Clay:				1.316	1.286	2.925	1.398				1.483	0.765	2.933	0.850
Codington:	1.722	1.659	2.817	1.344	1.295	2.901	1.016	2.321	2.096	4.954	1.437	0.834	2.913	1.488
Corson:				0.918	0.873	2.863	0.873							
Custer:				1.226	1.047	2.866	1.145							
Davison:	1.476	1.294	2.740	1.207	0.955	2.824	1.575	1.496	1.507	2.700	1.204	0.071	2.934	1.082
Day:				1.416	1.207	2.919	1.321							
Deuel:	1.564	1.514	2.799	1.146	1.079	2.920	1.430							
Dewey:				1.108	1.026	2.909	0.994							
Douglas:				1.208	1.222	2.990	1.107							
Edmunds:				1.241	1.093	2.856	1.314							
Fall River:				1.484	1.223	2.897	1.360							
Faulk:				1.155	1.426	2.916	0.573							
Grant:	1.571	1.706	2.850	1.043	0.972	2.882	1.388							
Gregory:				1.269	1.309	2.893	1.112							
Haakon:				1.262	0.856	2.841	1.111							

APPENDIX C

INDIVIDUALS INTERVIEWED AS A PART OF SD1999-04

Jeff Brosz	SDDOT
Chuck Fergen	SDDOT
Gill Hedman	SDDOT
Mark Hoines	FHWA
Rocky Hook	SDDOT
Tom Johnson	SDDOT
John Noyes	SDDOT
Daris Ormesher	SDDOT
Ben Orsbon	SDDOT
Evelyn Putzier	SDDOT
Richard Ray	SD Department of Revenue
Hal Rumpca	SDDOT
Daniel Strand	SDDOT
Dave Voeltz	SDDOT
Dennis Winters	SDDOT