Final Report

Operational and Safety Review

Highway 101, Mount Uniacke to Bridgetown

Nova Scotia Department of
Transportation and Public Works

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Executive Summary

Background

The 140 km long Study Section of Highway 101 from Mount Uniacke to Bridgetown is primarily a two lane controlled access highway with secondary road access via interchanges, except for one at-grade intersection at Ben Jackson Road. It has been designated as part of the National Highway System, making it eligible for federal cost sharing.

The eastern part of the Study Section provides the primary transportation link for Valley industries to the port of Halifax, Central and Eastern Nova Scotia, and other Canadian markets. It also provides for commuter travel for many who travel daily from the Kentville/Wolfville/Windsor areas to work in the Halifax Regional Municipality (HRM). In recent years 'reverse' commuting has also become common as people travel from HRM to work in Valley communities. West of Coldbrook, Highway 101 provides for long distance through traffic from HRM to Western Nova Scotia and is also heavily utilized by intra-Valley travel between mid-Valley towns and the commercial/retail and university areas of Kentville/Wolfville.

Due to increasing traffic volumes and numerous fatal collisions in recent years, the Nova Scotia Department of Transportation & Public Works (TPW) plans to upgrade the corridor between Mount Uniacke and Coldbrook, a distance of approximately 75 km, to a four lane, divided, wide median facility. The upgrading will be phased with timing dependent upon the allocation of available funding from the Federal and Provincial governments, as well as satisfaction of environmental regulations.

The reality of the current and foreseeable economic situation is that even the 20 km first section from Mount Uniacke to the existing short four lane section at Ellershouse may not be completed for several years, and the remaining 55 km to Coldbrook will probably take five to ten years to complete.

TPW requested the ***Highway 101 Operational and Safety Review*** to develop a traffic management and improvement plan that will ensure satisfactory safety performance levels will be maintained on the two lane sections until the roadway is upgraded to a four lane divided facility.

Study Objectives

The stated ***primary objective*** of the Study was:

> "*. . .to complete a comprehensive operational and safety review of Highway 101, from Mount Uniacke to Bridgetown, . . .to ensure preservation of a level of service greater than or equal to C and preservation of an acceptable level of safety performance.*"

Study Team

Atlantic Road & Traffic Management (*AR&TM*) has completed an operational and safety review of the Study Section. The following multi-disciplinary team has worked to complete this project:

- Bruce Atwell, P. Eng., *BV Atwell Engineering*;
- Dr. Bob Dewar, *Western Ergonomics, Inc.*;
- Bruce Higgins, P. Eng., *CBCL Limited*;
- Randy Linzel, P. Eng., *Leadership by Design*;
- Greg O'Brien, EIT, *AR&TM*; and
- Ken O'Brien, P. Eng., *AR&TM*.

Typical Highway 101 Characteristics

Highway 101 typically has the following characteristics throughout the Study Section:

- It is a two lane controlled access highway, except for two short sections (0.7 km at Ellershouse and 3.0 km at Avonport) which have four lanes with a wide median.
- The highway was designed and constructed in Imperial units with an approximate 70 mph design speed.
- The speed limit is 100 km/h, except for a 2.6 km section posted at 90 km/h at the Avon River Causeway between Windsor and Falmouth.
- Except for the at-grade intersection at Ben Jackson Road (Exit 8A), all access to the study section is by interchanges and all crossing roads are grade separated.
- The approximately 75 km from Mount Uniacke to Trunk 1 at Coldbrook passes through rolling terrain. In addition to the two four lane sections, there are seven westbound and eight eastbound marked passing (climbing) lane sections.
- The approximately 64 km from Trunk 1 at Coldbrook to Trunk 1 at Bridgetown consists of flat terrain and does not have any auxiliary climbing lane sections.

Public Concerns

Discussions with 'Twin to Win' representatives, truck drivers and focus groups have provided lengthy lists of public concerns which are summarized in the following paragraphs.

A major public concern is that volumes are so high that any cross centerline movement has a high probability of a head-on crash. Fatal collisions, which are often head-on crashes, are creating trauma to attending professionals who often know the victims. Many people are reluctant to become volunteer firemen because they do not want to attend highway crash scenes.

All groups interviewed were concerned with shoulder drop-offs, winter road maintenance, hydroplaning, pavement markings (especially at the end of climbing lanes), inattentive and aggressive drivers, and the need for passing lanes between Coldbrook and Bridgetown. Specific mention was made concerning winter road conditions between Mount Uniacke and Windsor with regard to frequent and rapid changes in weather. It was concluded that there are several micro-climates throughout this section of highway that drivers must be aware of so they can adjust driving speeds in accordance with road conditions.

RCMP Concerns

Interviews with RCMP officers from the Bridgetown, Kings, and Windsor detachments provided a listing of many concerns with regard to the safety of the Study Section.

While they consider Highway 101, for the most part, to be a 'good' two lane controlled access highway, there were a number of specific highway related concerns:

- Poor shoulders have been involved in many collisions.
- 'Downhill' passing in the center climbing lane is a problem.
- Ben Jackson intersection should be eliminated.
- There is a need for better traffic lines that will last longer.
- When a winter storm is imminent, salt trucks should be prepared to act immediately so that there is no delay in preventing or reducing slippery road conditions.

Since driver inattention and fatigue are involved in many collisions, the officers thought that rest areas would be beneficial where there are long sections of highway between interchanges. Many Highway 101 drivers are reported to be reckless and aggressive, and high travel speeds are a major concern. Additional highway patrols, new speed enforcement methods, and graduated speeding fines would help reduce speeding and improve driving behaviour.

Current Traffic Volumes

Annual Average Daily Traffic (AADT) volumes vary from 13500 vpd towards the easterly end of the Study Section to 3300 vpd at the west end. Trucks account for 7% to 8% in the 'high' volume sections east of Exit 14 to about 11% in the 'lower' volume sections to the west.

Design Hourly Volume is 11% of AADT

Volumes vary by season of the year, day of the week and hour of the day. Since it is not economically practical to design roadways for the highest hour of the year, a 'design hourly volume' (DHV) is needed for each road section so that existing and future levels of service, and appropriate design criteria can be determined. Normally, the 30th or 50th highest hourly volume of the year has been used as the DHV. For ease of calculation, the DHV is generally indicated as a percentage of AADT volume, usually between 10% and 14%. From a review of volumes for the various sections, it was determined that the design hourly volume would be assumed to be 11% of the AADT throughout this Study.

Historical Traffic Volume Growth Rates

TPW has maintained traffic count records on Highway 101 since the first sections of road opened in 1968. Regression analyses of the historical AADT data for each of the 20 sections of highway in the Study Section indicate linear growth with high correlation factors ($R^2 = 0.90$ to $R^2 = 0.95$). Growth rate equations were prepared for each section. Volumes towards the eastern end of the Study Section are expected to grow at about 300 vpd per year, while volumes towards the western end will have a lower growth rate of about 125 vpd per year.

Future AADT and Design Hourly Volumes

AADT volumes for 2000 to 2020 were projected using the growth rate equations and future design hourly volumes were estimated based on the assumed 11% of AADT volume. If historical growth rates are sustained during the next twenty years, 2020 AADT volumes of 20000 are expected on several highway sections between Mount Uniacke and Coldbrook. AADT's of this magnitude mean that daily volumes of 22000 to 27000 will be common.

Level of Service

The Level of Service (LOS) objective of the Study is to 'ensure preservation of a level of service greater than or equal to C' to horizon year 2020.

The LOS analysis indicated that currently all two lane sections between Mount Uniacke and Coldbrook experience LOS 'E', while sections west of Coldbrook achieve LOS 'C' and 'B'. In order to achieve LOS 'C' during 2020, all sections east of Kingston will require four lanes. Sections west of Kingston will continue to achieve LOS 'C' for projected 2020 traffic conditions.

Collision History - 1990 to 1999

There were 1410 reported collisions on the 140 km Study Section during the ten years 1990 to 1999, including 909 property damage only (PDO), 385 personal injury, 74 incapacitating serious injury, and 42 fatal collisions.

The 42 fatal collisions included two pedestrian collisions, eight single vehicle collisions and 32 involving two or more vehicles. Of the multi-vehicle collisions, 28 involved vehicles traveling in opposite directions (cross centerline) and three were classified as 'right angle'. There were 55 victims, including two pedestrians, 18 passengers and 35 drivers.

Although a high proportion of the fatal collisions occurred during ideal conditions of weather, and road surface and light conditions, there were still many collisions that occurred during darkness or on snow / ice / slush or wet pavement.

Human (driver or pedestrian) condition or action accounted for 86% of the contributing factors for fatal collisions. Human factors such as, 'driver inattention', 'had been drinking / impaired', 'fell asleep', 'inexperience', 'failure to yield right-of-way' and 'driving too fast for conditions / speeding' accounted for 34 of the 42 fatal collisions. Other factors were vehicle condition (2%), animals / deer (5%), and road conditions (7%). This data is comparable to other collision research that has concluded that over 90 percent of all road accidents involve human error, and that only a small proportion of collisions can be attributed to vehicle defects or faults in road design or maintenance.

Comparison of Highway 101 Collision Rates with Those for Other 100 Series Highways

The safety objective of the Study was 'preservation of an acceptable level of safety performance', by achieving a collision rate equal to or better than that for all provincial two lane controlled access highways.
Highway 101 PDO, injury and total rates are much lower than the average rates for all provincial two lane controlled access highways and the fatal rate for the Study Section is almost equal to the average published fatal rate.

Study Section PDO, injury and total rates are also comparable to those for all four lane divided highways in the Province. However, compared to the safety of a four lane highway, the ten year fatal collision rate is considerably higher than that for the average four lane divided wide median highways in Nova Scotia. While fatal collisions do occur on four lane highways, they usually are single vehicle crashes with a single fatality. Collisions on Highway 101, on the other hand, are usually cross centerline, head-on crashes, often having multiple fatalities.

Comparison of Highway 101 Collision Rates to Rates for Other Highways

Highway Class	Years	Collision Rates per HMVK by Severity			
		PDO	Injury	Fatal	TOTAL
Highway 101 Study Section	1990-99	24.8	12.5	1.1	38.5
Highway 101 Study Section	1994-98	22.2	11.9	1.1	35.2
All two lane controlled access 100 series highways	1994-98	35.7	17.0	1.0	53.7
All four lane divided wide median highways	1994-98	23.9	10.5	0.3	34.7

A sensitivity or quality control analysis determined that none of the highway sections in the Study Section can be identified as having safety performance that compares unfavorably with the average for similar class (two lane controlled access) highways.

Highway 101 Difference

If Highway 101 PDO, injury and total rates are better than those for all two lane controlled access highways, and the fatal rates are comparable, how is Highway 101 different?

The length and AADT volumes of the eastern half of the Study Section, make it unique in Nova Scotia. The AADT volumes on the 75 km segment between Mount Uniacke and Coldbrook are in excess of 10000 vpd, often with weekday average volumes of 14000 to 15000 vpd. There has never been a section of two lane controlled access highway so long and with such a high volume in Nova Scotia.

Highway 101 provides transportation services for industries, many of which rely on 'just-in-time' delivery of goods to reduce storage and inventory costs. Also, many commuters, who 'must' travel regardless of weather and road conditions, use the highway every day.

Although, at first glance, Highway 101 appears to be 'like' other 100-series controlled access two lane highways, the above factors indicate that much of the Study Section is a unique and challenging 'study' in traffic operations and highway safety performance.

Under 'normal' conditions of highway infrastructure upgrading, there is a high probability that twinning would have been completed to Ellershouse or

Windsor, with work now scheduled to complete twinning to Coldbrook. Rural primary arterial controlled access highways should generally be upgraded to four lane divided highways before volumes reach 10000 AADT.

Development of a Traffic Management and Improvement Plan

Completion of a four lane divided wide median highway is the long term solution for the level of service and fatal collision concerns of the Study Section. However, there are many changes that could be implemented that will collectively improve the safety of the two lane highway until twinning can be achieved. The Study Team considered the four E's of traffic safety - Ergonomics (Human Factors), Education, Engineering and Enforcement - in determination of an improvement strategy. The study included review of human factors, engineering design and highway maintenance evaluations, and consultation to determine public and police concerns.

Ergonomics (Human Factors)

Numerous factors must be considered in determining the safety of a highway. These factors include traffic volume, vehicle mix (proportion of trucks, RVs, and cars), adequacy of traffic control devices, proportion of unfamiliar drivers, weather conditions, and highway geometry (lane and shoulder width, median width, slope of the median, number of lanes, lane separation, horizontal and vertical curves, sight distance, number and design of intersections or interchanges).

The driving task involves three main components - ***driver***, ***vehicle*** and ***road/environment***. Significant improvements have occurred with the last two, but human abilities and limitations have changed little over the centuries.

Drivers often have difficulty processing all the information they require while driving. This limitation is reflected in the conclusion of one researcher that the driver is an "outdated human with stone-age characteristics and performance who is controlling a fast, heavy machine in an environment packed with unnatural, artificial signs and signals."

Expectancy relates to a driver's readiness to respond to conditions, situations, events and information. It influences the speed and accuracy of information processing, and is one of the more important driver-related characteristics in the design and operation of highways. The highway itself conveys more information to its users than any other single source. Drivers operate with a set of expectancies. For example, freeway exits will be on the right side of the roadway and advance warning will be given of hazards on the road. If these expectancies are violated there is an increase in driver perception-reaction time, more driver errors and the potential for an accident.

Education

The most frequent contributing factors to collisions are related to driver behaviour or condition and decision making - inattention/distraction, fell asleep/fatigue and speed too fast for conditions. Driver factors (risky behaviour, condition and faulty decision making) can be addressed through education and enforcement campaigns. Graduated licensing, such as that used in Nova Scotia, with an emphasis on the human factors that contribute to accidents, is a beneficial educational phase for newly licenced drivers.

Engineering

Design Speed - The vertical and horizontal alignments appear to be designed in accordance with applicable standards at the time, with a margin of 10 mph (or over 15 km/h) between the design speed and the posted speed, at the time the highway was designed and constructed. However, *revisions to the standards for vertical curves means that the vertical alignment design would now be considered appropriate for approximately the posted speed of 100 km/h only.*

It appears that the vertical alignment will govern the overall design speed in the rolling terrain. Therefore, it has been concluded that by current guidelines **design speed of the alignment is generally 100 km/h from Exits 3 to 14, and 110 km/h from Exits 14 to 20.**

Cross Section - Travel lane widths of 3.7 m [12 feet], consistent with both historical and current design guidelines, are provided throughout the Study Section. The shoulder width is considered deficient where it is less than 3m [10 feet], except at bridge structures and their immediate approaches. While the Study Section generally has 3 m shoulders throughout, narrow shoulders occur at several areas (representing about 5 km total) typically where there are high embankments with guide rail.

Intersections - The only intersection on the Study Section, the Ben Jackson Road (Exit 8A) intersection is functionally inappropriate and should be eliminated.

Interchanges - The most common interchange type in Nova Scotia is the diamond interchange which is readily understood by drivers. The series of interchanges from Exit 3 to Exit 9 is inconsistent in design configuration, and several substandard ramps are likely to be beyond driver expectations and may 'surprise' drivers unfamiliar with the area. Eastbound exit ramps at Exit 5A and Exit 9 have unorthodox designs with slow 30 km/h or 40 km/h posted ramp speeds. The Exit 9 ramp has the greatest potential to betray expectations since an eastbound motorist traveling the length of the Study Section would have passed by ten diamond interchanges with high speed exit ramps. The Exit 8 interchange was constructed utilizing the two lane Halfway River bridge, and as such, does not have an adequate westbound acceleration lane. These three areas should have preliminary design completed for the future alignment of the four lane highway and interchanges. This would then permit selected interim improvements which would be consistent with the four lane highway design.

Eastbound 85th percentile travel speeds vary from 109 to 114 km/h throughout the Study Section. Westbound speeds are consistently higher and vary from 112 to 117 km/h. It was noted that up to 80% of drivers exceed the legal 100 km/h speed limit at all sample locations. Also, generally, more than 22% exceed 110 km/h; more than 12% exceed 115 km/h; and more than 4 % exceed 120 km/h. While there is no readily available historical data for direct comparison, it is believed that traffic speed has increased over the years.

As indicated above, revisions in design guidelines, and deficiencies noted in the roadway have effectively reduced the "design speed" of the roadway. The combined effect of increased operating speed and decreases in design speed of the roadway now means that probably the majority of traffic now exceeds what would likely be deemed a "safe" design speed of the highway. There is a definite need to reduce the travel speeds on the Study Section.

Drivers do not necessarily recognize geometric design features which should cause them to reduce their speed. Despite improvements in vehicles, the design speed of the roadway is basically restricted by human perception and reaction and the geometric features of the road. However, it is evident that the widely assumed concept that the roadway is designed for the large majority (say 85%) of driving speeds, and that there is a comfortable margin between the average traveling speed and the design speed, is not valid. The obvious inference, of course, is that when a tolerance for highway enforcement is added to the speed limit, speeders are not merely disregarding the speed limit but almost certainly exceeding the design speed of the highway.

Enforcement

While there are 91 approved highway patrol positions throughout the Province, only about 60 of these are actually assigned to highway patrol. Each of the three RCMP detachments responsible for patrolling the Study Section is 'missing' at least one approved highway patrol position. Additional police presence and speed enforcement are required to reduce prevailing travel speeds and to generally promote safe driving habits. The reinstatement of the 'missing' highway patrol positions would be a 'start', however, additional enforcement funding will also be needed. Four hour blocks of paid overtime would be a cost effective way to overcome staff shortages.

Highway Maintenance

The highway maintenance evaluation involved review of ARAN (Automated Road ANalysis) vehicle data, including video logs, and ride quality and wheel track rut depth files. On-site evaluation was completed for the entire Study Section and interviews were held with appropriate TPW staff.

It was generally concluded that written highway maintenance performance standards must be developed so that consistent, proper and timely repairs can be provided to ensure the safest possible road system. Items that should be included are inspection of bridge decks, road surface and shoulders, provision of timely repairs, pavement condition with regard to ride quality and wheel track rutting, guide rail, and the road side beyond the shoulder (side slope, ditch and back slope).

Snow and Ice Control

The review of winter maintenance activities indicated that all areas responsible for snow and ice control put considerable effort into the program and provide a high level of service. Highway 101 must remain priority number one for snow and ice control in the respective areas. Patrolling of the highway in the early morning before commuter traffic starts, as well as in the early evening, and additional use of the Road Weather Information System (RWIS) and Web Cam installations are needed. Areas should coordinate their salting and plowing with adjacent areas to minimize the time gap of service at county lines and attempt to provide a seamless level of service along Highway 101. It was also concluded that shift change times should be adjusted to ensure that vehicles and staff are available to be 'on the road' during peak travel periods.

Recommendations

Completion of a four lane divided wide median highway is the long term solution for the level of service and fatal collision concerns of the Study Section. However, this Study has revealed many recommendations for changes that will collectively improve the overall level of safety, as well as the comfort and convenience of using Highway 101.

Short Term - Immediately to Twelve Months

1. ***Shoulders*** - Complete grading of shoulders to ensure that drop off at the edge of the pavement does not exceed 50 mm.

2. ***Pavement Markings*** -
   - Eliminate all downhill passing sections on climbing lanes;
   - Evaluate the pavement markings for passing zones on two lane sections;
   - Evaluate passing zones on the approaches to interchange ramps.

3. ***Interchanges*** -
   - The pavement markings and signing at the west end of the short four lane section at Ellershouse and the Exit 4 (St. Croix interchange) exit should be reviewed, and necessary changes made, to ensure 'positive guidance' for motorists;
   - The eastbound access ramp of the Exit 5A, (Wentworth Road interchange) enters Highway 101 at the end of an eastbound climbing lane. Options to eliminate this confusing and potentially hazardous situation should be investigated.

4. ***Speed Limits*** - There are four closely spaced interchanges between Trunk 14 (Exit 5) and Falmouth (Exit 7). To reduce the speed variation between through traffic and slower entering and exiting traffic, a study should be completed to consider lengthening the 90 km/h zone, until the section is upgraded to four lanes.

5. ***Ben Jackson Road Intersection*** - Complete plans for the elimination of this intersection. In the short term, implement the following changes:
   - Establish a 90 km/h zone;
   - Erect INTERSECTION warning signs with flashing amber lights; and
   - Install pavement arrows on Highway 101.

6. ***Highway Maintenance*** - Review the Study Section with regards to the condition of road surface and shoulders, pavement (ride quality and wheel track rutting), guide rail, and the road side beyond the shoulder (side slope, ditch and back slope).

7. ***Snow and Ice Control*** - Ensure that Highway 101 continues to be the number one priority for snow and ice control. Determine whether changes concerning winter patrolling, increased use of Road Weather Information System (RWIS) and Web Cams, coordination of plowing and salting activities, and shift change times, can be incorporated into the 2000-01 winter maintenance program.

8. ***Education*** - Recognizing that human factors account for a large percentage of collisions, and changes in driver attitudes have the greatest potential to reduce collisions, include the following themes in any upcoming highway safety advertising campaigns:
   - DRIVE TO ARRIVE (be attentive; stay awake; wear seat belts; don't drink and drive);

- Reduce Speed According to Road Conditions; and
- ONLY YOU CAN PREVENT ACCIDENTS.

9. ***Enforcement*** - Enforcement of speed and safe driving laws is an effective way to modify driver behaviour, since most drivers fear getting a ticket more than having an accident. Continue and increase enforcement in the following areas:
   - Alcohol and impaired driving laws;
   - Seat belt / child seat usage;
   - Speed limit; reduce the 85th percentile travel speed; and
   - Encourage / promote good driving habits by greater police presence.

10. **Signing** -
    - Relocate / remove improperly located signs; and
    - Inspect and repair guide signs that have 'non-reflecting' letters or route markers.

Mid-Term - One to Two Years

11. ***Twinning*** - Since twinning is required to improve both level of service and safety, it is important that this program begin as soon as possible. Preparation of environmental assessment, and land use, survey and design plans, should be initiated for all sections between Mount Uniacke and Kingston. Construction should be started on the section between Mount Uniacke and Ellershouse.

12. ***Land Owner Access Roads*** - Removal of all land owner access roads should be included in the twinning program. Accesses that can be removed without construction of underpasses or lengthy service roads should be removed as soon as possible.

13. ***Rest Areas*** - The TPW Rest Area Committee should investigate the need for rest areas on the Study Section, especially on the long section between Mount Uniacke and Ellershouse. Construction of rest areas should be included in the twinning program.

14. ***Shoulders*** - Paved shoulders are safer than unpaved shoulders. Considering the maintenance required to prevent unsatisfactory shoulder drop-off and the edge deterioration of the existing narrow paved shoulders, it is recommended that the benefits and costs of wider paved shoulders and shoulder rumble strips be evaluated.

15. ***Lane Lines*** - Wider lane lines, similar to those used on the US Interstate System, provide better 'positive guidance' and may not wear or fade as quickly as the current line width used on NS highways. Also, in addition to traffic paint, there is a variety of alternate marking materials that offer longer life at extra cost. It is recommended that the use of wider lane lines and alternate marking materials be investigated for lane markings on 100 series highways.

16. ***Guide Rail*** - Guide rail is an integral part of the roadside safety program. Critical areas include end treatment, length of coverage, and bridge end connection design. Work required includes:
    - Straighten leaning sections;
    - Develop improved 'state of the art' standards for fastening guide rails to bridge ends;
    - Develop upgraded standards for placement of guide rail; and
    - Replace guide posts with small delineator posts.

17. ***Passing Lanes*** - Complete planning of number and location of passing lanes between Coldbrook and Bridgetown. Since twinning will be required between Coldbrook and Kingston, the construction of one or two carefully located short (approximately two km) four lane divided sections should be considered to provide needed passing lanes. Also, since the highway will be twinned to Kingston, it is probable that passing lanes will only be required between Middleton and Bridgetown.

18. ***Highway Maintenance*** - Develop and adopt performance standards for road maintenance. Begin a program to replace highway signs; many large green signs are over twenty years old.
19. ***Winter Maintenance*** - Develop and adopt performance standards for snow and ice control. Install additional RWIS and web cams to detect black ice and other winter road conditions. Plan and install changeable message signs to warn of adverse road conditions and need to adjust speed to road conditions.

20. ***Animal Control Fencing*** - Investigate need for and install animal control fencing in appropriate areas

21. ***Safety Programs*** -
    - Develop community based safety programs to promote good driving habits and to provide education on the rules of the road and meanings of signs / markings;
    - Involve the insurance industry in funding of safety programs based

on potential to reduce accidents and insurance claims; and

- Complete studies to relate the cost of treatment and rehabilitation of accident victims to the potential for savings with funds invested on road safety programs.

22. ***Enforcement*** -
    - Return all seconded RCMP highway patrol officers to their areas so that all detachments are at full strength;
    - Use paid overtime (using funding from insurance companies) as a cost effective mechanism to provide additional highway patrol enforcement and visibility during peak demand periods;
    - Continue RCMP combined efforts in the Checkpoint program; TPW to assist where needed; and
    - Continue the program to reduce travel speeds; investigate additional methods of speed control.

23. **Motor Vehicle Act Changes** -
    - Introduce graduated speeding fines based on km/h over limit; post advisory signs;
    - Introduce minimum speed laws so that RCMP can enforce unsafe slow speeds;
    - Introduce laws concerning 'inattention' so that police can control blatant inattentive driving, such as reading a book;
    - Introduce a law making the registered owner responsible for Motor Vehicle Act violations when the driver's identity is not known; and
    - Consider changes to remove the 24 hour reporting period for collisions and require collision reporting as soon as possible, to the nearest practical police department.

Long Term - Two to Ten Years

24. ***Twinning*** - Twin Highway 101 from Mount Uniacke to Kingston; approximately 105 km of twinning are required.
    - Twin Mount Uniacke to Ellershouse as soon as possible; attempt to complete this project by the fall of 2002;
    - Twin west from Ellershouse and both west and east from the Avonport four lane section to avoid concentrating too much construction activity in one area;
    - Plan to open twenty kilometres of twinning every two years;
    - Upgrade guide rail and guide rail / bridge end treatments as sections are twinned; and
    - Review centerline profile / cross section / horizontal alignment of the 'existing' highway during twinning.

25. ***Interchange Upgrading during Twinning*** -
    - Connect acceleration and deceleration lanes at closely spaced interchanges as required, and where practical;
    - Reconstruct Wentworth Road (Exit 5A) eastbound exit ramp;
    - Reconstruct three of the four ramps at Avonport (Exit 9); and
    - Widen the Halfway River bridge at Hantsport (Exit 8) to provide an appropriate acceleration lane, if the existing bridge continues to be used for the westbound lanes.

26. ***Passing Lanes*** - Construct passing lanes between Kingston [Middleton] and Bridgetown.

Summary

1. Completion of a four lane divided wide median highway between Mount Uniacke and Kingston is the long term solution for the level of service and fatal collision concerns of the Study Section.

2. The Study has revealed many recommendations for changes that will collectively improve the overall level of safety, as well as the comfort and convenience of using Highway 101.

1.0 Introduction

Study Area

The Highway 101 study section (Figure 1.1) is from the end of twinning at Mount Uniacke westerly to Bridgetown, a distance of about 140 km.

Background

Highway 101 is a provincial east-west two lane primary arterial highway that connects the Halifax Regional Municipality (HRM), and Central and Eastern Nova Scotia, to Yarmouth by way of the Annapolis Valley. It has been designated as part of the National Highway System since it was recognized by both the Provincial and Federal Governments to be of national significance.

The eastern part of the study section provides the primary transportation link for Valley industries to the port of Halifax, Central and Eastern Nova Scotia, and other Canadian markets. It also provides for commuter travel for many who travel daily from the Kentville/Wolfville/Windsor areas to work in HRM. In recent years 'reverse' commuting has also become common as people travel from HRM to work in Valley communities. West of Coldbrook, Highway 101 provides for long distance through traffic from HRM to Western Nova Scotia and is also heavily utilized by intra-Valley travel between mid-Valley towns and the commercial/retail and university areas of Kentville/Wolfville.

Due to increasing traffic volumes and numerous fatal collisions in recent years, the Nova Scotia Department of Transportation & Public Works (TPW) plan to upgrade the corridor between Mount Uniacke and Coldbrook, a distance of approximately 75 km, to a four lane, divided, wide median facility. Since this is part of the National Highway System, the upgrading is eligible for Federal government cost sharing. The upgrading will be phased with timing dependent upon the allocation of available funding from the Federal and Provincial governments, as well as satisfaction of environmental regulations.

Twinning Highway 101 is TPW's Long Term Goal

The long term goal of TPW is to twin Highway 101 from Mount Uniacke to Coldbrook. However, the reality of the current and foreseeable economic situation is that even the 21 km first section from Mount Uniacke to the existing short four lane section at Ellershouse may not be completed for several years, and the remaining 55 km to Coldbrook will probably take five to ten years to complete.

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Study Objectives

The stated **primary objective** of this study in the Terms of Reference is:

> *". . .to complete a comprehensive operational and safety review of Highway 101, from Mount Uniacke to Bridgetown, . . .to ensure preservation of a level of service greater than or equal to C and preservation of an acceptable level of safety performance.*"

Addendum No. 1 made it quite clear that the study is not intended to be a detailed safety audit. It is to be "an operational and safety review of areas along this stretch of highway that are prone to accidents . . . ".

The **goals to be attained** by this study are:

1. Complete an operational and safety review of the Highway 101 Study Section;
2. Perform comparative analyses with highways of similar classification;
3. Obtain input from established community groups and RCMP interested in Highway 101 safety issues;
4. Identify current and projected (20 years) operational and safety deficiencies;
5. Recommend practical (cost effective) short and medium term engineering, education and enforcement strategies to provide an acceptable level of safety and maintain a level of service of LOS 'C' or better.

2.0 Traffic Data

General Overview

Highway 101 from Mount Uniacke to Bridgetown (Figure 1.1) is a two lane, controlled access facility, except for two short sections of four lane divided roadway. All secondary road crossings are by grade separated structures and all access is via interchanges, except for the at-grade intersection at Ben Jackson Road (Exit 8A). The Study Section begins just east of Exit 4 (Mount Uniacke) and continues westerly to Exit 20 (Bridgetown).

2.1 Characteristics of Highway 101

Typical Characteristics

Highway 101 typically has the following characteristics throughout the Study Section:

- It is a two lane controlled access highway, except for two short sections (0.7 km at Ellershouse and 3.0 km at Avonport) which have four lanes with a wide median.
- The highway was designed and constructed in Imperial units with an approximate 70 mph design speed.
- The speed limit is 100 km/h, except for a 2.6 km section posted at 90 km/h at the Avon River Causeway between Windsor and Falmouth.
- Except for the at-grade intersection at Ben Jackson Road (Exit 8A), all access to the study section is by interchanges and all crossing roads are grade separated. Interchange locations, Exit Numbers, interchange types, and approximate distance east of the start of the Study Section (at the end of the four lane section at Mount Uniacke) are included in Table 2.1.
- In the approximately 75 km from Mount Uniacke to Trunk 1 at Coldbrook, there are seven separate westbound marked passing (climbing) lane sections and two four lane sections with a total length of approximately 20 km (27%).
- Between Coldbrook and Mount Uniacke there are eight separate eastbound marked passing lane sections and two four lane sections with a total length of approximately 22 km (29%).

Table 2.1 - Highway 101 Interchange Locations

Exit Number	Location	Secondary Road Location (Km from End of 4 Lanes)	Interchange Type
End 4 Lanes	East of Exit 3	0.00	
3	Mount Uniacke	0.76	Trumpet
4	St. Croix	22.70	Modified Parclo
5	Trunk 14	27.56	Diamond
5A	Wentworth Road	31.90	Diamond (modified eastbound exit ramp)
6	Nesbitt Street	34.06	Modified Parclo
7	Falmouth	35.76	Trumpet
8	Hantsport	41.97	Parclo
8A	Ben Jackson Road	45.99	INTERSECTION (4 way)
9	Avonport	50.31	Modified Parclo
10	Hortonville	52.89	Diamond
11	Greenwich	62.05	Diamond
12	New Minas	68.28	Diamond
13	Trunk 12	72.44	Diamond
14	Coldbrook	76.16	Diamond
15	Berwick	90.83	Diamond
16	Aylesford	99.16	Diamond
17E	Kingston East	108.45	Split Diamond (easterly ramps)
17W	Kingston West	110.19	Split Diamond (westerly ramps)
18A	Middleton East	118.22	Half Diamond (easterly ramps)
18	Middleton	121.60	Diamond
19	Lawrencetown	130.12	Diamond
20	Bridgetown	141.27	Parclo

Typical Characteristics (Continued)

- The approximately 64 km from Trunk 1 at Coldbrook to Trunk 1 at Bridgetown does not have any auxiliary climbing lanes.
- There are a number of gated at-grade agricultural machinery crossings between Coldbrook and Bridgetown which are used by large combines or potato harvesters too high to pass through the pipe arch farm underpasses.
- Annual Average Daily Traffic Volumes (AADT) vary from 13500 vpd towards the easterly end of the Study Section to 3300 vpd at the west end (See Table 2.2).
- Trucks generally account for 7% to 8% in the 'high' volume sections east of Exit 14 at Coldbrook to about 11% in the 'lower' volume sections to the west.

2.2 Historical Traffic Volume Data

AADT Volumes

During 1999 and the spring of 2000, TPW obtained machine counts from road tubes on all highway sections in the Study Section of Highway 101, except for Sections 095, 140 and 170 which were counted from vehicle detector loops buried in the pavement. Estimated AADT's were calculated for each location and are recorded in Table 2.2.

Weekday and Hourly Volumes

Hourly and daily volume records have been tabulated for each count and are included as Tables B-1 to B-20, Appendix B. The average weekday, peak day (Friday) and the peak hour (Friday afternoon between 3:00 PM and 5:00 PM) volumes for each count location, as well as the ratio of each to AADT, are included in Table 2.2.

Design Hour is 11% of AADT

Volumes vary by season of the year, day of the week and hour of the day. Since it is not economically practical to design roadways for the highest hour of the year, a 'design hourly volume' (DHV) is needed for each road section so that existing and future levels of service, and appropriate design criteria can be determined. Normally, the 30^{th} or 50^{th} highest hourly volume of the year has been used as the DHV. For ease of calculation, the DHV is generally indicated as a percentage of AADT volume, usually between 10% and 14%. Since many of the peak hours in Table 2.2 are between 11% and 12% of the AADT, the design hourly volume will be assumed as 11% of the AADT throughout this Study.

Table 2.2 - Highway 101 Volumes and Factors

Highway Section	1999/ 2000 AADT	Data Table	Average Weekday			Peak Day		Peak Hour	
			Count Month	vpd	vpd / AADT	vpd	vpd / AADT	vph	% AADT
040 - Mount Uniacke to St. Croix	11400	B-1	Oct.	13060	1.15	16187	1.42	1466	12.9
050 - St. Croix to Trunk 14	11200	B-2	Jul.	14042	1.25	15615	1.39	1280	11.4
060 - Trunk 14 to Wentworth Road	13300	B-3	Sep.	15079	1.13	17870	1.34	1615	12.1
065 - Wentworth Road to Nesbitt Street	13500	B-4	Nov.	14327	1.06	17001	1.26	1574	11.7
070 - Nesbitt Street to Falmouth	13400	B-5	Sep.	14387	1.07	17663	1.32	1510	11.3
080 - Falmouth to Hantsport	12300	B-6	Oct.	13466	1.09	15776	1.28	1383	11.2
090 - Hantsport to Ben Jackson Road	12000	B-7	May	12406	1.03	15214	1.27	1328	11.1
095 - Ben Jackson Road to Avonport [1]	11300	B-8	Jun.	13456	1.19	15229	1.35	1340	11.9
100 - Avonport to Hortonville	12000	B-9	May	14712	1.23	17597	1.47	1496	12.5
110 - Hortonville to Greenwich	10200	B-10	May	11143	1.09	13130	1.29	1068	10.5
120 - Greenwich to Highbury	10500	B-11	May	11633	1.11	13348	1.27	1158	11.0
130 - Highbury to Trunk 12	12600	B-12	May	14000	1.11	15882	1.26	1374	10.9
135 - Trunk 12 to Coldbrook	12700	B-13	May	13899	1.09	16709	1.32	1401	11.0
140 - Coldbrook to Berwick [1]	6910	B-14	Jun.	8405	1.22	9442	1.37	809	11.7
150 - Berwick to Aylesford	7400	B-15	May	8202	1.11	9749	1.32	860	11.6
160 - Aylesford to Kingston East	6600	B-16	May	7244	1.10	8665	1.31	779	11.8
170 - Kingston East to Middleton East [1]	3260	B-17	Jun.	3842	1.18	4384	1.34	384	11.8
180 - Middleton East to Brooklyn Road	3460	B-18	May	3860	1.12	4623	1.34	393	11.4
190 - Brooklyn Road to Lawrencetown	3730	B-19	May	4174	1.12	4969	1.33	452	12.1
120 - Lawrencetown to Bridgetown	3340	B-20	May	3835	1.15	4320	1.29	352	10.5

NOTE: Counts for Sections 095, 140 and 170 were obtained from detector loop traffic counts.

2.3 Projected Traffic Volumes

Annual AADT Growth Rates

TPW has maintained traffic count records on Highway 101 since the first sections of road opened in 1968. Regression analyses of the historical AADT data for each of the 20 sections of highway in the Study Section indicate linear growth with high correlation factors (R^2 = 0.90 to R^2 =

0.95). The calculated growth rates are shown in Table 2.3 and the historical AADT data and growth rate equations for each section are included as Figures B-1 to B-20.

Future AADT and Design Hourly Volumes

AADT volumes for 2000 to 2020 (Table 2.3) have been projected using the growth rate equations. Future design hourly volumes have been estimated based on 11% of AADT volume as determined in Section 2.2.

Table 2.3 - Highway 101 Growth Rates and Projected Volumes

Highway Section	Growth Rates		Projected AADT (from Growth Rate Equations) and DHV Volumes									
	Data Figure	Annual AADT Growth	2000		2005		2010		2015		2020	
			AADT	DHV	AADT	DHV	AADT	DHV	AADT	DHV	AADT	DHV
040	B-1	265	11070	1220	12400	1360	13700	1510	15000	1650	16400	1800
050	B-2	270	10900	1200	12300	1350	13600	1500	15000	1650	16300	1790
060	B-3	345	13100	1440	14800	1630	16600	1830	18300	2010	20000	2200
065	B-4	320	13300	1460	14900	1640	16500	1820	18100	1990	19700	2170
070	B-5	355	13200	1450	15000	1650	16800	1850	18500	2040	20300	2230
080	B-6	275	12000	1320	13400	1470	14800	1630	16100	1770	17500	1930
090	B-7	270	11100	1220	12500	1380	13800	1520	15200	1670	16500	1820
095	B-8	270	11700	1290	13100	1440	14400	1580	15800	1740	17100	1880
100	B-9	260	11900	1310	13200	1450	14500	1600	15800	1740	17100	1880
110	B-10	240	9840	1080	11000	1210	12200	1340	13400	1470	14600	1610
120	B-11	270	9950	1090	11300	1240	12700	1400	14000	1540	15400	1690
130	B-12	340	11200	1230	12900	1420	14600	1610	16300	1790	18000	1980
135	B-13	460	12200	1340	14500	1600	16800	1850	19100	2100	21400	2350
140	B-14	175	7100	780	8000	880	8900	980	9700	1070	10600	1170
150	B-15	180	6900	760	7800	860	8700	960	9600	1060	10500	1160
160	B-16	160	6260	690	7100	780	7900	870	8700	960	9500	1050
170	B-17	150	3400	370	4200	460	4900	540	5700	630	6400	700
180	B-18	125	3700	410	4300	470	5000	550	5600	620	6200	680
190	B-19	125	3700	410	4300	470	5000	550	5600	620	6200	680
200	B-20	125	3500	390	4100	450	4800	530	5400	590	6000	660

AADT Growth Rates Vary from 125 to 460 vpd per Year

While AADT volumes on sections from Mount Uniacke to Trunk 12 at Kentville (040 to 130) are expected to increase at approximately 300 vpd per year, Section 135, Trunk 12 to Coldbrook, has exhibited considerably higher growth at 460 vpd per year. Sections from Coldbrook to Middleton (140 to 170) will experience AADT growth of from 150 to 200 vpd per year, and the remaining westerly sections are expected to increase at 125 vpd per year.

AADT's of 20000 and Daily Volumes of 27000 are Expected by 2020

If historical growth rates are sustained during the next twenty years, 2020 AADT volumes of 20000 are expected on several highway sections between Mount Uniacke and Coldbrook. Also, since peak daily volumes are usually about 135% of AADT (see Table 2.2), daily volumes of 22000 to 27000 will be common.

2.4 Collision History

1410 Reported Collisions from 1990 to 1999

The TPW collision data base contains records of 1410 collisions on the approximate 140 km Study Section for the ten years from 1990 to 1999. Collision numbers by configuration and severity are shown in Table 2.4.

Table 2.4 - Number of Collisions by Configuration and Severity 1990 to 1999

Collision Configuration	**Number of Collisions by Severity**			
	Property Damage	**Personal Injury**	**Fatal**	**Total**
Struck Object	227	27	3	257
Ran off Road	211	183	6	400
Rear End	76	66	0	142
Right Angle	12	6	3	21
Sideswipe, Same Direction	16	6	1	23
Sideswipe, Opposite Directions	19	25	9	53
Head On	22	34	19	75
Passing, Left / Right Turns	35	15	0	50
Other; Not Stated	291	97	1	389
TOTALS	**909**	**459**	**42**	**1410**

Fatal Collision Data

The following data concerning fatal collisions from 1990 to 1999 has been extracted from tabular collision information provided by TPW:

- There were 42 fatal collisions including 2 pedestrian, 8 single vehicle, and 32 two or more vehicles;
- There were 55 fatal victims, including 2 pedestrians, 18 passengers and 35 drivers;
- 37 (88%) occurred when weather condition was clear or cloudy, with only 5 (12%) reported during rain / snow / or freezing rain;
- 27 (64%) occurred when road surface condition was dry pavement; 7 (17%) occurred on snow / ice / slush and 8 (19%) occurred on wet pavement;
- 26 (62%) occurred during daylight; 14 (33%) occurred during dark and 2 (5%) during dusk / dawn;
- December and August with 8 and 7 collisions, respectively, were the 'worst' months; May, the best with 0 collisions; all other months had 2 to 4 collisions.

In summary, a high proportion of the fatal collisions occurred during 'ideal' conditions of weather, and road surface and light conditions. However, there were still many collisions that occurred during darkness, (14) or under less than ideal road surface conditions (15).

Collision Reports have a High Percentage of 'Self Reporting'

Collisions involving death or injury must be reported to the police immediately. However, when a collision involves property damage only (PDO) and the 'apparent' damage is $1000 or more, the drivers involved have 24 hours before they must complete a *Report of Motor Vehicle Accident* (MV58A)

The 24 hour reporting period and the largely 'self reporting' nature of the PDO collision reporting system create two major problems for collision analysts when attempting to use the data to plan collision countermeasures:

1. Exact location information for collisions is not provided since the involved drivers are usually not familiar with the area and often report to an office far from the scene where those assisting in completing the form are also unfamiliar with the area. The highway number is usually known and a highway section can usually be determined, but an 'exact' location within a section is rarely indicated.
2. Indicated contributing factors to many collisions are not objective since it is unlikely that drivers would incriminate themselves. Factors such as 'driver inattention','exceeding

speed limit', 'driving too fast for road conditions' or 'tired', may be the actual primary contributing factors to a collision. However, 24 hours later, the collision may be attributed to 'animal action (deer)' or 'slippery surface'. Other factors such as, time of day, light condition, weather condition and road surface condition, may also be improperly reported.

A review of the collision data base for the 1410 reported collisions in the Study Section revealed that only 866 sites were visited by the police, indicating that the locations and details for the remaining 40% of the collisions was self reported.

Collision Contributing Factors

The Nova Scotia *Report of Motor Vehicle Accident* form includes space for reporting up to four 'major contributing factors' for each vehicle involved in a collision. The contributing factors are grouped as driver condition, driver action, vehicle condition and road / environment condition. The most important or primary contributing factor is supposed to be reported as the 'first' contributing factor. However, as noted above, the self reporting system for collisions, probably reduces the accuracy and objectivity of the reported data.

Table 2.5 includes contributing factors by collision severity for four collision severities. Data for 'serious injury' collisions has been included as a separate severity class since vehicle occupants (73 driver and 49 passengers) received incapacitating injuries requiring hospitalization in 74 collisions. The recorded data includes the information recorded for the first contributing factor for each involved vehicle.

Human Condition or Action Accounts for 86% of Fatal and 71% of Serious Injury Collisions

Human (driver or pedestrian) condition or action accounts for 86% of the 'stated' contributing factors for fatal collisions and 71% of serious injury collisions. Other factors contributing to fatal collisions were vehicle condition (2%), animals (5%) and roadway (7%). Vehicle condition accounted for 6% of serious injury contributing factors, while animals (4%), roadway condition (17%) and uninvolved vehicles (2%) accounted for the balance. This data is comparable to other collision research that has concluded that over 90 percent of all road accidents involve human error, and that only a small proportion of collisions can be attributed to vehicle defects or faults in road design or maintenance.

Table 2.5 - Traffic Collisions by 'First' Contributing Factor and Severity

Contributing Factor	Frequencies by Collision Severity				
	Property Damage	'Minor' Injury	'Serious' Injury	Fatal	Total
Driver Inattention / Distraction	133	82	18	6	239
Had been Drinking / Driving while Impaired	18	25	9	10	62
Extreme Fatigue / Fell Asleep	35	28	11	7	81
Driver Inexperience / Confusion	30	20	6	3	59
Lost Consciousness / Medication / Illness	5	6	1	2	14
Failure to Yield Right-of-Way	7	8	2	1	18
Following too Closely	2	1	0	0	3
Driving too Fast for Conditions	28	18	4	6	56
Exceeding Speed Limit	3	0	0	1	4
Turning / Passing Improper; Wrong Way	11	4	2	0	17
Pedestrian Error / Confusion	0	2	1	1	4
Crossed Centre Line	1	6	1	1	9
Vehicle Defect	43	21	5	1	70
Animal Action	240	23	3	2	268
Slippery Surface	234	93	10	3	340
Snow Drift	7	1	1	0	9
Obstruction / Debris	14	6	0	0	20
View Obstructed / Limited	6	7	0	0	13
Glare	3	1	0	0	4
Construction Zone	3	3	0	0	6
Defective Driving Surface	5	1	0	0	6
Shoulders Defective / Inadequate	2	0	0	0	2
Crosswind	5	4	0	0	9
Hydroplaning	32	13	2	0	47
Uninvolved Vehicle	36	21	2	0	59
TOTALS [1]	**903**	**394**	**78**	**44**	**1419**

NOTE: 1. Totals differ from those in Table 2.4 since contributing factors were not provided for some vehicles or, in other instances, were provided for more than one vehicle in each collision.

Collision Rates

Since highway sections are of varying lengths with different volumes, collision frequencies are combined with section length and AADT volumes to calculate a collision rate based on exposure. The collision rate for each section, calculated as the 'number of collisions per HMVK (Hundred Million Vehicle Kilometres)', can then be compared to the rate for each section of the Study Section, as well as collision rates for similar classes of roadway.

A comprehensive study of yearly collision frequencies and rates by highway section and severity is included in Table B- 21, Appendix B. A summary of 1990 to 1999 collision rates for the twenty Highway 101 sections is included in Table 2.6. The approximate locations for the 42 fatal collisions that occurred between 1990 and 1999 are plotted on Figure 2.1.

Table 2.6 - Ten Year Summary of Collision Frequencies and Rates

Highway		1999	1990-99	Number of Collisions (1990 to 1999)				Collision Rates (1990 to 1999)			
Section	Length	AADT	HMVK	PDO	Injury	Fatal	Total	PDO	Injury	Fatal	Total
101-040	21.03	11400	7.4711	128	89	14	231	17.1	11.9	1.9	30.9
101-050	7.67	11200	2.7225	58	23	2	83	21.3	8.4	0.7	30.5
101-060	2.33	13300	0.9427	31	8	2	41	32.9	8.5	2.1	43.5
101-065	2.13	13500	0.9127	36	18	1	55	39.4	19.7	1.1	60.3
101-070	1.70	13400	0.6915	35	17	1	53	50.6	24.6	1.4	76.6
101-080	6.28	12300	2.3609	62	43	1	106	26.3	18.2	0.4	44.9
101-090	3.93	11400	1.3484	60	25	2	87	44.5	18.5	1.5	64.5
101-095	3.88	11300	1.4614	37	14	2	53	25.3	9.6	1.4	36.3
101-100	3.00	12000	1.1313	19	15	0	34	16.8	13.3	0.0	30.1
101-110	9.17	9800	2.7728	67	26	3	96	24.2	9.4	1.1	34.6
101-120	6.13	10100	1.9152	67	34	1	102	35.0	17.8	0.5	53.3
101-130	4.23	12100	1.3292	35	10	1	46	26.3	7.5	0.8	34.6
101-135	3.62	12100	1.2051	27	22	3	52	22.4	18.3	2.5	43.1
101-140	14.64	6910	3.2736	70	44	5	119	21.4	13.4	1.5	36.4
101-150	8.31	7100	1.7911	37	19	1	57	20.7	10.6	0.6	31.8
101-160	9.28	6300	1.8253	27	10	0	37	14.8	5.5	0.0	20.3
101-170	9.73	3260	1.0976	26	11	1	38	23.7	10.0	0.9	34.6
101-180	3.09	3400	0.3453	11	6	0	17	31.9	17.4	0.0	49.2
101-190	8.53	3700	0.9233	30	16	0	46	32.5	17.3	0.0	49.8
101-200	10.48	3200	1.0904	46	9	2	57	42.2	8.3	1.8	52.3
TOTALS	139.16		36.6114	909	459	42	1410	24.8	12.5	1.1	38.5

Table 2.6 contains the Property Damage Only (PDO), Injury, Fatal and Total collision rate summaries for 1990 to 1999 for each of the twenty sections of Highway 101 in the Study Section. The last row in the table also provides the 10 year weighted average collision rates by severity for the entire 140 km Study Section.

Comparison of Highway 101 Collision Rates to Other Highway Types

How do Highway 101 collision rates compare to those for other 100 series highways? Highway 101 collision rates for the ten year period covered by this study, as well as for five years 1994 to 1998, are compared to rates for all 100 series two lane controlled access highway sections and all four lane divided wide median highways in Table 2.7. The collision rates for all controlled access and four lane divided highways have been extracted from TPW publication *Motor Vehicle Accident Rates for Numbered Highways and Sections 1994 to 1998*.

Highway 101 PDO, injury and total rates are much lower than the average rates for all two lane controlled access highways in Nova Scotia, and the fatal rate is almost equal to the published rate. Also, Highway 101 PDO, injury and total rates are comparable to the equivalent rates for all four lane divided highway sections in the Province.

Although the Highway 101 fatal collision rate of 1.1 per HMVK is comparable to the fatal rate for two lane controlled access highways, it is almost four times the 0.3 fatal collisions per HMVK rate for four lane wide median highways. If the fatal collision rate on the Highway 101 Study Section had been restricted to 0.3 per HMVK for the past ten years, there would have been considerably fewer fatal collisions on the approximate 140 km of highway.

Table 2.7 - Comparison of Highway 101 Collision Rates to Rates for Other Highways

Highway Class	Years	Collision Rates per HMVK by Severity			
		PDO	Injury	Fatal	TOTAL
Highway 101 Study Section	1990-99	24.8	12.5	1.1	38.5
Highway 101 Study Section	1994-98	22.2	11.9	1.1	35.2
All two lane controlled access 100 series highways	1994-98	35.7	17.0	1.0	53.7
All four lane divided wide median highways	1994-98	23.9	10.5	0.3	34.7

Quality Control Check of Highway 101 Section Rates

Since accident rates based on exposure are calculated using section length and AADT volumes, the impact of one additional collision has much greater impact on the rates for a short section with a low volume (such as 101-180) than for a long section with a high volume (such as 101-040).

Quality control techniques have been developed to determine the significance of section collision rates compared to the average for a highway class. This technique is used to identify highway sections where safety performance compares unfavorably with the average for similar class highways. The following equation is used to calculate the 95th percentile upper control rate for each section collision rate:

$$\mathbf{UCL = R_o + 1.96(R_o / HMVK)^{0.5} + (1/2HMVK)} \qquad (2.1)$$

where

UCL = the upper control rate for a highway section that will only be exceeded by chance 5% of the time;

R_o = the overall average collision rate for a highway class in collisions per HMVK; and

HMVK = the vehicle kilometres of travel for the section to be analyzed in Hundred Million Vehicle Kilometres.

Upper Control Limit Rates for Total and Fatal collisions have been calculated for each Highway 101 section and are compared with the 10 year average rate for each section in Table 2.8. The Five Year Average Total and Fatal Collision Rates for all two lane controlled access highways (53.7 and 1.0, Table 2.7) have been used as the ‘R_o’ values in Equation 2.1.

Since section Total and Fatal collision rates are less than the calculated UCL collision rates, it can be concluded that none of the sections can be identified as having safety performance that compares unfavorably with the average for similar class (two lane controlled access) highways. As noted, however, the 140 km Study Section does have a ten year average fatal collision rate that is considerably higher than that for the average four lane divided wide median highways in Nova Scotia.

Table 2.8 - Quality Control Check of Highway 101 Fatal and Total Collision Rates

Highway Section	Section Length	1999 AADT	Total Collisions 1990-99	Average Annual HMVK	Collision Rates (1990 to 1999) Total Rate [1]	Total UCL Rate [2]	Fatal Rate [3]	Fatal UCL Rate [4]
101-040	21.03	11400	231	0.7471	30.9	70.7	1.9	3.6
101-050	7.67	11200	83	0.2722	30.5	81.4	0.8	4.9
101-060	2.33	13300	41	0.0943	43.5	100.5	2.1	7.4
101-065	2.13	13500	55	0.0913	60.3	101.3	1.1	7.5
101-070	1.70	13400	53	0.0691	76.6	108.4	1.4	8.5
101-080	6.28	12300	106	0.2361	44.9	83.4	0.4	5.2
101-090	3.93	11400	87	0.1348	64.5	92.9	1.6	6.4
101-095	3.88	11300	53	0.1461	36.3	91.3	1.4	6.2
101-100	3.00	12000	34	0.1131	30.1	96.5	0.0	6.9
101-110	9.17	9800	96	0.2773	34.6	81.1	1.1	4.9
101-120	6.13	10100	102	0.1915	53.3	86.6	0.5	5.6
101-130	4.23	12100	46	0.1329	34.6	93.2	0.8	6.4
101-135	3.62	12100	52	0.1205	43.1	95.1	2.5	6.7
101-140	14.64	6910	119	0.3274	36.4	79.0	1.5	4.6
101-150	8.31	7100	57	0.1791	31.8	87.7	0.6	5.7
101-160	9.28	6300	37	0.1825	20.3	87.4	0.0	5.7
101-170	9.73	3260	38	0.1098	34.6	97.1	0.9	7.0
101-180	3.09	3400	17	0.0345	49.2	131.0	0.0	11.6
101-190	8.53	3700	46	0.0923	49.8	101.0	0.0	7.5
101-200	10.48	3200	57	0.1090	52.3	97.3	1.8	7.0

NOTES:
1. These are the 10 year average Total Collision Rates for each section
2. The Total UCL Rates were calculated using the Five Year Average Total Collision Rate (53.7) for all two lane controlled access highways as the 'R_o' values in Equation 2.1.
3. These are the 10 year average Fatal Collision Rates for each section.
4. The Fatal UCL Rates were calculated using the Five Year Average Fatal Collision Rate (1.0) for all two lane controlled access highways as the 'R_o' values in Equation 2.1.

2.5 Travel Speeds and Headways

Travel Speeds

Travel speeds were provided by TPW for four locations within the Study Section. One hour radar samples were obtained for both eastbound and westbound vehicles on Section 040 about half way between Mount Uniacke and Ellershouse. Week long speed studies were obtained for Section 040, as well as for three other locations, using automated machines and paired road tubes. Speed data from these studies, for both eastbound and westbound traffic, are recorded in Table 2.9. 85th percentile speeds, as well as percentages of vehicles exceeding speeds from 100 km/h to 120 km/h, are recorded in the table.

Frequency Distribution of Travel Speeds

A typical frequency distribution of travel speeds from the radar study is shown in Figure 2.2. The Cumulative Frequency curves indicate the percentage of vehicles traveling slower than the speeds indicated on the 'x' axis of the figure. The 85th percentile speed for eastbound traffic from this sample is 109.2 km/h, indicating that 85% of vehicles are traveling less than that speed. The 85th percentile speed for westbound vehicles is 112.4 km/h.

Table 2.9 - Speed Data - Mount Uniacke to Bridgetown

Location	Direction of Travel	85th Percentile Speed, km/h	Percent Exceeding Speeds			
			100 km/h	110 km/h	115 km/h	120 km/h
Section 040, between Mount Uniacke and Ellershouse [1]	EB	109.2	72	13	6	1
	WB	112.4	80	21	10	3
Section 040, between Mount Uniacke and Ellershouse [2]	EB	110.8	68	17	9	2
	WB	115.5	81	30	17	4
Section 110, between Hortonville and Greenwich [2]	EB	111.0	69	17	10	2
	WB	113.0	73	22	12	3
Section 140, between Coldbrook and Berwick [2]	EB	113.7	80	23	13	4
	WB	114.0	78	23	14	4
Section 200, between Lawrencetown and Bridgetown [2]	EB	113.9	76	24	14	5
	WB	116.9	83	34	21	8

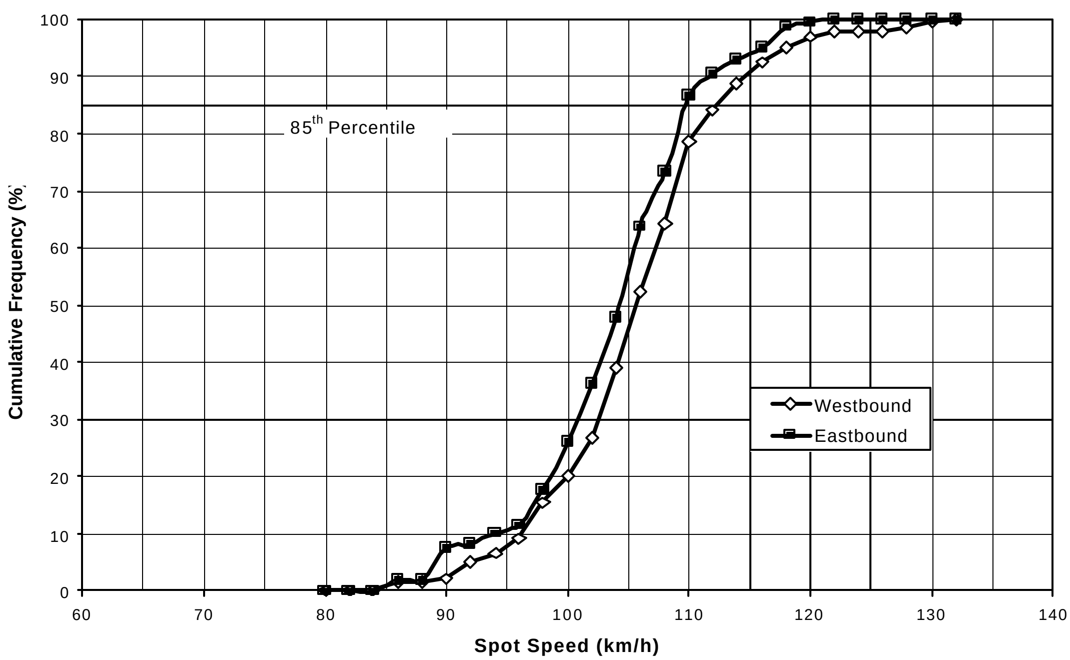
NOTES:
1. Speeds at this location were measured by radar during a one hour period on June 16, 2000
2. Speeds at this location were measured by machine during a one week period June 7 to 14, 2000

Large Percentages of Vehicles are Exceeding the Speed Limit

The Cumulative Frequency curve for westbound traffic in Figure 2.2 indicates that 20% of those vehicles are going less than 100 km/h. Stated another way, 80% of the vehicles are traveling in excess of the legal 100 km/h speed limit.

Eastbound travel speeds (Table 2.9) vary from 109 to 114 km/h throughout the Study Section. Westbound speeds are consistently higher and vary from 112 to 117 km/h. Referring to Table 2.9, it is noted that up to 80% of drivers exceed the legal 100 km/h speed limit at all sample locations. Also, generally, more than 22% exceed 110 km/h; more than 12% exceed 115 km/h; and more than 4 % exceed 120 km/h.

Figure 2.2 - Speed Radar Samples, Highway 101 Section 040



Vehicle Headways

The longitudinal distribution of vehicles in a traffic stream is measured as either the time between vehicles in seconds, or the distance between vehicles in metres. The spacing of vehicles in a traffic stream affects merging, passing and crossing maneuvers on a highway. *Headway* is the time interval in seconds between successive vehicles traveling past a point on the highway. Headway is inversely proportional to traffic volume, so that high volume roads have short headways and lower volume roads have longer headways.

Frequency Distribution of Headways

TPW measured headways for both eastbound and westbound traffic at the same four locations where speeds were recorded (see Table 2.9). Frequency distributions of headways for westbound traffic during a PM peak hour in June 2000 are recorded in Figure 2.3 for the four locations.

50% of Observed PM Peak Hour Headways Between Mount Uniacke and Ellershouse are less than 3 Seconds

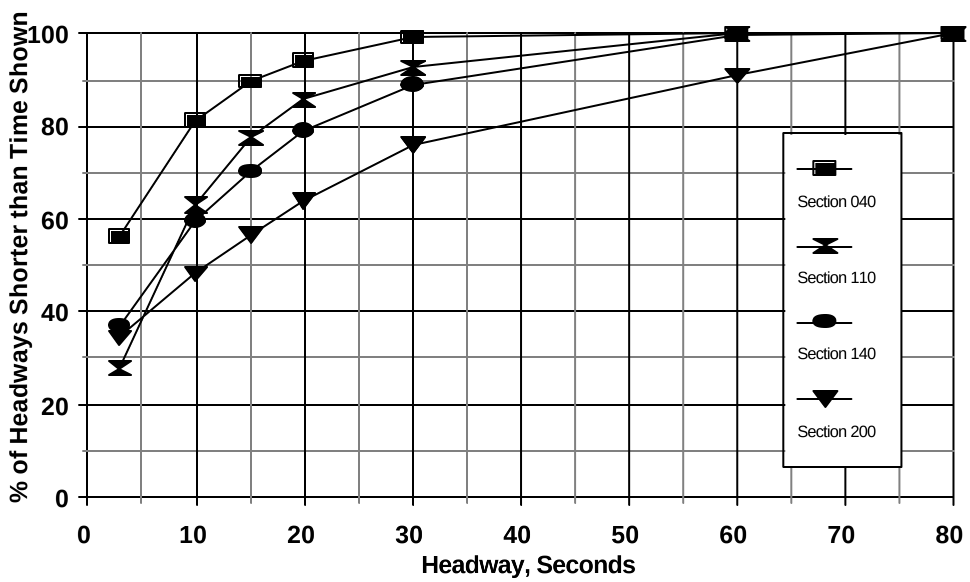
As indicated above, headway is inversely proportional to volume, so that during the PM peak hour Section 040 (between Mount Uniacke and Ellershouse) has shorter headways than Section 200 (between Lawrencetown and Bridgetown). While over 80% of the headways for

Section 040 are less than 10 seconds, only 48% of the headways for Section 200 are less than 10 seconds.

It is also noted that during the PM peak hour about 58% of the measured headways between Mount Uniacke and Ellershouse are less than three seconds. Highways with such short headways can be ‘unforgiving’ to vehicles that cross the centerline, whether due to inattention, slippery roads or to initiate passing maneuvers, as there is a high probability that there will be an opposing vehicle. Short headways also create problems, such as rear end collisions, for vehicles traveling in the same direction. Also, when vehicles are closely spaced, a passing vehicle may have difficulty returning to the right hand lane.

The frequency distributions for eastbound traffic during the AM peak exhibit similar characteristics.

Figure 2.3 - Headways by Section
PM Peak Hour June 2000



3.0 Public Consultation

Overview

The Operational and Safety Review Study of Highway 101 has included considerable public consultation. Comments and recommendations from the following meetings and contacts will be discussed throughout this section of the Report:

1. May 15, 2000 - Bob Dewar and Ken O'Brien interviewed three groups in New Minas and Windsor
   - Representatives of 'Twin to Win' Group (New Minas)
   - Representatives of RCMP Kings and Bridgetown detachments (New Minas)
   - Representatives of RCMP Windsor detachment.

2. May 16, 2000 - Bob Dewar and Ken O'Brien met representatives of the Department of Justice and RCMP Highway Patrol in Halifax.

3. May 30, 2000 - Ken O'Brien interviewed truckers at a combined RCMP and Business & Consumer Services Vehicle Compliance Checkpoint on Highway 101 westbound at Ellershouse. RCMP members also distributed 400 questionnaire requests for Focus Group volunteers.

4. June 12, 2000 - Focus Group meeting in New Minas.

5. June 14, 2000 - Focus Group meeting in Windsor.

6. June 27, 2000 - Focus Group meeting in Bedford.

3.1 Meetings with 'Twin to Win' and RCMP

Twin to Win

Bob Dewar and Ken O'Brien met with representatives of Twin to Win at the TPW office in New Minas on May 15, 2000. In recent years the 'Twin to Win' group has been campaigning for the twinning of Highway 101. The Valley economy is growing and they rely on Highway 101 for a two way flow of raw materials and consumer goods. Public transportation is not readily available so Highway 101 must be used when traveling between the Valley and Halifax area whether for work, shopping, recreation or medical treatment. While commuting has been traditionally thought of as 'from home in the Valley to work in Halifax', a 'reverse commuting' trend has developed in recent years prompted by changes such as -

- Shearwater closed and those transferred to Greenwood still live in Metro;
- When one spouse has a job in the Valley and the other has a job in Metro, they often choose to live in the Sackville area. For example, some Michelin employees live in Sackville.
- Some medical professionals work in various Valley sites but live in Halifax.

With regards to twinning, the Group representatives observed that the effects of highway fatalities are like the ripple of a pebble in a pond. Many people are affected and impacts are even greater in the smaller, more connected, Valley communities. The fear continually is that the next Highway 101 crash may involve a friend or a family member. Most people are becoming tired of hearing excuses why twinning cannot get started. Everyone knew that 'Death Valley' [Highway 104] was dangerous, but now the Cobequid Pass has all but eliminated fatal crashes.

Although the group has resolved that 'We Need the Road Now!', many comments concerning observations of safety problems and suggestions for improvements were included in the discussion. Several comments are recorded below :

- Volumes are so high that any cross centerline movement has a high probability of a head-on crash.
- Fatal crashes are creating a lot of trauma to attending professionals who often know the victims. Many people are reluctant to become volunteer firemen because they do not want to attend highway crash scenes.
- Shoulder designs and roadside are not good but single vehicle 'run off road' type of accidents are not usually fatal. Most fatal accidents are head-on crashes.
- Slush is a factor in many winter accidents.
- There are several micro-climates between Windsor and Mount Uniacke. Black ice is a problem.
- Most people talk about the fatalities in relation to twinning. We should also consider that twinning would reduce the high medical costs of caring for seriously injured victims.
- There is careless driving everywhere, but not with the same level of severity as on Highway 101.

- TPW should post signs ‘Slow Down - x People Killed next xx Kms’.
- The ends of climbing lanes are confusing, Solid lines are of various lengths and right-of-way is not defined. Newfoundland paints YIELD on the center lane.
- It is assumed that people are aware of traffic rules and regulations, but it is obvious that considerable education is needed.
- Secondary roads are in need of repair so cannot be used for bypassing sections of concern on Highway 101.
- Cell phones are a distraction problem. [Bob Dewar indicated that talking on a cell phone while driving was the equivalent of driving drunk.]
- Should drivers be tested after a certain age? Some ‘old’ drivers can drive; some cannot.
- Young female drivers are becoming more reckless and aggressive.
- Pets loose in a car or the back of a truck are a hazard.

RCMP Kings and Bridgetown Detachments

Bob Dewar and Ken O’Brien met with members of the RCMP Kings and Bridgetown detachments at the RCMP office in New Minas on Monday morning, May 15, 2000. The Kings detachment patrols all of Highway 101 sections in Kings County and the Bridgetown detachment patrols Annapolis County study sections between Kingston and Bridgetown.

The discussion opened with a comment that the members generally consider that Highway 101 is as good as any of the other 100 series highways that they patrol throughout Nova Scotia, however, there have been many fatal crashes. They are entering partnerships with TPW and emergency medical services, and are attempting to involve the insurance industry, to use the three E’s (Engineering, Education and Enforcement) to make the road as safe as possible until it can be twinned. They are ‘pooling’ resources from Halifax, Windsor, Kings and Bridgetown detachments to organize major Checkpoint activities at periodic times in the various patrol areas. The Kings detachment has six highway patrol positions, but two are seconded to other projects. Bridgetown detachment has three highway patrol positions, however, they have also ‘lost’ one to another project.

Several comments made at the meeting are:

- Funding is needed for additional enforcement.
- Four hour blocks of paid overtime at a cost of about $200

would be an effective way to overcome staff shortages.

- Funding arrangements with insurance companies, similar to the safety support in British Columbia, is needed to support safety advertising.
- RCMP need the support of the community to aid in creating better driving habits.
- Should photo radar be introduced for speed enforcement? If implemented, the Nova Scotia Motor Vehicle Act would require changes to permit charging the registered owner of a vehicle 'caught' in a radar photo .
- Driver inattention was involved in most fatal crashes.
- Graduated speeding fines would help reduce speeding.
- Slow drivers are also a problem; need a minimum speed limit.
- Over steering and poor shoulders have been involved in many collisions.
- 'Downhill' passing in the center climbing lane is a problem.
- Reductions in speed limits should be considered at St. Croix as well as east and west of the exiting 90 km zone at Windsor.
- Ben Jackson intersection should be eliminated.

RCMP Windsor Detachment

Bob Dewar and Ken O'Brien met with members of the RCMP Windsor detachment at the RCMP office in Windsor on Monday afternoon, May 15, 2000. The Windsor detachment patrols all of Highway 101 in Hants County. While the detachment has four highway patrol positions, only two were available at the time of the May meeting. It was expected however, that three highway patrol members would be available after the end of May.

Although many of the observations are similar to those made at the preceding meeting, the following comments have been noted;

- Volumes on the Hants County sections of Highway 101 are so high that any crossing of the centerline has a high probability of a crash.
- Inattentive driving is a serious problem. Drivers have been observed talking on a cell phone, eating breakfast, reading a book, putting on makeup, and shaving while attempting to drive.
- Drivers on the long wooded section between Mount Uniacke and Ellershouse seem to be prone to highway hypnosis. On one occasion a driver who was stopped after passing a marked patrol car at a speed well in excess of the legal limit, did not recall having seen the police vehicle!

- Downhill passing on climbing lanes is a problem in Hants County that has been a factor in many near misses reported to the detachment office, often by shaken and angry tourists.
- Since there is often two or three days warning of a pending snow storm, and weather reports are good so that it almost always snows when expected, salt trucks should be loaded and spotted at either end of the patrol area so that there is no delay in preventing or reducing slippery roads.
- The Stillwater railroad overpass seems to be very rough.
- ‘Milepost’ markings are required to provide some identification of locations on long remote sections of highway.

Department of Justice and RCMP Halifax

Bob Dewar and Ken O’Brien met with representatives of the Department of Justice Police & Public Safety Services Division and the RCMP Highway Patrol in Halifax on Tuesday morning, May 16, 2000. There are 91 approved highway patrol positions throughout the Province, however, only about 60 of these are actually assigned to highway patrol. It was indicated that there are changes coming in traffic law enforcement and that a ‘white paper’ on policing is being prepared.

The following comments were noted during the discussion:

- How do drivers respond to police presence? How long is a driver affected by seeing a police car?
- Rest areas or pull-offs are required where there are long sections of highway between interchanges.
- High risk areas should be marked with illuminated changeable message signs. There is a need for better traffic lines that will last longer.
- Traffic accident costs should be related to health care costs.
- Has the installation of shoulder rumble strips (snooze grooves!) been considered.

3.2 Interviews with Truck Drivers

May 30, 2000 Checkpoint

Ken O'Brien interviewed truckers at a combined RCMP and Business & Consumer Affairs Vehicle Compliance Checkpoint on Highway 101 westbound at Ellershouse, on Tuesday, May 30, 2000. Questions asked concerned establishing familiarity with Highway 101 and drivers comments concerning any problems that they had experienced or noted on Highway 101. Questions were also asked concerning Highway 103 and the four lane sections of Highway 102 and 104.

Comments were obtained from fourteen truck drivers. Most were driving six axle tractor trailers and made several trips per week on various section of Highway 101. Several drivers interviewed indicated that they make up to four return trips per day between New Minas / Kentville / Coldbrook and the Halifax area. The following comments were noted concerning the Study Section of Highway 101:

- Passing lanes are required between Coldbrook and Bridgetown.
- Slow drivers going 70 to 80 km/h impede truck traffic. Often cars behind a truck blame the truck for the delay and then show their displeasure by cutting in too quickly when passing the truck.
- There seem to be many 'idiot' drivers who pass on solid lines or in the face of oncoming traffic.
- Drivers don't yield at entrance ramps. Some ramps, such as the westbound entrance at Exit 8 Hantsport, are much too short.
- End of climbing lanes causes confusion. Car drivers insist on 'racing' the truck to the end of the lane and then don't permit the truck to merge properly.
- Winter maintenance is a problem in Hants County. Plows and salt trucks do not seem to get out soon enough after the start of a storm.

Truck drivers also provided the following comments concerning the two lane controlled access Highway 103 and four lane Highways 102 and 104:

- Two truckers reported that driving Highway 103 is easier and less stressful than driving Highway 101. The drivers on Highway 103 don't seem to be in as much hurry as those on Highway 101 and are much less aggressive.
- Other drivers commented that Highway 103 was about the same as Highway 101, except Highway 103 had more passing

lanes and was more hilly than Highway 101.

- Several drivers had only one word - GREAT! - to describe four lane highway 102 and 104, except they thought both highways had some sections with extremely poor pavement.
- Four lane highways are safer because slower vehicles can be passed safely and because 'off the road' vehicles simply go in the median or ditch without the hazards of head-on crashes.
- There are many cars off the road on Highway 102 during winter months. People still do not pay attention and fail to adjust travel speeds to meet adverse road conditions.

3.3 Focus Groups

Introduction

Three Focus Group meetings were held as part of the public input to this project. The meetings were held in TPW area office boardrooms in the following communities:

1. New Minas; Monday June 12; 11 in group;
2. Windsor; Wednesday June 14; 10 in group;
3. Bedford; Tuesday June 27; 6 in group.

The purpose of the Focus Groups was to:

1. Obtain input from diverse user groups; i.e. male/female, young/middle age/senior.
2. Obtain input from local residents.
3. Create an interactive forum to focus on the issues and driving experiences from a users perspective.
4. Collect evaluation data and written comments on the highway.

Focus Group Members

It was originally intended that Focus Group volunteers would be obtained by random calling from community telephone directories. As the study progressed, however, it was realized that the public generally are being 'hounded' by too many telephone interviews and are not receptive to even a few minutes on the telephone unless they are extremely interested or committed to the topic being discussed. After meeting with the Windsor RCMP in mid-May and learning of their planned May 30 Checkpoint on Highway 101, it was decided that:

1. Trucker interviews obtained at the roadside Checkpoint would provide a 'focus' group type of response from professional truckers who might not otherwise be available to attend evening group meetings; and
2. The RCMP would distribute questionnaire requests for Focus Group volunteers.

The truckers interviews were completed on May 30 as planned (see Section 3.2). Also, the RCMP distributed 400 short questionnaires intended to collect information concerning the persons resident community, age, gender and driving habits. The flyer indicated that since drivers of Highway 101 were an important source of Highway 101 safety information, focus groups were planned for both New Minas and Windsor. Those interested in joining a focus group were invited to fax, email or mail their completed questionnaires. The returned questionnaires formed the basis for forming each group. When people were called, they were already agreeable to taking the time to get involved. Additional 'volunteers' were solicited from 'twinning' petitions that were made available as Study resource material.

Typical Session Operation

At the start of each session, participants completed a survey form allowing collection of demographic data, their ratings on highway features, and their comments on difficulties they have experienced as well as difficulties they've noticed others experience. Complete documentation of group demographics, comments, results and focus priorities are included in Appendix C for each of the three groups as indicated in Table 3.1.

After completion of the form, the Nominal Group Technique was used to solicit issues each participant had regarding the highways. To increase individual generation of issues, the group facilitator asked everyone to think of different driving scenarios such as rush hour, daytime, nighttime, seasons of the year, types of other vehicles on the road, and any driving problems they had experienced.

Individuals typically had five to ten issues each with a few having fifteen or more. After participants completed their own list of issues, the group facilitator asked each person in turn for one issue at a time. The issue would be clarified so everyone had a good understanding of the issue after which it was itemized on a flip chart. This method of obtaining and clarifying issues gave each individual equal opportunity to participate without anyone dominating the floor. As issues were tabled, discussion was encouraged to FOCUS in on the specific part of the highway where issue was taken. In one example, an individual stated an issue with Highway 101 is ALL passing lanes were too short. After discussion, specific passing lanes were identified as too short versus all of them to which the individual agreed. After continually going around the room to each participant clarifying and capturing issues, a master list was obtained with 28 to 30 issues for each of the three groups.

It was recognized that it was not practical to discuss and recommend specific solutions for all 28 to 30 issues and there was need to prioritize what issues should be dealt with and in what order. To accomplish this, each participant wrote down what they felt were the top five issues from the master list. The facilitator then asked each participant what their top five issues were, keeping a count of which issues were selected. The counts were totaled and prioritized based on the total counts.

The issues were then discussed starting with the highest priority. As part of the discussion, possible solutions were suggested for each issue discussed. The number of issues that were discussed in detail ranged from six to eight for each focus group.

Table 3.1 - Guide to Focus Group Data

Data Item	Table in Appendix C that Contains Group Data		
	New Minas	Windsor	Bedford
Demographics	C-1	C-5	C-9
Comments Concerning Highway Features	C-2	C-6	C-10
Responses to Questions	After C-2	After C-6	After C-10
Group Results or Issues	C-3	C-7	C-11
Priorities and Possible Solutions	C-4	C-8	C-12

Summary of Focus Group Priorities

The comments at the end of each session were positive. Participants appreciated the opportunity to discuss a prioritized list in an orderly manner. Using the Nominal Group Technique and prioritizing the issues kept everyone involved with no one person dominating the conversation for extended periods. Participants left the session feeling they made a contribution to a high profile issue. FOCUS was brought to the issues raised.

Focus was definitely achieved with the diverse individuals from local communities who use the highway in a variety of vehicles and times of day and year. The 21 prioritized issues from the three groups could be narrowed down to eight focused issues. Of these eight issues (Table 3.2), six of them are related to the physical issues with the actual highway and two are related to driver issues. There were more issues (see Appendix C) that time did not permit discussion. Table 3.2 lists the key focus issues.

Table 3.2- Key Focus Issues for the Three Groups

Number	Issue	Highway or Driver Related?
1	Passing Lanes	Highway
2	Hydroplaning	Highway
3	Road Markings	Highway
4	Speed	Driver
5	Ben Jackson Intersection	Highway
6	Shoulders	Highway
7	Stillwater Overpass	Highway
8	Driver Inattention	Driver

4.0 Highway Design and Construction

Overview

The Study required a general review and description of roadway geometry. This section of the Report considers the geometric design standards used for the study sections of Highway 101 and comments on how the constructed highway complies with these standards. Discussion includes horizontal and vertical alignment, cross section and bridge structures. Mr. Bruce Higgins, P. Eng., of *CBCL Limited.*, has completed this task.

4.1 General Description of Highway 101

Study Area and Classification

The study area of Highway 101 extends 140 km from Mount Uniacke (Exit 3) to Bridgetown (Exit 20). The highway cross section typically consists of two lanes, and is undivided, and the design speed is considered as 110 km/h, or 70 mph in the older section, except as noted below. Accordingly, the highway is generally classified as RAU 110 (rural arterial undivided, with a design speed of 110 km/h).

There are two short four lane sections, located at Ellershouse and Avonport. There are numerous uphill grades where there is an auxiliary climbing lane, in addition to the two basic lanes.

The study area, in its length, includes the transition section from four lanes to two lanes at Mount Uniacke, and the interchange at Bridgetown. The study area, in its width, is considered to include the paved lanes as well as the shoulder and slopes, as applicable. At interchanges, the study area includes the portion of entrance and exit ramps immediately adjacent Highway 101, and does not extend to the ramps in general or their intersections with the minor roads.

Road Segments

The exit numbers increase from east to west, and this direction has been used for the sequence of road segments discussed. Segments are considered the portions of roadway between interchanges, and distances along the segments are taken from the eastern end of segment, i.e. lower exit number. Exit and Section Numbers are included on Figure 1.1. Exit numbers, locations, and interchange types are included in Table 2.1.

4.2 Geometric Design Standards

Reference Standards and Guidelines

The design and construction of Highway 101 from Mount Uniacke to Bridgetown took place between approximately 1966 and 1985. Work proceeded generally from Mount Uniacke westward. During this period, highway design and construction methods changed, as evident from the different standards used. The design standards used as reference are as follows, with abbreviations as noted:

- *Geometric Design Standards for Canadian Roads and Streets*, Canadian Good Roads Association, 1963 and revised to 1973 (CGRA 1963)
- *Geometric Design Standards for Canadian Roads and Streets*, Roads and Transportation Association of Canada, 1976 (RTAC 1976)
- *Manual of Geometric Design Standards for Canadian Roads*, Roads and Transportation Association of Canada, 1986 (RTAC 1986)
- *Geometric Design Guide for Canadian Roads*, Transportation Association of Canada, 1999 (TAC 1999)
- *A Policy on Geometric Design of Rural Highways*, 1965, American Association of State Highway Officials (AASHO 1965)
- *Standard Specification, Highway Construction and Maintenance*, Nova Scotia Department of Transportation and Public Works, 1997 and revised to 2000 (TPW 1997).

The **original roadway design** would have been based on the Canadian and provincial standards of the day. Accordingly, this would primarily mean the CGRA 1963 and RTAC 1976 documents. The AASHO 1965 publication, often referred to as the "Blue Book", was commonly used as a reference document to the Canadian standards. While the major design criteria would be covered in these national standards, other details not specifically covered would usually be governed by provincial standard specification.

The original design can be compared to **current roadway design**, which would typically refer to TAC 1999 and TPW 1997 documents. This will illustrate where the standards or guidelines have been upgraded.

Based on reported dates of Highway 101 design and construction, it is therefore assumed that CGRA 1963 will apply from Mount Uniacke to Kingston, and that RTAC 1976 applies from there to Bridgetown.

Design Components

The geometric design components are dealt with separately, with the entire section from Mount Uniacke to Bridgetown discussed under each appropriate design item. The various design topics are generally those cited in reference publications : horizontal and vertical alignment, cross-section elements, interchanges, structures, as well as other items.

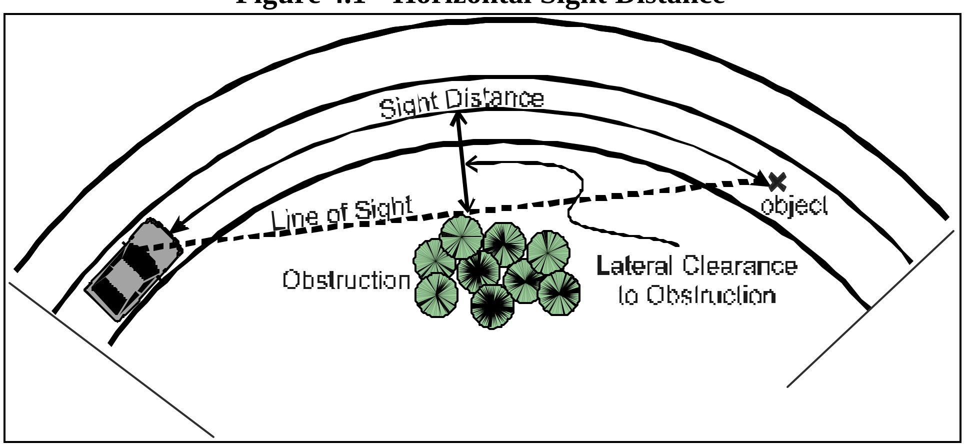
4.3 Horizontal Alignment

Design Issues

The main aspect of horizontal alignment is the relationship between curves and tangents, and transition spirals, if used. The rate of curvature used must be safe and comfortable, and is related to the design speed, friction factor of the pavement, and the superelevation of the highway. (Superelevation is the slope of the roadway in the direction transverse to traffic, and is used in combination with pavement friction to compensate for the effects of centrifugal force from the vehicle; it is adjusted according to the rate of horizontal curvature to give a consistent "feel" to the roadway.)

Horizontal curvature can also affect sight distance (Figure 4.1). Objects on the side of the road (e.g. vegetation, backslopes, bridge structure, etc.) can restrict the driver's ability to see oncoming cars or an obstruction on the roadway. Sight distance is required to safely stop for such an obstruction (stopping sight distance) or pass other vehicles (passing sight distance).

Figure 4.1 - Horizontal Sight Distance



The design speed used for design would probably be 10 mph over the posted speed limit. In the case of Highway 101, with a posted speed of 65 mph, the presumed design speed was 70 mph for the portion previous to 1976. After 1976, the RTAC manual is in metric units, and it is presumed that the design speed was 110 km/h.

Therefore, based on CGRA 1963 and AASHO 1965, the maximum permitted horizontal curve would be a 3º00' curve (or minimum 1910' radius) for 70 mph design speed, which would be revised to 4º30' curve (or 1274' radius) for 60 mph. (Please note that degree of curve, a term which is no longer used with design in metric units, refers to the angle subtended by a chord of 100' ; consequently, the larger the degree of curve, the sharper it is or the smaller the radius.)

The current equivalent recommendations from TAC 1999 are 750 m for a design speed of 120 km/h, and 440 m for 100 km/h, using a maximum superelevation of 6%. Essentially, this represents a soft conversion from English units of earlier standards into metric units of the current code.

Site Conditions

The highway in the Windsor area has a reduced speed zone (to 90 km/h) and several horizontal curves, the sharpest a 4º30' curve, suggesting a design speed of 60 mph. This speed is confirmed by the rate of superelevation used in the same area. Hence, the posted speed limit of 90 km/h is appropriate as it leaves a margin between the speed limit and the design speed.

The remainder of the Highway 101 in the study area is believed to have minimum radius curves consistent with a 110 km/h design speed.

Accordingly, the posted operating speed is consistent with the apparent design speed, and the design for horizontal curvature is generally consistent with current and previous design guidelines.

4.4 Vertical Alignment

Design Issues

The most important criterion for vertical alignment is the **maximum grade** permitted for the classification of roadway. Heavy vehicles have difficulty maintaining their speed on uphill grades, which affects other following vehicles. This causes other vehicles to slow down, increases the passing maneuvers required, and thereby reduces the capacity of the roadway. Accordingly design criteria are set for the desirable maximum grades and the extreme maximum grade, based on the classification of roadway, including the design speed, and the type of terrain encountered. Grade of a roadway is simply the vertical change in elevation divided by the horizontal distance, expressed as a per cent.

Vertical alignment (Figure 4.2), often called the profile, is quite often the determining factor in sight distance. **Crest vertical curves** occur when there is a negative change in grade in the direction of travel e.g. tops of hills; this limits sight distance (Figure 4.3) as objects are effectively hidden behind the crest of the roadway from the driver's view.

Figure 4.2 - Vertical Alignment

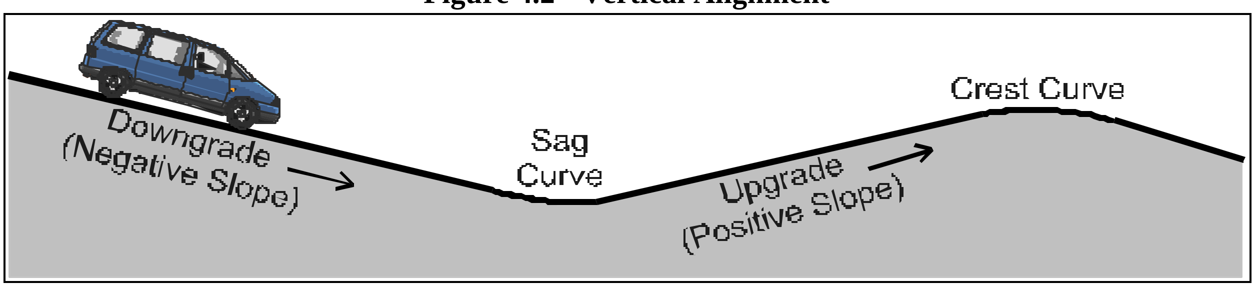
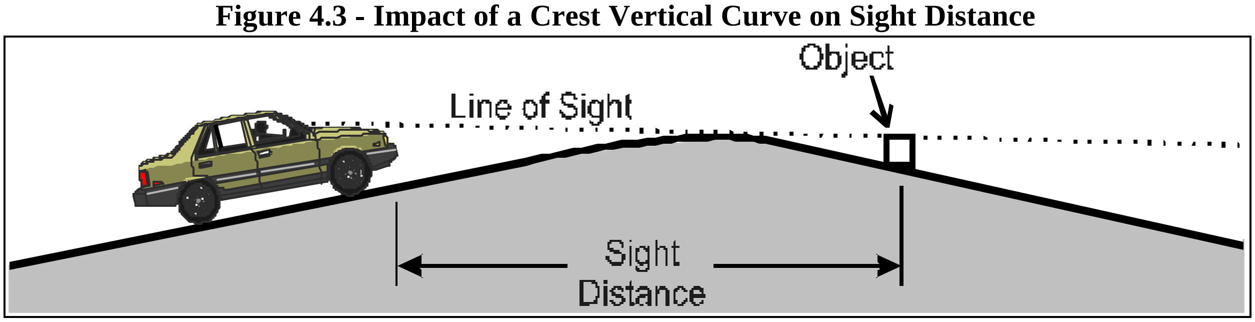


Figure 4.3 - Impact of a Crest Vertical Curve on Sight Distance



As mentioned during the design for horizontal alignment, sight distance is required for both stopping and passing. Sight distance can be improved by making longer vertical curves for the slopes at either end of the vertical curve. The design parameter used to define the curvature for a vertical curve is called the K-factor**.** The larger the K-factor, the longer the vertical curve, and the greater the sight distance.

Recommended K-factors have changed in the last 40 years in design guidelines. The recommended K-factors changed from imperial units (feet) to metres in the RTAC 1976 code. But the actual design values were generally increased in 1986, and then increased again in 1999. The example below illustrates a history of how recommended values have gradually increased.

Publication	Design Speed (km/h)	Minimum K-factor (ft)	Minimum K-factor (m)
CGRA 1963	110*	230	70
RTAC 1976	110	n.a.	85
TAC 1986	110	n.a.	85
TAC 1999	110	n.a.	110

* interpolated value

Sag vertical curves occur when there is a positive change in grade, e.g. bottom of valley. Since they are not subject to a blind spot over the crest of curve, the sag vertical curve is usually governed by driver comfort or the nighttime sight distance limited by the motorist's headlights.

Site Conditions

The steepest grades observed in the study area were west of the Hantsport Interchange (Exit 8) at +6.0% westbound, and the long hill east of the Avonport Interchange (Exit 9) at +5.8% eastbound These areas both have climbing lanes. This indicates that the standard used was to satisfy a design speed of 60 mph by CGRA 1963. Based on the later RTAC 1976, the maximum grade of 6% is consistent with a design speed of 110 km/h, while it drops to 5% for a design speed of 120 km/h. Consequently, the maximum grades used are a little steeper than would ideally be desirable. Considering the terrain involved, this is not unreasonable. Meanwhile, the terrain after Exit 14 (Coldbrook) becomes quite flat, and the maximum grade requirement does not apply.

The vertical curve information observed shows K factors in the 75m (250') range. This is consistent with minimum stopping sight distance for 70 mph by CGRA 1963, but only a design speed of 100 km/h by RTAC 1976, then to under 100 km/h by the TAC 1999 guidelines. Thus, although the length of vertical curve is in conformance with the standard of the day in 1963, it does not meet the current design guidelines. This of course reflects poorly on the section of the study area constructed before 1976, i.e. almost 100 km from Mount Uniacke to Kingston. This area obviously contains the area with the more difficult terrain, and likely has numerous crest vertical curves that are suited to a design speed of slightly under 100 km/h by current design guidelines.

4.5 Road Cross-Section

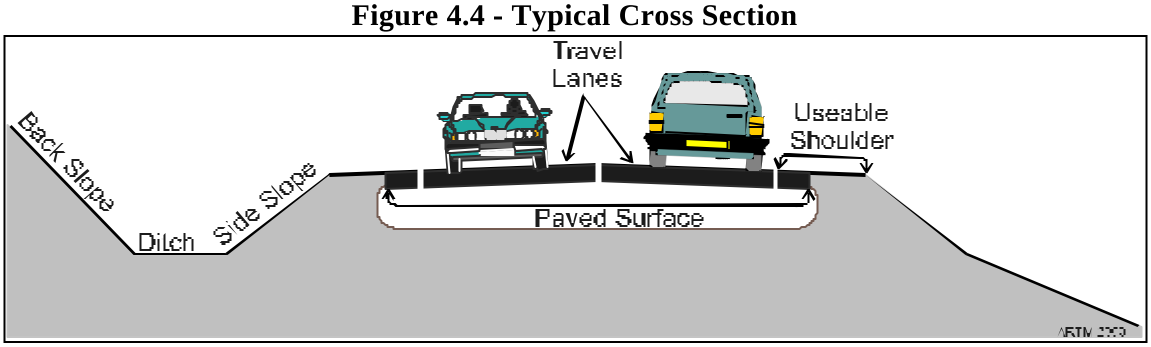
Design Issues

Design **lane widths** for an RAU 70 were typically 12'. This basic width was increased slightly to 3.75m for RAU 120 in 1976, which was rounded to 3.7m in TAC 1986.

For these same roadway classifications, recommended **usable shoulder** widths in 1963 were 8' to 10', based on the roadway volume. Shoulder widths were reduced to 6' at climbing lanes. There was no stipulation as to whether the shoulder would be paved or gravel. The usable shoulder requirement, given as 3.0m in RTAC 1976, still applies today.

Pavement widenings are theoretically required for heavy vehicle traffic at curves. Transition spirals are not commonly used in the province for horizontal alignment, and this would give more reason for widening on curves. Fortunately, the modest horizontal curvature does not suggest significant widening. This effect is compensated by the paved shoulders, although that is not the intended reason.

Figure 4.4 - Typical Cross Section



Railing systems are not discussed in detail in the CGRA 1963 or RTAC 1976 standards, which would have been applicable at the time of construction. Since then, both TAC 1986 and TAC 1999 have chapters discussing railings and barriers. These guidelines are quite general in nature, and design of railing systems can be somewhat judgmental.

While **sideslopes** are suggested as desirable at 4:1 for fill heights of up to 25' height, in CGRA 1963, it goes on to reckon that 2:1 is a reasonable minimum for stability, in earth fill, and 1½ :1 in rock fill, where railing is used. RTAC 1976, as well as TAC 1986 and 1999 effectively maintain these criteria. However, it is recognized that these side slopes are minimal and flatter slopes are encouraged wherever possible to improve safety for vehicles leaving the roadway.

Site Conditions

Lane widths are consistent through the study area, and meet the design guidelines.

The **shoulder widths** vary considerably throughout the study area, and range from 2.0m to 4.0m. The locations where the shoulder is less than 3.0m are often adjacent guide rail, which make the shoulder even more difficult to use. Where the shoulder is less than 3.0m, there is insufficient room to safely pull off the roadway. A disabled vehicle would therefore likely encroach on the traveled lane and be a definite hazard. Approximately 5 km of the study area is estimated to have shoulders less than 3m.

There are several areas where the gravel shoulder has not been built up after the asphalt repavement. This was most noticeable in the segment between Exits 4 and 5, where the **drop-off** or difference in height was measured at 120mm. The associated problem is breakup of the edge of asphalt, as it is unsupported. The sudden change in cross-section is startling to drivers who consciously pull over to the side, and even more so to those who may do so unknowingly.

Another constant hazard through the length of the project is access provided to the highway at woods road or farm road **driveways.** While many of these access points are dormant, as seen in the field, the sheer number of these “driveways” is a concern. Over 95 of these driveways were noted on a site visit. When the highway was constructed, it probably had volumes of around 2000 vpd, and such access did not pose serious problem. This is no longer the case.

The practice of using wooden posts to mount **delineators** is somewhat questionable. The maintenance of these seems to be erratic, and these unprotected wooden posts present a hazard for collision.

Guide rail posts are frequently out of plumb by up to 30º, likely from snowplow operations, and the structural integrity of the posts becomes a concern.

4.6 Interchanges

Design Issues

Interchanges are the connection between the highway and the road network. They must efficiently deal with traffic at highway speed, at one end of ramp, and often a stop condition where the ramp meets the minor road. The ramps are called exits or entrances relative to their function for the highway. The main aspects of interchanges which are relevant to this study are interchange type, ramp designs notably at the highway end, interchange spacing and consistency.

The most common **interchange type** by far in Nova Scotia is the diamond interchange, which is the shape normally described by the four ramps which require use of all four quadrants; the **diamond** interchange assumes that a stop condition at the intersecting road is suitable, and hence the near perpendicular alignment to the minor road. The basic diamond interchange is readily understood by the driver, and relies on natural right hand turns.

The second most prevalent type of interchange is the **parclo**, essentially an abbreviation for ‘part cloverleaf’. The parclo shape is usually utilized when one or more of the quadrants is not practically available due to terrain, or to property requirements. The typical parclo incorporates two loop ramps and two direct ramps outside of the loops. Parclos are subdivided into type A where the loop ramps are in the near sides of the minor road (as viewed by traffic on the highway), type B where the loops are on the far side, or type AB with loops on adjacent quadrants on one side only of minor road.

The type of interchange selected will depend on factors such as classification of roadways, traffic speed and volume, topography, property, land use, safety, and economics.

Ramps must be designed to accommodate deceleration for exit ramps, and acceleration for entrance ramps. This change of speed must be considered in the geometric design of the ramps. Ramp design speed should be related to the highway speed.

From CGRA 1963, the desirable ramp speeds are 10 mph less than the highway design speed, and the minimum ramp design speed is 30 mph for highway design speeds of both 60 and 70 mph. These values were nearly soft converted to metric units for RTAC 1976; the increment between highway design speed and desirable ramp design speed was 20 km/h, while the minimum ramp design speeds are 50 km/h from a 100 km/h highway or 60 km/h from 110 or 120 km/h highway design speeds.

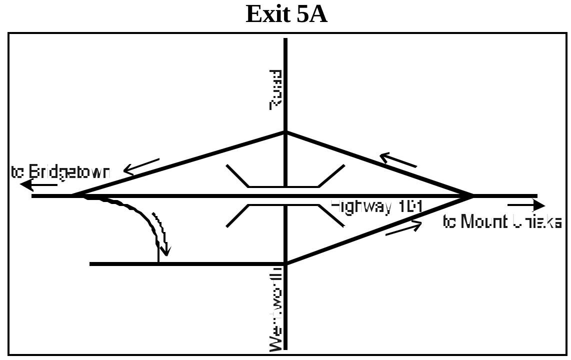
Interchange spacing is determined by the need to serve surrounding communities, and interchanges are often located to incorporate access to an arterial roadway. While service to the community is important, interchange spacing must be balanced with the need to provide ample separation of interchanges along the highway to allow for safe operation of the interchanges. Spacing must not be so close as to attract local traffic, which reduces the highway capacity, and compromises the safety of the highway with mixing of local (usually slower) traffic and the through traffic.

Site Conditions

The western section of the study area is generally a good example of selection of interchange types and interchange spacing. Diamond interchanges, or portions thereof, are utilized exclusively from Exit 10 (Hortonville / Grand Pre) to Exit 19 (Lawrencetown) and the average spacing between interchanges is about 8 km. Most of the interchange design concerns are located in the older, eastern section of the study area.

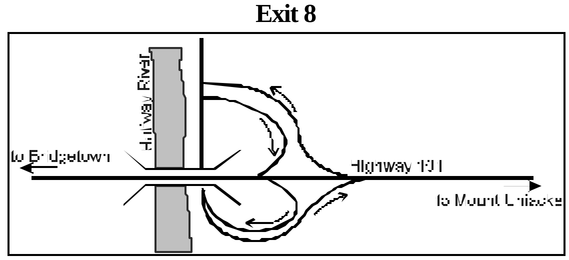
Exit 5A at Wentworth Road to Windsor has an unusual configuration. The exit ramp on the eastbound side is compromised by combination with an access road to properties in the SW quadrant, and apparent limited property availability. The net result is an intersection on the ramp, and a low speed exit ramp (approximately 30 km/h) for highway traffic eastbound.

Exit 5A



Exit 8 near Hantsport is located in difficult terrain in a deep valley with the Halfway River. The loop

Exit 8

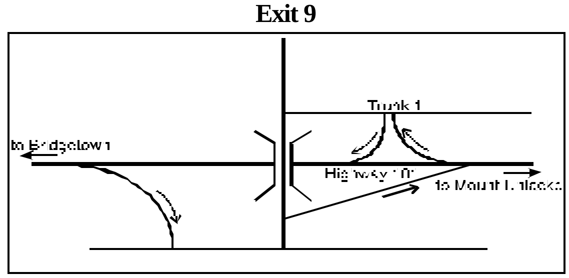


entrance ramp for westbound traffic has an advisory speed sign for 30 km/h, then merges with the highway just before the bridge across the river ; a climbing lane is located on the far side of the bridge on a 6% slope. Heavy vehicles entering the highway at this location are unable to reach highway speed and are particularly exposed to downhill traffic approaching from the east, as the climbing lane is not available until after the two-lane bridge.

Exit 8A, Ben Jackson Road, is an at-grade intersection, a clear anomaly for a 100 series controlled access highway. While the intersection is located in an area with generous sight distance, the fact that it is an intersection, rather than an interchange, is unexpected and places unreasonable demands on the driver. Auxiliary turning lanes are included on the highway, which invites vehicles stopped for left turns to sit between 100+ km/h streams of traffic. Vehicles entering Highway 101 are accelerating from a stop condition and are a hazard to Highway 101 traffic. This intersection is a carry over from early construction on Highway 101 and does not belong on a controlled access highway.

Exit 9 at Avonport has an unusual configuration and ramp design. The configuration is crudely a combination of parclo and diamond style interchange, but staggered to fit the apparent limited property available. The ramps, except for the eastbound access ramp, are short and do not provide ample room to accelerate and decelerate to and from Highway 101.

Exit 9



Interchange spacing in the Windsor / Falmouth area has four interchanges (Exits 5, 5A, 6 and 7) within less than 6 km. The close spacing of these interchanges (from 1.7 to 2.2 km) has the potential to reduce highway capacity and compromise the safety of the highway with mixing of local (usually slower) traffic and the through traffic. Trunk 1 provides an alternative route in this area, but the close spacing would still attract local traffic. "Twinning" of the highway in this area could result in a new alignment, as the railway and the Avon River present formidable restrictions. The interchange spacing and provision of adequate and convenient accesses for the area can be rationalized during the twinning process.

The other close interchange spacing is at 17E and 17W. However, this split diamond interchange do not have consecutive exits and the design suits the location.

4.7 Bridge Structures

Design Issues

Overpasses are defined where the structure carries Highway 101 over a minor road, river or railway.

There are design cross sections for overpasses given in CGRA 1963 .The recommended lateral clearance (from traveled way to face of sidewalk) for a RAU 70 roadway is 8' when there is a sidewalk, and 10' without. (The safety curb concept used in Nova Scotia was not depicted in the standard details). The safety curb, in conjunction with a traffic railing system, is intended to resist a lateral design load, representing an errant vehicle which could be redirected towards the road.

In 1976, RTAC gives the horizontal clearance at safety curb for short overpasses to be 3.0m for 110 km/h, and 3.25m for 120 km/h, which is including a 500mm dimension for the curb. In 1986, the clearance of 3.0m is given for both of these speeds. The corresponding figure for long overpasses (>50m) is 1.8m, for both 1976 and 1986. The short overpass guidelines were maintained for TAC 1999, with a slight relaxation on long overpass clearances.

The railing system on the bridge should function in continuity with the railing system on the adjacent portion of roadway.

The most noticeable feature of an overpass to the motorist is usually the number and quality of the bridge joints, which are transverse to the direction of traffic. Simple spans have joints at the end of each span, while more recent structures have continuous designs which reduce the required number of joints. Rough joints are often objectionable for driving comfort, but can be a hazard for vehicle control in slippery conditions, where accompanied by breakup of the asphalt, or for snowplows.

Drainage of bridges is often facilitated by a series of small diameter drains at the curb line. While spacing of drains is often more frequent than necessary, they are often prone to clogging with debris. One of the most important aspects are the grades on the bridge and immediate area, such that positive drainage will be achieved on the bridge structure. This is important, as the bridge structures will freeze before the adjacent roadway, as typically noted on signage.

Underpasses are where the major highway passes under a bridge carrying the minor road above. The main concerns for an underpass are lateral clearances to railings and piers, vertical clearance to the underside of the bridge superstructure, and restriction in sight distance by the structure.

Clearances at underpasses are given in the Canadian standards as follows for RAU 70 (mph) or RAU 120 (km/h) are recommended at 10' in 1963, then increased to 3.5m in 1976, and to 4.7m in 1999. The clearance dimension is taken from the edge of the traveled lane to the pier face, with guide rail understood to be located in front of the piers.

While the geometric design criteria for bridges has not changed substantially since original construction, the **design truck loading**, as well as the actual truck traffic, has become progressively heavier. This is true across the province, and in itself is a significant safety issue. However, it is considered outside the scope of work of this study.

Site Conditions

There are approximately 28 overpasses and 19 underpasses in the study area. There are many consistencies in the design of the typical three span overpasses from Mount Uniacke to approximately Exit 17W.

These bridges were constructed up until 1978. The similarities include the **safety curbs** being typically 0.5m wide, with a curb height of approximately 200mm, reduced in varying amounts by the thickness of asphalt. The railing system is a steel beam guide rail, which is supported on 6" steel posts which are bolted to the side of the deck. The spans are simply supported, meaning that on a typical three span overpass that there are four joints. The offset from the painted edge of the traveled lane to the face of curb is typically around 2.5m. The safety curb and offsets generally fit the RTAC 1976 standards.

The offset distance from the edge of traveled lane to face of curb is reduced to 1 to 1.5m for long bridges, e.g. Halfway and Gaspereau Rivers.

At several underpasses, there was some variation noted in the existing **lateral clearances**. The oldest underpasses have a clearance of 3m, while most from Exit 12 to the west are in the range of 3.5 to 4.0 m. Hence, the railing offsets meet the requirements at the time they were built, but not the most recent recommendations.

The common **railing detail** which is consistent from start of the study area to near Kingston is that the roadway and bridge guide rail are completely independent, and the gap between the two railing systems can be as large as 2m. The overpasses past Kingston have a detail where the roadway railing is directly connected to the end block on the abutment wing wall; this arrangement should help in vehicles avoiding a head-on collision with the concrete end block, and having a better chance at recovery.

One notable deficiency is the railing system on the westbound truss bridge over the Gaspereau River. The railing system itself is not typical of others, and is not considered a traffic railing, but essentially only a handrail. On the eastern approach to the bridge, three posts are noticeably off plumb; a previous collision has displaced the posts in an area which is exposed to the river below, and is beyond the through portion of the truss.

Drainage on bridges is important as bridge decks are prone to freeze before roadways, which is hazardous as drivers will tend to judge road conditions by the surface of the roadway proper. Two problems which were noticed were grading in the bridge vicinity, and bridge drains which were plugged with debris and organic material. The latter problem was quite evident on the overpass at Exit 20 near Bridgetown.; the drain locations are evident where grass grows in the gutter because of the deeper soil at the plugged drains.

Bridges where the low point in the roadway drainage is located very near the end of the bridge are the Halfway River Bridge, near Exit 8, and the Deep Hollow Bridge 1.4 km west of Exit 11. The concern here is that the longitudinal grade in combination with crossfall (or lack of it due to the transition area of superelevation) creates very flat areas which are still on the deck, which could be compounded if curbs or expansion joints hinder positive drainage. These areas have the potential for serious icing hazard, and should be monitored during storm runoff to better assess the problem.

4.8 Discussion

Changes in Design Standards or Guidelines

During the life of Highway 101 in the study area, national and provincial geometric design standards and guidelines have evolved. Current publications are more comprehensive than earlier documents. The current TAC publication is called a “design guide”, whereas earlier documents used the term “design standard.” This subtle name change reflects the intended use of the documents, and essentially acknowledges the complexity of roadway design. Earlier publications tended primarily to give “hard” geometric design standards, with associated tables and numerical values. While the TAC 1999 guide still includes most of the basic “hard”geometric criteria, it also includes “soft”recommendations such as extensive reference material, design discussion and philosophy, and suggested practice, and covers a much wider range of topics. The net effect requires more professional judgement by the design engineer, rather than reducing the design exercise to a relatively straightforward application of numerical values.

Notwithstanding the above, the changes in basic geometric design have been relatively modest. Recommended lane widths, horizontal curves and maximum grades have not really changed, with respect to the relevant design speed. Vertical curvature design has become more conservative i.e. longer sight distances are recommended for the same speed. While the current TAC guide encourages improvements in cross section elements such as shoulders, side slopes and roadside features, previous design standards are still considered in the range of acceptability, albeit presumably as minimum design.

In summary, while current industry practice encourages a much broader approach to the geometric design of roadways, during the life of Highway 101 **there have been only minor revisions to the basic geometric design criteria.**

Design Deficiencies of Roadway Alignment

The alignment of Highway 101 proper in the study area appears to have been designed generally in accordance with the relevant design standards current at the time. The most restrictive horizontal curvature appears to be in the Windsor area near Exit 6, at 4º30' curve, which is consistent with a design speed of 60 mph. The posted speed here is 90 km/h, about 10% below the design speed.

The vertical alignment, particularly in the rolling terrain between Exits 3 and 14, features frequent vertical curves. Data was not available to check all the vertical geometry. However, it appears that many of the crest vertical curves are marginal in that they would have been designed to CGRA 1963 vertical curve criteria, which has subsequently been upgraded. Consequently, it is felt that many vertical curves here would have stopping sight distances now considered appropriate for the posted speed of 100 km/h, with no margin between the design speed and posted speed.

In summary, the horizontal and vertical alignments appear to be designed in accordance with applicable standards at the time, with a margin of 10 mph (or over 15 km/h) between the design speed and the posted speed. However, revisions to the standards for vertical curves means that the vertical alignment design would now be considered appropriate for approximately the posted speed of 100 km/h only.

It must be noted that detailed examination of all the highway geometry was not performed, as it was not readily available. However, it appears that the vertical alignment will govern the overall design speed in the rolling terrain. Therefore, it appears that by current guidelines **design speed of the alignment is generally 100 km/h from Exits 3 to 14, and 110 km/h from Exits 14 to 20.**

Design Deficiencies of Cross Section

The shoulder width is considered deficient where it is less than 3m, except at bridge structures and their immediate approaches. (This is irrespective of the shoulder having a paved or gravel surface.) Narrow shoulders occur at several areas (representing about 5 km total) typically where there are high embankments with guide rail. The railing system further reduces the usable width of shoulder. Narrow shoulders effectively prevent a vehicle from pulling safely off the traveled way. This problem appears to have been a compromise in the original design.

There are numerous areas where there is a bothersome dropoff between the edge of the paved shoulder and the gravel shoulder. Many existing areas of guide rail are in poor condition. While these items are essentially maintenance issues, they are also part of the design of the basic cross section.

There are several areas where wooden posts are used to mount delineators, which should be reviewed for replacement by guide rail.

The frequency of access of farm road and woods road driveways is nearly one per km, and is inconsistent with a controlled access highway, especially the future four lane roadway. Since these will be eliminated during twinning, it is recommended that these accesses be reviewed and, where practical, phased out in preparation for the future four lane alignment.

In summary, the noted **deficiencies in the cross section compromise the safety and design speed of the roadway.**

Design Deficiencies at Interchanges

The series of interchanges from Exit 3 to Exit 9 is inconsistent in design configuration, including several substandard ramps as well as a section of interchanges with undesirable close spacing. The area also includes two short four lane segments. This area should have preliminary design completed for the future alignment of the four lane highway and interchanges. This would then permit selected **interim improvements in the present interchange deficiencies**, which would be consistent with the four lane highway design. **The Ben Jackson Road intersection is functionally inappropriate and should be eliminated.**

Design Deficiencies at Bridge Structures

The discontinuity of guide rail on bridge approaches with **railing** on the bridge should be corrected with connection of guide rail to the abutment end wall. This applies from Exit 3 to Exit 17W. The railing on the westbound Gaspereau River bridge should be upgraded to a traffic railing.

Grading and **drainage** at the local area on the ends of the Halfway River and Deep Hollow bridges should be checked for potential freezing hazard due to flat grades and/or bridge deck area. Deck drains should be cleaned and or repaired as necessary to prevent plugging, e.g. Bridgetown Overpass at Exit 20.

Observed Highway Speeds

As noted in Section 2.5, the 85^{th} percentile speeds observed on Highway 101 are generally 115 km/h. Only about 20% of traffic was found to be observing the speed limit of 100 km/h. While there is no readily available historical data for direct comparison, it is believed that traffic speed has increased over the years.

As noted above, revisions in design guidelines, and deficiencies noted in the roadway have effectively reduced the “design speed” of the roadway. The combined effect of increased operating speed and decreases in design speed of the roadway now means that probably the majority of traffic now exceeds what would likely be deemed a “safe” design speed of the highway.

Drivers do not necessarily recognize geometric design features which should cause them to reduce their speed. Despite improvements in vehicles, the design speed of the roadway is basically restricted by human perception and reaction and the geometric features of the road.

It is quite difficult to define a “design speed”, as there are so many factors and variables to consider and the characteristics of the roadway are changing. However, it is evident that the widely assumed concept that the roadway is designed for the large majority (say 85%) of driving speeds, and that there is a comfortable margin between the average traveling speed and the design speed, is not valid. The obvious inference, of course, is that when a tolerance for highway enforcement is added to the speed limit, speeders are not merely disregarding the speed limit but almost certainly exceeding the design speed of the highway.

Speed enforcement on Highway 101 should recognize these design concerns.

5.0 Highway Maintenance

Introduction

BV Atwell Engineering was assigned to review the maintenance aspects of Highway 101, which will include surface and shoulder conditions along with snow and ice control.

5.1 Maintenance Definition

Maintenance is Intended to Preserve, Repair and Restore

Highway maintenance can be defined as a program to preserve, repair and restore a system of roadways with its elements to its designed or accepted configuration. Also highway maintenance serves to keep the system in a condition that provides a high level of safety to the traveling public.

It is a matter of the agent being responsible to be prudent and reasonable in the level of maintenance that is provided. System elements normally include travel way surfaces, shoulders, roadsides, drainage facilities, bridges, signs, markings, and lighting. Included in the program are such traffic services as traffic signal operation and snow and ice control.

Maintenance performance standards should be available to define the physical conditions that indicate a need for maintenance and repair activities and indicate the character of workmanship and the properties of the completed product. Time and production standards should also be part of the performance standards.

Study Area Condition

TPW has not adopted written performance standards for highway maintenance programs. Staff interviews identified inconsistencies in maintenance activities and snow and ice control activities. There should be standards so the level of highway condition can be uniform across Nova Scotia. It is recommended that performance standards be developed.

5.2 Reviews Undertaken

Reviews and Interviews

In preparation for this report the following reviews were carried out:

1. Reviewed a list outlining the repaving / microsurfacing / chip seal of Highway 101 for the previous fifteen years.
2. Interviewed Area Managers: David Hamilton, Hants County; Bob Bieren, Kings County and Paul Stone, Annapolis County.
3. Visually inspected Highway 101 from Mount Uniacke (Exit 3) to Bridgetown (Exit 20).
4. Reviewed ARAN tapes as filmed this year by Transportation and Public Works.

5. Reviewed Ride Comfort Index (RCI) Reading graphs for the west bound lane.
6. Reviewed Wheel Track Rutting graphs for the west bound lane.
7. Reviewed Winter Operator's Manual.
8. Reviewed the Provincial salting summary for fiscal year 1999/2000 (Appendix 'E-5').

5.3 Roadway Maintenance

Surface Maintenance

Deficiencies, irregularities and debris on the road surface should be identified very quickly so corrective action can be made immediately. This enhances the safety of the motoring public.

Holes in the pavement have to be a foot or more long and wider than a tire to be hazardous [1] [Footnotes are displayed at the end of Section 5]. Pot holes are steep sided holes of varying sizes in pavement resulting from localized disintegration. Pot holes and localized failures should be patched within 24 to 36 hours of being reported. Weather can be a factor in the carrying out maintenance repairs, particularly in Winter conditions, but repairs should be made as soon as weather conditions permit. If there is a delay due to weather then warning signs should be erected to advise motorists. The placement of warning signs should be documented and the date and time of repairs should be documented.

Debris on the highway can be a very serious safety hazard therefore all debris found during an inspection should be removed immediately.

Surface Maintenance - Study Area Condition

The Area Managers interviews indicated that there was a form of road inspection which differed from area to area. There should be a consistent inspection method for Highway 101.

Staff should be assigned to inspect the road surface and shoulders once per day and document the findings and deficiencies. If there are no deficiencies found then this should be documented as well. Once a deficiency, such as a pot hole, is found then plans should be made to make repairs within 24 to 36 hours. If the deficiency is a potential hazard, warning signs should be erected immediately to warn motorists of the hazard.

Road Comfort Index (RCI)

The riding quality of pavement is the degree of riding comfort which the pavement provides to the traveling public. Potholes, cracks, frost heaves and 'rough' bridge decks create an uncomfortable ride, cause uneven tire and suspension wear, and may, if sever enough, cause lose of control. The potential for loss of control on rough surfaces is greater when the road surface is snow or ice covered.

The Ontario Ministry of Transportation have developed a *Manual for Condition Rating of Flexible Pavements* (see Appendix 'E-3') that provides criteria for evaluating the ride quality of a paved road. The Manual uses a rating system of from 0 (very poor) to 10 (excellent) to rate a study section of highway. The different ratings are summarized in Table 5.1.

Table 5.1 - Ride Quality Rating of Flexible Pavements

Rating Number	Ride Quality	Ride Description
8 - 10	Excellent	Very smooth ride
6 - 8	Good	Smooth ride; just a few bumps or depressions
4 - 6	Fair	Still comfortable ride; intermittent bumps
2 - 4	Poor	Uncomfortable ride; frequent bumps and depressions
0 - 2	Very Poor	Uncomfortable ride; constant bumps or depressions resulting in rattle and shake of the rating vehicle.

ARAN information obtained by TPW in May 2000 provided data on road surface condition and was provided as three separate items:

1. A video showing the road surface and shoulder surface proceeding first in a westbound direction and secondly in the eastbound .
2. A graphical printout of the Road Comfort Index (RCI) reading which is an indication of the road surface smoothness (see Table 5.1).
3. A graphical printout of the Wheel Track Rutting.

The videos were reviewed and chainages taken from the videos were noted and applied to the RCI graphs and the Wheel Track Rutting graphs. Also during site inspection odometer readings were taken at various land marks and the video chainages and odometer readings matched within 0.10 kilometers over the total length of approximately 141.26 kilometers.

The following information was added to the RCI Reading graph for the westbound lane (Appendix 'E-1'):

1. Exit numbers and names.
2. Repaving, final paving and chip seal records for the last fifteen years.
3. Scheduled repaving and microsealing for 2000.
4. Shoulder drop off measurements.
5. County Lines.
6. Some structure locations.

The minimum RCI acceptable to TPW is 5.5. This would be considered at the high end of 'fair' with the ride quality considered to be 'comfortable with intermittent bumps'.

Road Comfort Index - Study Area Condition

It was observed from the videos, site inspection and RCI graphs that all overpass structures had deck surfaces that are very rough with poor or very poor riding comfort levels. Several overpass locations were noted on the RCI Reading graphs and they are associated in most cases with RCI reading well below 5.5. Most of the westbound lane can be classified in the 'good' category with the exception of the section from the Newport Road Overpass (west of Exit 4 at chainage 25.76) to the Trunk 1 overpass west of Falmouth (chainage 37.1) which has an average RCI Reading below 5.5. Strictly to TPW's minimum RCI Reading standard of 5.5 this 11.3 kilometer section would qualify for repaving (see Appendix 'E-3').

The following sections are scheduled for repaving and microsealing in the current construction season:

1. Repaving, from approximately 1.4 km east of Exit 11 to Exit 13, Kings County.
2. Microsealing, from Exit 19 to Exit 20, Annapolis County.

The section in Kings County has an approximate average RCI Reading of 6.0 and the section in Annapolis County has an approximate average RCI Reading of 6.5, however, there is extensive density wheel track rutting in excess of 13 mm depth.

Wheel Track Rutting

Wheel Track Rutting can be defined as longitudinal depressions which can take the form of a single rut or double ruts, left in the wheel tracks after repeated load applications. Wheel track rutting results from densification and permanent deformation under load, combined with displacement of pavement materials. The depth of the depression is measured in millimetres (mm).

Refer to Appendix 'E-2' for the Wheel Track Rutting graph for the westbound lanes. Added to this graph are the exit numbers and names, and areas that are recommended for remedial treatment to remove ruts.

The hazard of wheel track rutting is that it can contribute to hydroplaning. The ruts will hold water and/or slush in the wheel tracks and not allow the cross slope of the road surface to drain water resulting from rain, thus increasing the water film thickness in the wheel tracks or sheets of ice in freezing weather. Also in snow conditions snowplows cannot clean snow from the distorted road surface easily because of the depressions. Ruts can be particularly dangerous to high speed traffic.

A tire is said to hydroplane when a thin film of water gets between the tire and the road surface, causing the tire to lose contact with the road surface. The hydroplaning wheel and tire will slow, causing steering and control to be eventually lost.[2] When wheel track water depth is sufficient to cover the macro texture, that is the exposed gravel in the pavement surface, and approaches the tread depth of the tire, hydroplaning may occur depending on vehicle speed and tire pressure.
The following equations are used to determine the speed at which an automobile tire will hydroplane:[3]

$$S = 1.6x10.4\sqrt{P}$$ for good or new tires (5.1)

$$S = 1.6x9.0\sqrt{P}$$ for worn or smooth tires (5.2)

where S = speed in kilometres per hour
P = tire pressure is in pounds per square inch
1.6 is the constant that converts miles per hour to kilometres per hour
10.4 and 9.0 are constants that account for tread wear and water depth

The factors that contribute to hydroplaning are as follows:

1. Speed of vehicle
2. Tire pressure
3. Tire tread depth
4. Thickness of water film on road surface

The Ontario Ministry of Transportation considers wheel track ruts of 13 mm or less to be classified as slight and not require remedial measures. Ruts over 13 mm in depth with a density of more than 10% require remedial action.

Refer to Appendix 'E-3' for this information.

Wheel Track Rutting - Study Area Condition

Wheel track rutting should be considered as a serious safety hazard since it is a contributing factor in hydroplaning. Road surfaces with wheel track rutting in excess of 13 mm should be given top priority for remedial action. The Wheel Track Rutting graph (Appendix 'E-2') outlines the locations where remedial action is recommended.

Shoulder Maintenance

Site reviews included an inspection of the gravel shoulders. Drop off measurements were taken at random locations along the west bound lane. Drop off is defined as the lip at the edge of pavement where it is more than about two inches (50 mm) higher than the abutting shoulder.[4]
If the drop off is four inches (100 MM) or more, an inattentive driver may be startled into a reflex overreaction when the right wheel goes off the pavement, especially if the shoulders are soft or rutted.[5]

Shoulder Maintenance - Study Section Condition

The shoulder drop off measurements are noted on the RCI Reading graphs in Appendix 'E-1'. Shoulder drop off should be considered as a potential safety hazard to motorists. Also shoulder drop off can cause the edge of pavement to crack and break away due to lack of lateral support.

It is recommended that shoulder drop off be checked once a year and if in excess of 50 mm (2 inches) remedial action should be taken. It is recommended that shoulder maintenance be carried out from the Mount Uniacke Interchange, (Exit 3) to the beginning of the section to be repaved this year near the Greenwich Interchange, (Exit 11). The drop off throughout this section is well in excess of 50 mm and the edge of pavement is breaking away leaving chunks of asphalt pavement along the shoulder.

Road Side Maintenance

Site inspection identified large chunks of rock in the ditch between Exit 3 and Exit 4. These rocks are the size of a two drawer filing cabinet or larger. Although rocks are not uncommon throughout this section, these rocks have fallen from rock cuts or back slopes and now present a potential traffic hazard if a vehicle goes off the road. Serious damage could result to vehicles and occupants if these large rocks were struck. It is recommended that the rocks be removed or guide rail be installed to protect motorists.

Guide Rail

An inspection of the guide rail was not made. Much of the guide rail appears to be surface corroded, tilted back and generally in poor repair. The aesthetics are poor to very poor. The guide rail is probably functional but further investigation is required to verify its degree of structural integrity. A plan should be developed to upgrade the guide rail so it will not deteriorate further. It is understood that current practice is to upgrade items such as guide rail, signs, and roadside vegetation, when sections of Highway 101 are repaved.

5.4 Snow and Ice Control

Overview

Slipperiness is the most common surface condition contributing to accidents.[6] Ice and snow makes surfaces very slippery.[7] Refer to Appendix 'E-4' for selected deceleration or drag factors on various types of surfaces. Snow and ice conditions have a considerably lower deceleration factor than other surface conditions, therefore, snow and ice conditions require much more time and distance to stop. Also, it is much easier to go into an uncontrolled skid on snow and ice compared to other surfaces.

Snow and ice control is a major requirement for Transportation and Public Works from anytime after December 1st and until March 31st of any year. Winter conditions can also happen before and after this envelope of time. The winter program requires major financial resources, ($31.4 million budgeted for 2000/2001), experienced and well trained human resources, well maintained equipment and an adequate supply of materials such as salt and sand. Much planning and preparation is required in advance of the winter season. In the public's view the snow and ice control program is extremely important and probably gets more public response than any other highway concern.

During the review of the snow and ice control program during May and June, actual operations could obviously not be observed. The review, therefore, relied on information from the Winter Operator's Manual, interviews with the Area Managers and past experience of the investigator with winter operations.

Interviews

Area Managers provided the following information when interviewed on May 18, 2000:

1. All Area Managers indicated that Highway 101 is number one priority for winter service in their respective areas.
2. The level of service provided is Level 1 as per Transportation and Public Works' Winter Operators Manual. Level 1 service is the highest level of service and attempts to provide bare pavement and allows for salt to be applied at the beginning of storm, during the storm, and after storm if required.
3. In the event of equipment breakdown, Highway 101 has priority over other roads and equipment will be reassigned to Highway 101 so service is not interrupted.

Winter Patrolling

4. **Winter patrolling**.
    < Hants County uses an operator with a salt truck at 4:00 AM. Other patrols are as needed as determined by weather forecasts.
    < Kings County patrols the western end of Highway 101 out of Berwick with operators with a salt truck at 3:00 AM. New Minas base is not scheduled and the dispatcher will call operators based on weather forecasts.
    < Annapolis County patrols with operators with salt trucks at 4:00 AM. and 6:00 PM. More frequent patrols are done if weather forecasts or conditions require them.
5. All Area Managers advised that they have sufficient equipment and human resources.

Training

6. **Training**
    < Hants County - provided weather training to supervisors; conducted by Environment Canada. Training dealt with site specific graphs, formation of black ice, three formations of storms and how they react and reading radar images. Hants County held a Snow Fighter Program (school) and trained five operators to conduct training sessions for the rest of the operators. There is no training for dispatchers since they have fifteen years of experience doing their job.
    < Kings County - trains supervisors and dispatchers on interpretation of weather information. Operators are trained according to the Winter Operator's Manual. It was indicated that training requires improvements.
    < Annapolis County - provided weather training to dispatchers, basemen, supervisors, office people and Area Manager. This was conducted by Environment Canada. All winter staff was also trained as per the Winter Operator's Manual and on customer service.
7. There is no attempt by any of the areas to coordinate plowing and salting operations with adjacent areas to minimize the time gap of service at the county lines.

Weather Forecasting Resources

8. **Weather Forecasting Resources**
    < Hants County - obtains winter weather information through the Internet which is site specific and supplied by Environment Canada. Mount Uniacke is a site specific location.
    < Kings County - has access to three RWIS sites (see 9. below) on Highway 101, the Internet weather information

that is provided by Environment Canada, and uses CFB Greenwood's weather information services and weather information from Seimac.

< Annapolis County - has access to the Internet weather information that is provided by Environment Canada. This has site specific weather information along with radar images. Also uses CFB Greenwood's weather information services.

Weather Stations

9. **Weather Stations**

Roadway Weather Information Systems (RWIS) weather stations have been installed at some locations on Highway 101 to automatically collect and transmit real time road surface condition information. There are temperature sensors in the pavement. RWIS stations provide air temperature, road surface temperature, humidity, wind direction and speed and visibility.

< Hants County - does not have any Roadway Weather Information Systems (RWIS) weather stations but the Area Manager puts a high priority on obtaining Web Cams at strategic locations such as the Mount Uniacke area.

< Kings County - has three RWIS stations on Highway 101 with a total of 5 stations in the area. The locations on Highway 101 are Kingston, Lovett Road and Avonport Mountain. Area Manager stated that this is adequate. Supervisors have computer connections to the RWIS stations but the Area Manager does not. Area Manager wants to upgrade the RWIS with Web Cams.

< Annapolis County - does not have any RWIS weather stations but believes that facilities such as weather stations would be a benefit to his area. It was advised that there is a Web Cam at Exit 20 but does not have a compatible telephone line so could not be used last winter but will be operational for this coming winter, also it was advised that Web Cams are preferred.

Special Problem Areas

10. All areas have "Bridges Freeze Before Road" signs and do not have other special warning signs.

< Hants County - does not have any particular problem areas but snow fall tends to be concentrated in the Mount Uniacke area.

< Kings County - winter weather problems occur at the Deep Hollow overpass, Avonport Mountain, and Exits 10 to 11 and 15 to 17. An RWIS station is located at Lovett

Road which has the same physical characteristics and topographical features as Deep Hollow Road therefore they are able to use the information from the Lovett Road for the Deep Hollow Road area. Avonport Mountain gets more snowfall due to the higher elevation and the sections mentioned have reduced visibility due to blowing snow.

- < Annapolis County does not have any particular problem areas.

Winter Awareness Programs

11. All areas have their own local winter awareness program. It stated that the Provincial awareness program was scaled back last year.
    - < Hants County - attend elementary schools with a "Winter Safety Day". They attended twelve schools and five were in West Hants. The strategy is that the children will learn and take the information home to other family members.
    - < In Kings County - Awareness Days are held once a year at three different schools. Winter equipment is displayed and safety stressed.
    - < Annapolis County - has awareness programs with elementary schools. The program is conducted by operators with equipment on display and fact sheets handed out.

Black Ice

12. **Black Ice** is extremely dangerous because it can be invisible from a driver's position and it can form in different ways:
    - < It can develop from the road surface being wet and there is sudden temperature drop to freezing or below.
    - < It can be caused by freezing rain.
    - < It can develop after a road surface has been salted, the road surface does not dry, the salt brine becomes diluted and the moisture on the surface freezes.
    - < It can develop by sublimation, a situation where weather conditions are usually calm, clear of clouds and the road temperature is at or below freezing. When the sun warms the air next to the ground, usually between 7:00 AM. and 8:30 AM, it causes this warmed air to rise and moist, colder air from above falls and hits the road surface and the water vapour **instantly** freezes on the road surface which is invisible from the drivers position. The water vapor changes directly into ice crystals without passing through the visible moisture stage. This is sublimation.

      Bridge decks are very susceptible because they are thin and can be colder than adjacent road surfaces and this phenomenon is common in late fall and early spring but can happen anytime through the winter.

< Hants County - "black ice" is not a problem; staff is able to anticipate and have equipment in place. Staff is aware of how black ice develops and supervisors are well trained in black ice formation.

< Kings County - "black ice" is not a problem, the RWIS stations work well in forecasting black ice.

< Annapolis County - at times it is a problem. Staff is aware of how it develops and attempts to anticipate black ice with the available resources.

Salting Time

13. **Salting Time**

< Hants County - It takes 1.5 hours to salt Highway 101 starting from the time the trucks leave the Brooklyn Base. They use 2 trucks. Total length to be salted is 88.8 km.

< Kings County - It takes 3.5 hours to salt Highway 101. One truck leaves from the Berwick Base and one truck leaves from the New Minas Base. A third truck assists and when not needed goes to other roads. Total length of Highway 101 to be salted is 119 km.

< Annapolis County - It takes 2 hours to salt Highway 101. One truck salts between the Kings County Line and Bridgetown. Total length to be salted is 45.3 km.

These times are for salting only and do not include call out time nor loading time.

Shift Change Times

14. **Shift Change Times**

< Hants County - Shift changes take place at 4:00 AM. and 4:00 PM.

< Kings County - Shift changes at Kings North take place at 6:00 AM and 6:00 PM; Kings South at 5:00 AM and 5:00 PM; and Berwick at 6:00 AM and 6:00 PM.

< Annapolis County - Shift changes take place at 5:00 AM and 5:00 PM.

Operator Call Out

15. **Operator Call Out**

< Hants County - If weather forecast is for storm conditions operators are put on "ready" and a weather watch is put in place by checking weather in Greenwood and the South

Shore. Operators are called out before the storms reaches Hants County.

< Kings County - Try to give operators one hour lead time before a storm arrives. Use all the weather forecasting resources and RWIS stations and follow the storm as it approaches.

< Annapolis County - Staff on duty use radar on the Internet, Greenwood weather information and follow storms by communicating with other areas to determine the time to call operators for salting and plowing.

Road Surface Conditions for Salting and Plowing

16. **Road Surface Conditions for Salting and Plowing**

< Hants County - Road surface conditions do not present a problem to salting and plowing.

< Kings County - Road surface conditions do not present a problem to salting and plowing.

< Annapolis County - The only problem section is from Exit 19 to Exit 20 but this will be corrected this summer by repaving.

Snow and Ice Control - Summary of Study Area Conditions

The following Observations and Opinions are offered:

1. It is evident that all three areas responsible for Highway 101 put considerable effort into the snow and ice control program and are very serious about providing a high level of service.
2. Highway 101 has top priority for snow and ice control and will be serviced before other roads if equipment breakdowns occur. Also Highway 101 qualifies for the highest level of service as indicated in the Winter Operator's Manual and is serviced at this level during and following a storm.
3. All areas use highway patrols to check road conditions, except the eastern section of Highway 101 in Kings County. (In eastern Kings County staff use RWIS installations to determine the need for plowing / salting activities). The benefit of using operators with salt trucks is that if slippery road conditions are encountered immediate action can be taken. For consistency purposes there should be standardization in the three areas that would give the same time for patrolling. Patrolling, when needed, should be carried out in the early morning and early evening when the temperature sometimes drops and causes icing conditions.
4. Weather forecast and interpretation training is provided in all areas by Environment Canada but varies in who is trained. This training is very important and essential and should be provided to

Area Managers, Supervisors, Base persons, Dispatchers, Operators who patrol and anyone involved in making the decision for call out of staff in the event of slippery road conditions.

5. There is no attempt to coordinate between the areas to minimize the time gap of service at county lines. Adjacent areas should coordinate activities and minimize the time gap of service at county lines and attempt to make a seamless level of service along Highway 101. Also there should be communication between the areas when storms are approaching.
6. Weather forecasting services are used such as site specific forecasts, radar and CFB Greenwood weather services. There is much confidence in the information obtained from CFB Greenwood. These services help to time call out of staff and predict weather conditions such as "black ice". These services should be continued to be used on a regular basis. All areas are making excellent use of weather forecasting services.
7. Kings County is the only area to be equipped with RWIS weather stations and they appear to make good use of the system. All areas believe that Web Cams would be of great value. Web Cams should be installed along Highway 101 at strategic locations and problem areas and access be provided through the Internet. The public, radio stations and television stations can use these for road condition information as well as TPW staff. Web Cams cost about $5000.00 each so they are affordable.
8. It is very important that TPW staff is aware of 'black ice' formation and when it can happen. They have to be well trained in weather forecasting and interpretation so 'black ice' conditions can be anticipated. 'Black ice' is considered to be a problem because it can happen instantly and can not be easily seen from the drivers position. TPW staff should continue to improve their capability to predict 'black ice'.
9. The number of salt and plow units assigned to Highway 101 is adequate based on the number of kilometres each unit has to service, all have less than 50 km. All units are tandem trucks equipped with salt spreading capacity and high speed plows. Maximum salting speed is 50 kph.
10. Shift Changes are necessary at least every 12 hours so fresh staff can take over from those that have worked for the previous 12 hours. The timing of these shift changes is important so service is not interrupted. It takes a minimum of about 1 to 1½ hours for the shift change to take place, trucks have to be refueled, serviced, loaded and perhaps minor repairs are required, for example a change of wiper blades. Shift changes should not take place

during peak traffic times when the commuter traffic is on the highway during the AM and PM peak traffic periods. Salting and plowing equipment should be on the highway providing service at peak traffic times. The service should be provided when needed, therefore shift changes should be made between 10:00 AM. and 2:00 PM. during the day and between 10:00 PM and 2:00 AM during the night. Also this splits the day light hours with the two shifts, therefore the night crew does not have to work all the shift in the darkness.

11. Operator call out is very important. It can take 30 to 60 minutes for an operator to report to the base after being called. Salt trucks are not normally loaded with salt and left in the garage because the weight will eventually cause damage to the suspension system and it becomes a costly maintenance problem. When the operator arrives at the base the trucks have to be loaded with salt before driving to Highway 101. Here again weather forecasting, RWIS stations and Web Cams become very useful in tracking weather conditions as it approaches an area. Dispatchers must be very vigilant in calling out staff to deal with a slippery road condition. Operators should be at their respective bases before the storm starts.

5.5 Summary of Recommendations

Highway Maintenance

It is recommended that:

1. Performance standards be developed to ensure consistent, proper and timely repairs thus providing the safest possible road system;
2. A routine inspection of the road surface and shoulders be completed once per day throughout the year; action taken and time of repairs should be documented;
3. Repairs be completed within 24 to 36 hours and warning signs to be erected before the repairs if needed;
4. Debris be removed from the highway immediately;
5. Sections of Highway 101 with a RCI reading of less than 5.5 be considered for repaving;
6. Remedial action be taken on the sections of Highway 101 where the wheel track rutting is in excess of 13 mm. The sections are noted on the graph in Appendix ‘E-2', and are summarized in Table 5.2.
7. Shoulder drop off be checked once a year and if in excess of 50 mm (2 inches) remedial action should be taken;
8. Shoulder maintenance be carried out on the section of Highway 101 between Exit 3, Mount Uniacke Interchange, to the beginning of year 2000 repaving near Exit 11, Greenwich Interchange;

9. The rocks in the ditches at the rock cuts between Exit 3, Mount Uniacke Interchange and Exit 4, St. Croix Interchange, be removed or guide rail install to protect motorists.
10. An inspection of all guide rail be made to verify its structural integrity and a plan be developed to upgrade the guide rail.

Table 5.2 - Locations of Suggested Corrective Action for Rutting

Approximate Location			Length of Affected Section, km
Between Exits	Km from end of Study Section		
	From	To	
3 and 4	4.5	16.0	11.5
7 and 8	38.5	39.5	1.0
10 and 11	55.5	56.5	1.0
14 and 15	77.5	78.5	1.0
15 and 16	90.8	99.2	8.3
16 and 17E	99.2	100.0	0.8
17E and 17W	108.5	109.5	1.0
17W and 18A	113.5	114.5	1.0
18A and 18	119.0	120.0	1.0

Snow and Ice Control

It is recommended that:

1. Highway 101 remain priority number one for snow and ice control in the respective areas;
2. Patrolling of Highway 101, when needed, be carried out twice daily, once in the early morning before commuter traffic starts and in the early evening using an operator with a salt truck;
3. Weather training be provided to Area Managers, Supervisors, Base Persons, Dispatchers, Operators who patrol and other staff involved in making the decision to call out operators for salting or plowing. This training should continue on an annual basis before the winter season commences.
4. Areas coordinate their salting and plowing with adjacent areas to minimize the time gap of service at county lines and attempt to provide a seamless level of service along Highway 101;
5. All areas continue to use weather forecast services that help to predict "black ice"and other adverse weather conditions;
6. Web Cams be installed at strategic locations along Highway 101 to help forecast adverse road conditions and "black ice";

7. Shift changes be made from 10:00 A.M. to 2:00 P.M. in the day time and from 10:00 P. M. to 2:00 A.M. in the night time;
8. Operators be called out and ready to salt and plow before a storm starts or adverse road conditions develop.

Footnotes for Section 5, Highway Maintenance

1. *The Traffic Accident Investigation Manual*, Northwestern University Traffic Institute, Topic 817, page 51, column 2.

2. *Advanced Traffic Accident Investigation Manual*, Institute of Police Technology and Management, University of North Florida, Chapter 2, page 82.

3. *Advanced Traffic Accident Investigation Manual*, Institute of Police Technology and Management, University of North Florida, Chapter 2, page 82.

4. *Traffic Accident Reconstruction Manual*, Volume 2, Northwestern University Traffic Institute, Index and Glossary, section D.

5. *The Traffic Accident Investigation Manual*, Northwestern University Traffic Institute, Topic 817, page 51, column 3.

6. *The Traffic Accident Investigation Manual*, Northwestern University Traffic Institute, Topic 817, page 50, column 2.

7. *The Traffic Accident Investigation Manual*, Northwestern University Traffic Institute, Topic 817, page 50, column 3.

6.0 Human Factors in Highway Design

The Driving Task Involves Driver, Vehicle and Road / Environment

The driving task involves three main components - ***driver***, ***vehicle*** and ***road/environment***. Significant improvements have occurred with the last two, but human abilities and limitations have changed little over the centuries.

Driving may be viewed as requiring three types of information, related to ***control***, ***guidance*** and ***navigation*** (Alexander and Lunenfeld, 1975). The first involves the physical operation of the vehicle (steering, braking, etc.). Guidance refers to maintaining a safe speed and path, while navigation is finding your way from one location to another. Guidance information comes from the roadway alignment, hazards, traffic control devices and other vehicles using the roadway. It is therefore essential to take into account the information needs of the driver as well as his/her information processing and decision making capabilities when designing highways and traffic control devices.

Driving is a dynamic process, since the roadway scene and the information from it are continually changing as one proceeds along the highway. Under high speeds the information which the driver needs comes in and must be processed very quickly. Hence, rapid and accurate information processing is essential to safe driving. The time to respond successfully to any driving situation, such as an emergency, involves four stages: perception (detection, and identification), decision, reaction, and response of the vehicle.

Factors Affecting Highway Safety

In determining the safety of a highway numerous factors must be taken into account, including: traffic volume, vehicle mix (proportion of trucks, RVs, and cars), adequacy of traffic control devices, proportion of unfamiliar drivers, weather conditions, and highway geometry (lane and shoulder width, median width, slope of the median, number of lanes, lane separation, horizontal and vertical curves, sight distance, number and design of intersections or interchanges).

Human Factors Contribute to Over 90% of all Accidents

Drivers often have difficulty processing all the information they require while driving. This limitation is reflected in the conclusion by Rumar (1981) that the driver is an "outdated human with stone-age characteristics and performance who is controlling a fast, heavy machine in an environment packed with unnatural, artificial signs and signals."

On the basis of an extensive study of by Treat et al. (1979) involving 2,258 on-site accident investigations and 420 in-depth investigations by a multi-disciplinary team, it was concluded that human factors contribute much more to traffic accidents than do vehicle or environmental variables. Various factors were classified as "definite" or "probable" causes. The in-depth analyses revealed that human factors contributed to about 70 to 92 (definite - probable) percent of all accidents. Results of the on-site analyses were only slightly lower than these figures. While it is evident that causes typically do not occur in isolation, it was found that over half of the accidents studied resulted from "human only" factors. Table 6.1 contains a percentage breakdown for "specific human direct causes" for the in-depth analysis for definite (and probable) causes.

Table 6.1 - Specific Human Direct Causes for Traffic Accidents

Specific Human Direct Causes	Percentage of Accidents	
	Definite	Probable
Improper lookout	17.6	23.1
Excessive speed	7.9	16.9
Inattention	9.8	15
Improper evasive action	4.8	13.3
Internal distraction	5.7	9
Improper driving technique	6	9
False assumption	4.5	8.3
Improper maneuver	5	6.2

Information Perception and Processing are Problems for Many Drivers

Approximately 1/3 or more of all traffic accidents involved human error associated with difficulties in information processing or perception. It is of interest to note that this study found drivers 65 years of age and older to be over-involved in "improper lookout" accidents. Of those in this age category who caused accidents, about half made errors of this kind.

The driving task has become less physically and more cognitively demanding each decade. The mechanics of driving are learned fairly quickly by most novices, but the cognitive and information processing aspects of driving take years to master. Availability of automatic transmissions, power steering and brakes, more comfortable vehicles and better designed roads make driving less physically demanding, but put greater demands on drivers' mental capacity by more and faster traffic, complex road geometry, and a multitude of traffic control devices (many of which are poorly designed, complex and confusing).

In view of the central role played by the driver in traffic accidents, it is essential to understand the human component as related to the design and safety of Highway 101. This section reviews some of the relevant literature, summarizes the focus group findings and the highway accident statistics provided and interprets these to determine potential countermeasures that would make the highway safer for all users.

6.1 The Role of Human Factors in Road Design and Traffic Safety

Positive Guidance is Essential for Highway Safety

The design of a highway can impact driver behaviour and traffic safety, as drivers must be able to see clearly the road ahead and what is on the road. Sight distance is an important design feature here. Other factors which influence drivers include number and width of lanes, presence of passing lanes, shoulder width, degree of road curvature, hills, road surface conditions and the legibility and understandability of traffic signs, signals and markings. Drivers' perception of the road and their ability to detect hazards are greatly influenced by unexpected conditions or events (e.g., left exits off freeways, lane drops around curves). For this reason it is essential to avoid surprising drivers and to present them with information where and when they expect it.

In order to accomplish this the "Positive Guidance" philosophy (Alexander and Lunenfeld, 1975) has come into widespread use. The basic tenets of this approach are:

Primacy - Information should be placed according to its importance to the driver. In situations where information competes for drivers' attention, unneeded and low priority information is shed.

Spreading - Where all the information required by the driver cannot be placed on one sign or on a number of signs at one location, spread it out over space so as to reduce the information load on the driver. It must be spread out at locations where critical driver decisions and/or actions are required. Signs must be spaced to allow time to detect and take in all the information required.

Coding - Where possible organize pieces of information into larger units. Colour and shape coding of traffic signs accomplish this by representing specific information about the message based on the colour of the sign background and the shape of the sign panel. Signs are coded on the basis of colour and shape.

Redundancy - Say the same thing in more than one way. The STOP sign in North America has a unique shape and message, both of which convey the message to stop. The same information may also be given with two devices (e.g., "no passing" indicated with a sign and pavement markings).

Expectancy greatly influences driver behaviour. The highway itself conveys more information to its users than any other single source. Drivers operate with a set of expectancies. For example, freeway exits will be on the right side of the roadway, advance warning will be given of hazards on the road, other drivers will obey traffic rules. If these expectancies are violated there is an increase in driver perception-reaction time, more driver errors and the potential for an accident.

Three Types Of Expectancy

Expectancy relates to a driver's readiness to respond to conditions, situations, events and information. It influences the speed and accuracy of information processing, and is one of the more important driver-related characteristics in the design and operation of highways.

There are three types of expectancy:
Continuity - events of the immediate past will be repeated (drivers tend to maintain small headways as they expect the vehicle ahead will not slow suddenly),
Event - events that have not happened previously will not happen (we may disregard a railroad grade crossing if a train has never been encountered before there),
Temporal - when events will be cyclic, the longer a state occurs the more likely it will change (drivers approaching an intersection will anticipate a red signal after seeing a green one for some time, so may increase their attention to the signal and prepare to stop, although some drivers use this cue to speed up to beat the red light).

Key considerations about expectancies include the following:

- expectancies are associated with all levels of the driving task and all phases of the driving situation.;
- drivers experience problems and commit errors when they are surprised;
- drivers anticipate upcoming situations and events that are common to the route they are driving;
- the more predictable the design, information displays or traffic operation, the less likely will be the chance for driver error;
- in the absence of information to the contrary, drivers assume they will have to react only to standard (expected) situations; and
- the roadway, the information system and the environment upstream will structure expectancies of downstream conditions.

6.2 Focus Group Results and Interpretation

The focus group data revealed that drivers were least satisfied with pavement conditions and markings, passing lanes on hills, shoulder conditions, and winter road conditions. The items receiving the greatest satisfaction ratings were exit lighting and speed limits. Major concerns expressed, with potential countermeasures, are listed in Table 6.2.

Table 6.2 - Focus Group Concerns and Possible Countermeasures

Major Concerns	**Potential Countermeasures**
not enough or too short passing lanes	more and longer passing sections
drivers cut in too soon or dangerously at the end of passing lanes	warnings of dangers of doing this; fines for this; more and longer passing sections
speeding	graduated or double fines; increased enforcement; photo radar; warning signs
hydroplaning	signs warning of hydroplaning danger
pavement makings hard to see	replace frequently; use wider lane lines
poor pavement condition	improve pavement condition where necessary
tailgating	enforcement; education campaign
cell phone use	outlaw phone use; enforcement; education campaign
frustration due to slow drivers	minimum speed limit; warning signs; education
winter conditions	warning signs/CMS; weather sensors; education; rapid snow clearing
Exit 8A, Ben Jackson Road	eliminate left turns; close intersection; overpass

6.3 Accident Data Analysis and Interpretation

Percentage of Accidents by Type and Contributing Factors

The primary concern in understanding accident causation is having adequate accident data from which to draw conclusions. Accident percentages by ‘accident type’ and ‘contributing factors’ obtained from the TPW collision data base are itemized in Table 6.3. This data was obtained from the data files for 1410 collisions reported in the Study Section from 1990 to 1999. The following represents a brief summary and an interpretation of the main accident statistics available for the Study Section.

Table 6.3 - Percentages of Accidents by Type and Contributing Factors

Accident Type	Percent of All Accidents
Run off road	28.3
Struck object	18.2
Rear end	10.0
Passing	3.5
Head-on	5.3
Side swipe, opposite direction	3.8

Contributing Factors	Percent of All Accidents
Inattention/distraction	16.8
Fell asleep/fatigue	5.7
Inexperience/confusion	4.2
Impaired/had been drinking	4.4
Too fast for conditions	3.9
Failure to yield	1.3
Hydroplaning	3.3
Slippery surface	23.9
Animal action	18.9

Interpretation of Accident Types and Contributing Factors

The most frequent contributing factors are related to driver behaviour or condition and decision making - inattention/distraction, fell asleep/fatigue and speed too fast for conditions. While driver inexperience and confusion were also relatively prominent, it is difficult to know how to interpret the latter, as these two conditions often lead to distraction and excess speed (typically poor judgment by inexperienced drivers). Driver factors (risky behaviour, condition and faulty decision making) can best be addressed through an education campaign and through graduated licensing with an emphasis on the human factors that contribute to accidents.

Here some modification of driver behaviour and risk taking is required. The most frequently occurring accident types were run-off-road and struck object, as well as rear-end collisions. The first of these can best be explained by driver inattention, fatigue and excess speed, while rear-end crashes would be due in part to these same factors. The struck object collisions can only be accounted for if it is known in more detail what objects were struck and how they were. Striking a bridge abutment or guard rail is different from striking another vehicle, and the contributing factors are likely to be different.

By far the greatest concern was with the inadequacy of passing opportunities, which is evident not only from the focus group and accident data, but from the experience of driving the highway. This is a problem especially where there are long distances between passing lane sections. A central issue and complaint is drivers cutting in too soon when passing at the end of passing lanes, suggesting the need for more and longer passing lanes, as drivers become impatient to pass and take risks in doing so. The use of passing lanes on uphill sections is a safety feature that allows slower moving vehicles to pass, and reduces the degree of frustration which would otherwise be felt by many drivers if they had to drive long distances for a passing opportunity.

Frustration is encountered by many drivers on the flatter sections of the highway to the west, where there are no passing lanes. It would greatly reduce driver frustration and risky passing if there were a few passing lanes on these sections of the highway. This is especially true, as this highway experiences a good deal of large truck and camper/motor home traffic (the latter especially in the summer time). In addition, in the rural areas that are slow moving agricultural vehicles. The need to have passing lanes became obvious in discussions with RCMP who reported difficulty getting to emergency calls when traffic was heavy, as a steady line of vehicles in both directions made it impossible for them to pass, and to go faster than the current traffic flow speed.

The most appropriate solution to this is to twin the highway, so that passing would not be a safety issue. However, this is a long-term solution. In the meantime, there is a clear need for more (and possibly longer) passing lanes. Another partial solution is to provide carefully designed pulloff areas (large enough for two large trucks or a few cars), to provide the opportunity for tired drivers and those who drive slowly to pull off the highway to allow others to pass. It is noted that there are no such areas on the relevant section of the highway at present, an unusual situation for any major highway. At the present time drivers wanting to take a break must drive off the highway onto a side road or into a town, and then enter the highway again.

There should be a number of rest areas capable of parking several vehicles) along the section of Highway 101 of concern. This allows slow moving vehicles to pull off to allow passing, and affords tired drivers the opportunity to take a break from driving without having to leave the highway at one of the exits. This is especially important in view of the narrow shoulders and the sharp drop-off currently on this highway. The presence of large numbers of tourists, unfamiliar with the highway, also indicate the need for such areas to stop briefly along the highway.

While many of the focus group participants mentioned condition of the pavement, and the adequacy of signs and markings, the primary problem at the present is very narrow (and dangerous) shoulders, some with a sharp dropoff of 10+ cm in many areas. Drivers tend to drive more slowly and to drive closer to the centre line, increasing the possibility of a head-on collision where there are narrow shoulders. Such shoulders also make it difficult and hazardous for drivers to pull off the driving lane, and may account for the high number of run-off-road (ROR) accidents. The use of continuous shoulder rumble strips has the potential for reducing run-off-road accidents, which are fairly common on this highway. Research has shown that on highways these accidents can be substantially reduced by with rumble strips.

Some complaints from focus groups about the lane markings and signs may or may not be justified, as they appear to be reasonably good. Familiar drivers do not need most signs and markings, since they know the roadway, so it is not clear what the issue is here. However, use of wider lane lines would increase their visibility, especially in bad weather and darkness.

Impairment due to alcohol appears to be quite minor relative to what one might expect from general traffic accident statistics. This may be due in part to the large amount of accident data that is derived from self reports. It is unlikely that many drivers who had been drinking at the time of the collision would admit to this. Impairment from fatigue is a serious issue, which often gets overlooked in traffic accident analyses. It is much more common than most people realize, as indicated by the data gathered for this project. Driver fatigue is no doubt behind at least some of the inattention that contributes to accidents, especially ROR crashes.

The slippery surface accidents occur mainly in bad weather, but it needs to be determined whether these are primarily in winter or at other times of the year when there is rain or fog. Road condition and situational factors involved mainly slippery surfaces (including snow/ice and hydroplaning). These conditions lead to accidents largely because drivers do not adjust their speed and attention to the driving task sufficiently to handle the extra load and attentional requirements under these conditions. The main countermeasure for slippery road accidents is to change driver behaviour so as to reduce risk taking and excess speed, and to increase driver awareness of these hazards. For example, most drivers are unaware that when it starts to rain the road surface is most slippery during the first few minutes of rainfall, rather than after is has rained for some time.

Animal action (mainly deer) contributed to a substantial number of accidents (about 19%), but, surprisingly these were not mentioned as a factor in the focus groups. It is likely that these are rare events, and that few drivers encounter animals in a dangerous situation on the road, hence do not see this as a problem. Clearly, drivers need to be alerted to the dangers of wild animals on the road. These road condition and situational factors are best addressed through public education and with warning signs on the highway at appropriate locations.

Although education campaigns are often proposed as a solution to poor driver habits, they can be of limited value if not planned and executed carefully. They could be used to address issues such as speeding, unsafe passing, slippery roads and fatigue.

6.4 Specific Safety Issues Related to Highway 101

Traffic Sign Placement

Some traffic signs are poorly placed or missing. A number of road signing practices need to be examined with a view to providing drivers with information that would enhance their safety and reduce frustration levels of impatient drivers.

The following practices are recommended to accomplish this:

1. Place all less essential signs (those that need not be in specific locations) at locations where there are no other signs, curves, or entry/exit lanes. These would include SPEED LIMIT and USE SEAT BELTS signs, as well as confirmation distance signs.
2. Place PASSING LANE AHEAD (ID-23)* signs after, rather than before, locations where there are entry lanes (merge lanes). If the distance frequently used (e.g., 2 km) is not at these typically used locations, signs could be placed 1.5 or 2.5 km in advance of the passing lane ahead. This would be preferred placement, as drivers are concerned about attending to entering traffic and should not be overloaded with sign information that could be placed elsewhere.
3. Place PASSING LANE AHEAD (ID-23) signs on both sides of the highway, so that drivers starting to pass where they should not will see the message, even if the right side sign is blocked by the vehicle (such as a larger truck) being passed.
4. Place PASSING PROHIBITED (RB-31) signs, where relevant, on both sides of the highway for the same reason.
5. Place YIELD TO ONCOMING TRAFFIC (RB-36) signs

periodically along all sections with downhill passing, on both sides of the highway.

* sign numbers refer to those used in the *Manual of Traffic Control Devices for Canada* (1998 edition).

Pavement Marking of Passing Areas

At certain locations in both directions there are downhill passing lanes at the approach to entry lanes and ramps for oncoming vehicles. This may not be a problem (unless accident data show a number of crashes at such locations), but there is the potential for collisions here as drivers in the downhill direction could be passing as oncoming drivers are moving left to allow entering vehicles to join the traffic stream. This situation would apply to locations where there is passing allowed, whether it be downhill passing (on 3-lane sections) or regular passing on (2-lane sections).

Potential Safety Hazards Observed from the Westbound Video Logs

The following specific situations/conditions have been identified from the westbound video logs as potential safety hazards:

1. At chainage distance** 21.5 (Exit 4 westbound exit) the ROAD NARROWS (WA-23) sign is too close (about 5 seconds travel time) to where the road actually widens at the beginning of an exit lane. The road actually narrows some distance downstream after the entry lane ends. The sign could be eliminated or moved downstream. (** approximate chainage distances as shown on the videologs).
2. At chainage distance 32.8 (at Windsor near the railroad overpass) the 90 kph speed zone sign ought to be placed further upstream, as it is on a curve.
3. At chainage distance 35.9 (Falmouth Interchange, Exit 7) the PASSING LANE 2 KM AHEAD (ID-23) sign is near the start of an entry ramp which is about 300 m long. This is poor placement, as it could confuse drivers who are not fully attentive to the sign message into thinking that the passing lane started at the entry lane. It should be placed further downstream, beyond the entry ramp.
4. At chainage distance 45.6 (Ben Jackson Road) it is not clear why there is a RIGHT LANE MUST EXIT sign, as this sign is not used at other exit areas. Perhaps the painting of pavement arrows on the turning lanes at this intersection will reduce driver confusion.
5. At chainage distance 58.2 (between Hortonville and Greenwich) there is a KEEP RIGHT EXCEPT TO PASS (RB-34) sign very close (about 50 m) to a RIGHT LANE ENDS (WA-33R) sign, which could lead drivers to move to the right lane just before it ends, creating potential conflicts and erratic maneuvers.
6. At chainage distance 133.4 (west of Lawrencetown) it is not clear why the SLIPPERY WHEN WET sign is used here and not at many other

locations. There appears to be no difference between the road surface here and upstream of this location. The criteria for using this message needs to be examined. If this sign is used to advise of a wheel track rutting situation that may be hazardous during wet weather, perhaps TPW should consider development of a suitable sign to warn of this problem.

Potential Safety Hazards Observed from the Eastbound Video Logs

The following specific situations/conditions have been identified from the eastbound video logs as potential safety hazards:

1. At chainage distance 46.5 (just west of Ben Jackson Road), in advance of the only at-grade intersection on this stretch of highway (which will catch unfamiliar drivers by surprise) it may help to place, in both directions, a large INTERSECTION AHEAD (WA-11) sign. Also, alternating flashing amber lights mounted on the diagonals of the warning sign will assist in warning Highway 101 traffic of the unexpected intersection. The best solution to this problem is elimination of the intersection or replacing it with a grade-separated interchange.
2. At chainage distance 32.7 (the eastbound approach to Exit 5A) the RAMP SPEED 30 sign is on a curve and well in advance (about 400 m) of the ramp. It should be placed further downstream (100-150m) , as drivers should not have to read signs on curves.

7.0 Level of Service Analysis

Definitions of Level of Service

The primary measures of level-of-service or the performance quality of a two lane road are time delay, speed and capacity utilization. Two lane highways are quite complex, and capacities vary depending terrain and degree of passing restrictions. Volume-to-Capacity (v/c) ratios are based on the 'ideal capacity' of 2800 pcph (passenger cars per hour), total in both directions of flow.

Level-of-Service A - The highest quality of service occurs when motorists are able to drive at their desired speed. The passing frequency required has not reached a demanding level. Almost no platoons of three or more vehicles are observed. Drivers would be delayed no more than 30 percent of the time by slower moving vehicles. A maximum flow rate of 420 pcph, total in both directions, may be achieved under ideal conditions.

Level-of-Service B - Passing demand needed to maintain desired speeds becomes significant. Drivers are delayed up to 45 percent of the time on the average. Service flow rates of 750 pcph, total in both directions, may be achieved under ideal conditions.

Level-of-Service C- There are noticeable increases in platoon formation, platoon size, and frequency of passing impediment. At higher volumes, chaining of platoons begins to occur. While flow is stable, it is becoming susceptible to congestion due to slower moving vehicles. Percent time delays are up to 60 percent. Service flow rates of up to 1200 pcph, total in both directions, may be achieved under ideal conditions.

Level-of-Service D - Traffic flow becomes unstable. The two opposing traffic streams essentially begin to operate separately as passing becomes extremely difficult. Percent time delays are up to 75 percent. Maximum flow rates of up to 1800 pcph, total in both directions, may be achieved under ideal conditions.

Level-of-Service E - Passing is virtually impossible; platooning becomes intense when slower vehicles are encountered. Percent time delay is in excess of 75 percent. The highest volume attainable under level-of-service E defines the capacity of the highway. Under ideal conditions, capacity is 2800 pcph, total in both directions.

Capacity Analysis of Section within the Study

Level of service (LOS) was calculated for each highway section for each

Section

horizon year using *Highway Capacity Manual*, Chapter 8, Two Lane Highway analysis. Design hourly volumes were those recorded in Table 2.3 factored by the PHF from Table 8-3 of the *Highway Capacity Manual*. Percent 'no passing' and directional split for each section that were used in the analyses are shown in Table G-1, Appendix G.

LOS Analysis Results for each section are recorded in twenty tables included as Table G-2, Appendix G. Each table contains calculated Flow Rates and volume / capacity (v/c) ratios for LOS 'A' through LOS 'E' for an indicated highway section.

Summary of Results

The LOS objective of the Study is to 'ensure preservation of a level of service greater than or equal to 'C'. The LOS analyses results are summarized in Table 7.1. The left columns of the Table identify sections, section capacity and LOS 'C' calculated limiting values of service volume and v/c ratio for each highway section. The right columns of the Table contain the design hour flow rate (from Table 2.3), the v/c ratio and LOS for each section for 2000, 2005, 2010, 2015 and 2020.

2000 - All sections between Mount Uniacke and Coldbrook will experience LOS 'E', except the four lane section at Avonport will continue to experience LOS 'A'. Sections west of Coldbrook will experience LOS 'C' and 'B'.

2010 - All two lane sections east of Coldbrook are projected to operate at LOS 'E' or LOS 'F',except the four lane section at Avonport will continue to experience LOS 'A'. Sections 140 and 150, from Coldbrook to Aylesford will experience LOS 'D', and the remaining sections to Bridgetown will provide very good LOS 'B' or good LOS 'C'

2020 - The LOS's for most remaining two lane sections between Mount Uniacke and Coldbrook will experience LOS 'F', in some cases with very high v/c ratios of 1.15. While four lanes will be required for all sections east of Kingston to ensure a minimum LOS 'C', two lane sections between Kingston and Bridgetown will still provide LOS 'C'

Table 7.1 - Summary of Level of Service Analyses

Section	Capacity	Max flow for LOS C	max v/c LOS C	2000			2005			2010			2015			2020		
				Flow Rate[1]	v/c	LOS	Flow Rate[1]	v/c	LOS	Flow Rate[1]	v/c	LOS	Flow Rate[1]	v/c	LOS	Flow Rate[1]	v/c	LOS
040	1947	681	0.35	1298	0.67	E	1447	0.74	E	1589	0.82	E	1737	0.89	E	1895	0.97	F
050	2056	658	0.32	1277	0.62	E	1436	0.70	E	1579	0.77	E	1737	0.84	E	1884	0.92	F
060	2056	617	0.30	1516	0.74	E	1716	0.83	E	1906	0.93	F	2094	1.02	F	2292	1.11	F
065	2056	720	0.35	1537	0.75	E	1726	0.84	E	1896	0.92	F	2073	1.01	F	2260	1.10	F
070	2056	720	0.35	1526	0.74	E	1737	0.84	E	1927	0.94	F	2125	1.03	F	2323	1.13	F
080	2056	720	0.35	1404	0.68	E	1547	0.75	E	1716	0.83	E	1863	0.91	E	2010	0.98	F
090	2056	658	0.32	1298	0.63	E	1468	0.71	E	1600	0.78	E	1758	0.86	E	1896	0.92	F
095	2188	853	0.39	1372	0.63	E	1516	0.69	E	1663	0.76	E	1832	0.84	E	1958	0.90	E
100	4 Lane Section			1394		A	1526		A	1684		A	1832		A	1958		B
110	2188	700	0.32	1161	0.53	E	1287	0.59	E	1426	0.65	E	1547	0.71	E	1695	0.77	E
120	2188	766	0.35	1172	0.54	E	1319	0.60	E	1489	0.68	E	1621	0.74	E	1779	0.81	E
130	2188	766	0.35	1309	0.60	E	1495	0.68	E	1695	0.77	E	1884	0.86	E	2063	0.94	F
135	2122	743	0.35	1426	0.67	E	1684	0.79	E	1927	0.91	E	2188	1.03	F	2448	1.15	F
140	2447	1032	0.43	839	0.34	C	946	0.39	C	1054	0.43	D	1138	0.47	D	1245	0.51	D
150	2447	936	0.39	817	0.33	C	925	0.38	C	1032	0.42	D	1128	0.46	D	1234	0.50	D
160	2447	936	0.39	750	0.31	C	839	0.34	C	935	0.38	C	1032	0.42	D	1117	0.46	D
170	2523	965	0.39	407	0.16	B	505	0.20	B	587	0.23	B	685	0.27	C	761	0.30	C
180	2371	837	0.36	451	0.19	B	516	0.22	C	598	0.25	C	674	0.28	C	739	0.31	C
190	2371	907	0.39	451	0.19	B	516	0.22	B	598	0.25	C	674	0.28	C	739	0.31	C
200	2523	890	0.36	429	0.17	B	495	0.20	B	576	0.23	C	641	0.25	C	717	0.28	C

NOTE: 1. Flow rates were calculated by taking the DHV from Table 2.3 and factoring by the PHF from Table 8-3 of the Highway Capacity Manual

8.0 Summary and Conclusions

Traffic Volumes - 2000 to 2020

1. Current Annual Average Daily Traffic volumes (AADT) vary from 13500 vpd towards the easterly end of the Study Section to 3300 vpd at the west end. If historical growth rates are sustained during the next twenty years, 2020 AADT volumes of 20000 are expected on several highway sections between Mount Uniacke and Coldbrook. AADT's of this magnitude mean that daily volumes of 22000 to 27000 will be common.

Level of Service

2. The Level of Service (LOS) objective of the Study is to 'ensure preservation of a level of service greater than or equal to C' to horizon year 2020.

   The LOS analysis indicated that currently all two lane sections between Mount Uniacke and Coldbrook experience LOS 'E', while sections west of Coldbrook achieve LOS 'C' and 'B'. In order to achieve LOS 'C' during 2020, all sections east of Kingston will require four lanes. Sections west of Kingston will continue to achieve LOS 'C' for projected 2020 traffic conditions.

Collision History - 1990 to 1999

3. There were 1410 reported collisions on the 140 km Study Section during the ten years 1990 to 1999, including 909 property damage only, 385 personal injury, 74 incapacitating serious injury, and 42 fatal collisions.

4. The 42 fatal collisions included two pedestrian collisions, eight single vehicle collisions and 32 involving two or more vehicles. Of the multi-vehicle collisions, 28 involved vehicles traveling in opposite directions (cross centerline) and three were classified as 'right angle'. There were 55 victims, including two pedestrians, 18 passengers and 35 drivers.

5. A high proportion of the fatal collisions occurred during ideal conditions of weather, and road surface and light conditions. However, there were still many collisions that occurred during darkness or on snow / ice / slush or wet pavement.

6. Human (driver or pedestrian) condition or action accounted for 86% of the contributing factors for fatal collisions. Human factors such as, 'driver inattention', 'had been drinking / impaired', 'fell asleep', 'inexperience', 'failure to yield right-of-way' and 'driving too fast for conditions / speeding' accounted for 34 of the 42 fatal collisions. Other factors were vehicle condition (2%), animals / deer (5%), and road conditions (7%). This data is comparable to other collision research that has concluded that over 90 percent of all road accidents involve human error, and that only a small proportion of collisions can be attributed to vehicle defects or faults in road design or maintenance.

7. Collisions involving death or injury must be reported to the police immediately. However, when a collision involves property damage only (PDO) and the 'apparent' damage is $1000 or more, the drivers involved have 24 hours before they must complete a *Report of Motor Vehicle Accident* (MV58A). Exact collision location information and objective reporting of contributing factors are often lost because of the 24 hour reporting period and the largely 'self reporting' nature of the PDO collision reporting system used in Nova Scotia. Accurate and complete reporting of collision location and contributing factor details would greatly increase the value of collision report data in evaluating collision countermeasures.

Collision Rates - 1990 to 1999

8. *How do Highway 101 collision rates compare to those for other 100 series highways?*

The safety objective of the Study was 'preservation of an acceptable level of safety performance', by achieving a collision rate equal to or better than that for all provincial two lane controlled access highways. Highway 101 PDO, injury and total rates (Table 2.7) are much lower than the average rates for all two lane controlled access highways and the fatal rate for the Study Section is almost equal to the published average fatal rate.

Study Section PDO, injury and total rates are also comparable to those for all four lane divided highways in the Province. However, the ten year fatal collision rate is considerably higher than that for the average four lane divided wide median highways in Nova Scotia.

While fatal collisions do occur on four lane highways, they usually are single vehicle crashes with a single fatality. Collisions on Highway 101, on the other hand, are usually cross centerline, head-on crashes, often having multiple fatalities.

A sensitivity or quality control analysis determined that none of the highway sections in the Study Section can be identified as having safety performance that compares unfavorably with the average for similar class (two lane controlled access) highways.

9. *If Highway 101 PDO, injury and total rates are better than those for all two lane controlled access highways, and the fatal rates are comparable, how is Highway 101 'different'?*

The length and AADT volumes of the eastern half of the Study Section, make it unique in Nova Scotia. The AADT volumes on the 75 km segment between Mount Uniacke and Coldbrook are in excess of 10000 vpd, often with weekday average volumes of 14000 to 15000 vpd. There has never been a section of two lane controlled access highway so long and with such a high volume in Nova Scotia.

Highway 101 provides transportation services for industries, many of which rely on 'just-in-time' delivery of goods to reduce storage and inventory costs. Also, many commuters, who 'must' travel regardless of weather and road conditions, use the highway every day.

Although, at first glance, Highway 101 appears to be 'like' other 100-series controlled access two lane highways, the above factors indicate that much of the Study Section is a unique and challenging 'study' in traffic operations and highway safety performance.

Under 'normal' conditions of highway infrastructure upgrading, there is a high probability that twinning would have been completed to Ellershouse or Windsor, with work now scheduled to complete twinning to Coldbrook. Rural primary arterial controlled access highways should generally be upgraded to four lane divided highways before volumes reach 10000 AADT.

Public Concerns

10. Discussions with 'Twin to Win' representatives, truck drivers and focus groups have provided lengthy lists of public concerns which are included in Sections 3.1, 3.2 and 3.3, respectively.

A major public concern is that volumes are so high that any cross centerline movement has a high probability of a head-on crash. Fatal collisions, which are often head-on crashes, are creating trauma to attending professionals who often know the victims. Many people are reluctant to become volunteer firemen because they do not want to attend highway crash scenes.

All groups interviewed were concerned with shoulder drop-offs, winter road maintenance, hydroplaning, pavement markings (especially at the end of climbing lanes), inattentive and aggressive drivers, and the need for passing lanes between Coldbrook and Bridgetown. Specific mention was made concerning winter road conditions between Mount Uniacke and Windsor with regard to frequent and rapid changes in weather. It was concluded that there are several micro-climates throughout this section of highway that driver must be aware of so they can adjust driving speeds in accordance with road conditions.

RCMP Concerns

11. Interviews with RCMP officers from the Bridgetown, Kings, and Windsor detachments provided a listing of many concerns with regard to the safety of the Study Section (see Section 3.1).

While they consider Highway 101, for the most part, to be a 'good' two lane controlled access highway, there were a number of specific highway related concerns:

- Poor shoulders have been involved in many collisions.
- 'Downhill' passing in the center climbing lane is a problem
- Ben Jackson intersection should be eliminated.
- There is a need for better traffic lines that will last longer.
- When a winter storm is imminent, salt trucks should be prepared to act immediately so that there is no delay in preventing or reducing slippery road conditions.

Since driver inattention and fatigue are involved in many collisions, the officers thought that rest areas would be beneficial where there are long sections of highway between interchanges. Many Highway 101 drivers are reported to be reckless and aggressive, and high travel speeds are a major concern. Additional highway patrols, new speed enforcement methods, and graduated speeding fines would help reduce speeding and improve driving behaviour.

Human Factors

12. Numerous factors must be considered in determining the safety of a highway. These factors include traffic volume, vehicle mix (proportion of trucks, RVs, and cars), adequacy of traffic control devices, proportion of unfamiliar drivers, weather conditions, and highway geometry (lane and shoulder width, median width, slope of the median, number of lanes, lane separation, horizontal and vertical curves, sight distance, number and design of intersections or interchanges).

The driving task involves three main components - ***driver***, ***vehicle*** and ***road/environment***. Significant improvements have occurred with the last two, but human abilities and limitations have changed little over the centuries.

Driving may be viewed as requiring three types of information, related to ***control***, ***guidance*** and ***navigation***. It is therefore essential to take into account the information needs of the driver as well as his/her information processing and decision making capabilities when designing highways and traffic control devices.

Drivers often have difficulty processing all the information they require while driving. This limitation is reflected in the conclusion of one researcher that the driver is an "outdated human with stone-age characteristics and performance who is controlling a fast, heavy machine in an environment packed with unnatural, artificial signs and signals."

Expectancy relates to a driver's readiness to respond to conditions, situations, events and information. It influences the speed and accuracy of information processing, and is one of the more important driver-related characteristics in the design and operation of highways. The highway itself conveys more information to its users than any other single source. Drivers operate with a set of expectancies. For example, freeway exits will be on the right side of the roadway, advance warning will be given of hazards on the road, other drivers will obey traffic rules. If these expectancies are violated, there is an increase in driver perception-reaction time, more driver errors and the potential for an accident.

Education is Needed

13. The most frequent contributing factors to collisions are related to driver behaviour or condition and decision making - inattention/distraction, fell asleep/fatigue and speed too fast for conditions. Driver factors (risky behaviour, condition and faulty decision making) can be addressed through education and enforcement campaigns. Graduated licensing, such as that used in Nova Scotia, with an emphasis on the human factors that contribute to accidents, is a beneficial educational phase for newly licenced drivers.

Design and Construction Standards

14. ***Horizontal Alignment*** - The horizontal alignment of Highway 101 proper in the study area was designed generally in accordance with the relevant design standards current at the time it was constructed between 1968 and 1985. The road was originally designed to a 70 mph [113 km/h] rural arterial undivided (RAU) standard. The most restrictive horizontal curvature appears to be in the Windsor area near Exit 6, at a 4º30' curve, which is consistent with a design speed of 60 mph [97 km/h]. The posted speed here is 90 km/h, about 10% below the design speed.

15. ***Vertical Alignment*** - The rolling terrain between Exits 3 and 14 features frequent vertical curves. Although data was not available to check all the vertical geometry, it appears that many of the crest vertical curves are marginal in that they would have been designed to CGRA 1963 vertical curve criteria, which has subsequently been upgraded. Consequently, it is felt that many vertical curves here would have stopping sight distances now considered appropriate for the posted speed of 100 km/h, with no margin between the design speed and posted speed.

16. ***Design Speed*** - The vertical and horizontal alignments appear to be designed in accordance with applicable standards at the time, with a margin of 10 mph (or over 15 km/h) between the design posted speeds, at the time the highway was designed. However, *revisions to the standards for vertical curves means that the vertical alignment design would now be considered appropriate for approximately the posted speed of 100 km/h only.*
    It appears that the vertical alignment will govern the overall design speed in the rolling terrain. Therefore, it has been concluded that by current guidelines **design speed of the alignment is generally 100 km/h from Exits 3 to 14, and 110 km/h from Exits 14 to 20.**

17. ***Cross Section*** - Travel lane widths of 3.7 m [12 feet], consistent with both historical and current design guidelines, are provided throughout the Study Section. The shoulder width is considered deficient where it is less than 3m [10 feet], except at bridge structures and their immediate approaches. While the Study Section generally has 3 m shoulders throughout, narrow shoulders occur at several areas (representing about 5 km total) typically where there are high embankments with guide rail. The railing system further reduces the usable width of shoulder. Narrow shoulders effectively prevent a vehicle from pulling safely off the traveled way.

    While the *Geometric Design Guide for Canadian Roads* indicates that paved shoulders are safer than unpaved shoulders, minimum or 'best practice' widths of paved shoulder are not included. There is an indication that partially paved shoulders with a paved width of 0.8 m provide for minor deviations from the traveled lane. The Study Section has 0.8 m to 1.0 m partially paved shoulders, however, there are numerous areas where there is a bothersome dropoff between the edge of the paved shoulder and the gravel shoulder.

18. ***Intersections*** - The only intersection on the Study Section, the Ben Jackson Road (Exit 8A) intersection is functionally inappropriate and should be eliminated.

19. ***Interchanges*** - The most common interchange type in Nova Scotia is the diamond interchange which is readily understood by drivers. The series of interchanges from Exit 3 to Exit 9 is inconsistent in design configuration, and several substandard ramps are likely to be beyond driver expectations and may 'surprise' drivers unfamiliar with the area. Eastbound exit ramps at Exit 5A and Exit 9 have unorthodox designs with slow 30 km/h or 40 km/h posted ramp speeds. The Exit 9 ramp has the greatest potential to betray expectations since an eastbound motorist traveling the length of the Study Section would have passed by ten diamond interchanges with high speed exit ramps. The Exit 8 interchange was constructed utilizing the two lane Halfway River bridge, and as such, does not have an adequate westbound acceleration lane. These three areas should have preliminary design completed for the future alignment of the four lane highway and interchanges. This would then permit selected interim improvements in the present interchange deficiencies, which would be consistent with the four lane highway design.

Observed Highway Speeds

20. Eastbound 85th percentile travel speeds vary from 109 to 114 km/h throughout the Study Section. Westbound speeds are consistently higher and vary from 112 to 117 km/h. It was noted that up to 80% of drivers exceed the legal 100 km/h speed limit at all sample locations. Also, generally, more than 22% exceed 110 km/h; more than 12% exceed 115 km/h; and more than 4 % exceed 120 km/h. While there is no readily available historical data for direct comparison, it is believed that traffic speed has increased over the years.

As noted above, revisions in design guidelines, and deficiencies noted in the roadway have effectively reduced the "design speed" of the roadway. The combined effect of increased operating speed and decreases in design speed of the roadway now means that probably the majority of traffic now exceeds what would likely be deemed a "safe" design speed of the highway. There is a definite need to reduce the travel speeds on the Study Section.

21. Drivers do not necessarily recognize geometric design features which should cause them to reduce their speed. Despite improvements in vehicles, the design speed of the roadway is basically restricted by human perception and reaction and the geometric features of the road. However, it is evident that the widely assumed concept that the roadway is designed for the large majority (say 85%) of driving speeds, and that there is a comfortable margin between the average traveling speed and the design speed, is not valid. The obvious inference, of course, is that when a tolerance for highway enforcement is added to the speed limit, speeders are not merely disregarding the speed limit but almost certainly exceeding the design speed of the highway.

Additional Highway Patrols are Needed

22. While there are 91 approved highway patrol positions throughout the Province, only about 60 of these are actually assigned to highway patrol. Each of the three RCMP detachments responsible for patrolling the Study Section is 'missing' at least one approved highway patrol position. Additional police presence and speed enforcement are required to reduce prevailing travel speeds and to generally promote safe driving habits. The reinstatement of the 'missing' highway patrol positions would be a 'start', however, additional enforcement funding will also be needed. Four hour blocks of paid overtime at a cost of about $200 would be a cost effective way to overcome staff shortages.

Highway Maintenance

23. Conclusions concerning needed highway maintenance improvements are listed in Section 5.5.

    It was generally concluded that written highway maintenance performance standards must be developed so that consistent, proper and timely repairs can be provided to ensure the safest possible road system. Items that should be included are inspection of bridge decks, road surface and shoulders, provision of timely repairs, pavement condition with regard to ride quality and wheel track rutting, guide rail, and the road side beyond the shoulder (side slope, ditch and back slope).

Snow and Ice Control

24. Conclusions regarding winter road maintenance (snow and ice control) are discussed throughout Section 5.4 and a list of conclusions is included in Section 5.5.

    Highway 101 must remain priority number one for snow and ice control in the respective areas. Patrolling of the highway in the early morning before commuter traffic starts, as well as in the early evening, and additional use of the Road Weather Information System (RWIS) and Web Cam installations are needed. Areas should coordinate their salting and plowing with adjacent areas to minimize the time gap of service at county lines and attempt to provide a seamless level of service along Highway 101. It was also concluded that shift change times should be adjusted to ensure that vehicles and staff are available to be 'on the road' during peak travel periods.

9.0 Recommendations

Overview

The stated **primary objective** of this study is:

> *". . .to complete a comprehensive operational and safety review of Highway 101, from Mount Uniacke to Bridgetown,. . .to ensure preservation of a **level of service** greater than or equal to C and preservation of an acceptable **level of safety** performance."*

Level of Service (LOS) **-** Currently all two lane sections between Mount Uniacke and Coldbrook experience LOS 'E', while sections west of Coldbrook achieve LOS 'C' and 'B'. By 2020, all sections east of Kingston will require four lanes. Two lane sections west of Kingston will continue to achieve LOS 'C' for projected 2020 traffic conditions**.**

Level of Safety **-** Study Section property damage only (PDO), injury and total rates (Table 2.7) are much lower than the average rates for all provincial two lane controlled access highways and the fatal rate for the Study Section is almost equal to the published average fatal rate. Also, Study Section PDO, injury and total rates are comparable to those for all four lane divided highways in the Province. A sensitivity analysis determined that *none of the highway sections in the Study Section can be identified as having safety performance that compares unfavorably with the average for similar class (two lane controlled access) highways*.

However, *the ten year fatal collision rate is considerably higher than that for the average four lane divided wide median highways in Nova Scotia*. While fatal collisions do occur on four lane highways, they usually are single vehicle crashes with a single fatality. Collisions on Highway 101, on the other hand, are usually cross centerline, head-on crashes, often having multiple fatalities.

Completion of a four lane divided wide median highway is the long term solution for the level of service and fatal collision concerns of the Study Section. However, this Study has revealed many recommendations for changes that will collectively improve the overall level of safety, as well as the comfort and convenience of using Highway 101.

Short Term - Immediately to Twelve Months

1. ***Shoulders*** - Complete grading of shoulders to ensure that drop off at the edge of the pavement does not exceed 50 mm.

2. ***Pavement Markings*** -
   , Eliminate all downhill passing sections on climbing lanes;
   , Evaluate the pavement markings for passing zones on two lane sections to ensure that they are marked in accordance with the prevailing 85th percentile travel speeds;
   , Evaluate passing zones on the approach to an opposing access ramp to ensure that a conflict between a passing vehicle and an entering vehicle will not create a safety problem.

3. ***Interchanges*** -
   , The westbound lanes of the short four lane section at Ellershouse end at the Exit 4 (St. Croix interchange) westbound exit. The pavement markings and signing should be reviewed, and necessary changes made, to ensure 'positive guidance' for motorists;
   , The eastbound access ramp of the Exit 5A, (Wentworth Road interchange) enters Highway 101 at the end of an eastbound climbing lane. Options to eliminate this confusing and potentially hazardous situation should be investigated, including sign and pavement marking changes; extension of the climbing lane easterly to the Trunk 14 exit; or, removal of the short climbing lane.

4. ***Speed Limits*** - There are four closely spaced interchanges between Trunk 14 (Exit 5) and Falmouth (Exit 7). To reduce the speed variation between through traffic and slower entering and exiting traffic, it is recommended that a study be completed to consider extending the 90 km/h zone easterly to east of Trunk 14 and westerly to Trunk 1 west of Falmouth, until the section can be upgraded to four lanes.

5. ***Ben Jackson Road Intersection*** - Complete plans for the elimination of this intersection. Also, make the following changes or additions:
   , Establish a 90 km/h zone to cover the east and west approaches to the intersection;
   , Erect additional INTERSECTION warning signs with flashing amber lights; and
   , Install pavement arrows on Highway 101 to make through, left turn and right turn lanes.

6. ***Highway Maintenance*** - Referring to the recommendations in Section 5.5, review the Study Section with regards to the condition of bridge decks, road surface and shoulders, pavement (ride quality and wheel track rutting), guide rail, and the road side beyond the shoulder (side slope, ditch and back slope).

7. ***Snow and Ice Control*** - Referring to the recommendations in Section 5.5, ensure that Highway 101 continues to be the number one priority for snow and ice control. Within the next three months, determine whether the recommended changes concerning winter patrolling, increased use of Road Weather Information System (RWIS) and Web Cams, coordination of plowing and salting activities, and shift change times can be incorporated into the 2000-01 winter maintenance program.

8. ***Education*** - Recognizing that human factors account for a large percentage of collisions, and changes in driver attitudes have the greatest potential to reduce collisions, include the following themes in any upcoming highway safety advertising campaigns:
   - DRIVE TO ARRIVE (be attentive; stay awake; wear seat belts; don't drink and drive);
   - Reduce Speed According to Road Conditions; and
   - ONLY YOU CAN PREVENT ACCIDENTS.

9. ***Enforcement*** - Enforcement of speed and safe driving laws is an effective way to modify driver behaviour, since most drivers fear getting a ticket more than having an accident. Continue and increase enforcement in the following areas:
   - Alcohol and impaired driving laws;
   - Seat belt / child seat usage;
   - Speed limit; reduce the 85^{th} percentile travel speed; and
   - Encourage / promote good driving habits by greater police presence.

10. **Signing** -
    - Relocate / remove improperly located signs (Section 6.4); and
    - Inspect and repair guide signs that have 'non-reflecting' letters or route markers.

Mid-Term - One to Two Years

11. ***Twinning*** - Since twinning is required to improve both level of service and safety, it is important that this program begin as soon as possible. Preparation of environmental assessment, and land use, survey and design plans, should be initiated for all sections between Mount Uniacke and Kingston. Construction should be started on the section between Mount Uniacke and Ellershouse.

12. ***Land Owner Access Roads*** - Removal of all land owner access roads should be included in the twinning program. Accesses that can be removed without construction of underpasses or lengthy service roads should be removed as soon as possible.

13. ***Rest Areas*** - The TPW Rest Area Committee should investigate the need for rest areas on the Study Section, especially on the long section between Mount Uniacke and Ellershouse. Construction of rest areas should be included in the twinning program.

14. ***Shoulders*** - Paved shoulders are safer than unpaved shoulders. Considering the maintenance required to prevent unsatisfactory shoulder drop-off and the edge deterioration of the existing narrow paved shoulders, it is recommended that the benefits and costs of wider paved shoulders be evaluated. Shoulder rumble strips have been shown to reduce run off the road accidents. Since paved shoulder widths of 2 metres (1.2 m on the median lane) are required to support shoulder rumble strips, those widths should be considered for use on 100 series highways.

15. ***Lane Lines*** - Wider lane lines provide better 'positive guidance'. Also, there is a variety of alternate marking materials that offer longer line life at extra cost. It is recommended that the use of wider lane lines and alternate marking materials be investigated for lane markings on 100 series highways.

16. ***Guide Rail*** - Guide rail is an integral part of the roadside safety program. Critical areas include end treatment, length of coverage, and bridge end connection design. Work required includes:
    - Straighten leaning sections;
    - Develop improved 'state of the art' standards for fastening guide rails to bridge ends;
    - Develop upgraded standards for placement of guide rail; and
    - Replace guide posts with small delineator posts.

17. ***Passing Lanes*** - Complete planning of number and location of passing lanes between Coldbrook and Bridgetown. Since twinning will be required between Coldbrook and Kingston, the construction of one or two carefully located short (approximately two km) four lane divided sections should be considered to provide needed passing lanes. Also, since the highway will be twinned to Kingston, it is probable that passing lanes will only be required between Middleton and Bridgetown.

18. ***Highway Maintenance*** - Develop and adopt performance standards for road maintenance. Begin a program to replace highway signs; many large green signs are over twenty years old.

19. ***Winter Maintenance*** - Develop and adopt performance standards for snow and ice control. Install additional RWIS sites and web cams to detect black ice and other winter road conditions. Plan and install changeable message signs to warn of adverse road conditions and need to adjust speed, especially on the section between Ellershouse and Mount Uniacke.

20. ***Animal Control Fencing*** - Investigate need for and install animal control fencing in appropriate areas

21. ***Safety Programs*** -
    - Develop community based safety programs to promote good driving habits and to provide education on the rules of the road and meanings of signs / markings;
    - Involve the insurance industry in funding of safety programs based on potential to reduce accidents and insurance claims;
    - Complete studies to relate the cost of treatment and rehabilitation of accident victims to the potential for savings with funds invested on road safety programs.

22. ***Enforcement*** -
    - Return all seconded RCMP highway patrol officers to their areas so that all detachments are at full strength;
    - Use paid overtime (using funding from insurance companies) as a cost effective mechanism to provide additional highway patrol enforcement and visibility during peak demand periods;
    - Continue RCMP combined efforts in the Checkpoint program; TPW to assist where needed; and

- Continue the program to reduce travel speeds; investigate additional methods of speed control.

23. **Motor Vehicle Act Changes** -
    - Introduce graduated speeding fines based on km over limit; post advisory signs;
    - Introduce minimum speed laws so that RCMP can enforce unsafe slow speeds;
    - Introduce laws concerning 'inattention' so that police can control blatant inattentive driving, such as reading a book;
    - Introduce a law making the registered owner responsible for MVA violations when the driver's identity is not known; and
    - Consider changes to remove the 24 hour reporting period for collisions and require collision reporting as soon as possible, to the nearest practical police department.

Long Term - Two to Ten Years

24. ***Twinning*** - Twin Highway 101 from Mount Uniacke to Kingston; approximately 105 km of twinning are required.
    - Twin Mount Uniacke to Ellershouse as soon as possible; attempt to complete this project by the fall of 2002;
    - Twin west from Ellershouse and both west and east from the Avonport four lane section to avoid concentrating too much construction activity in one area.;
    - Plan to open twenty kilometres of twinning every two years;
    - Upgrade guide rail and guide rail / bridge end treatments as sections are twinned; and
    - Review centerline profile / cross section / horizontal alignment of the 'existing' highway during twinning.

25. ***Interchange Upgrading during Twinning*** -
    - Connect acceleration and deceleration lanes at closely spaced interchanges as required, and where practical;
    - Reconstruct Wentworth Road (Exit 5A) eastbound exit ramp;
    - Reconstruct three of the four ramps at Avonport (Exit 9); and
    - Widen the Halfway River bridge at Hantsport (Exit 8) to provide an appropriate acceleration lane, if the existing bridge continues to be used for the westbound lanes.

26. ***Passing Lanes*** - Construct passing lanes between Kingston [Middleton] and Bridgetown.

10.0 References

A Policy on Geometric Design of Rural Highways, 1965, American Association of State Highway Officials (AASHO 1965)

Geometric Design Standards for Canadian Roads and Streets, Canadian Good Roads Association, 1963 and revised to 1973 (CGRA 1963)

Geometric Design Standards for Canadian Roads and Streets, Roads and Transportation Association of Canada, 1976 (RTAC 1976)

Geometric Design Guide for Canadian Roads, Transportation Association of Canada, 1999 (TAC 1999)

Highway Capacity Manual, Special Report 209, Third Edition, Transportation Research Board, Washington, DC, 1994

Highway Capacity Manual, Special Report 209, Third Edition, Transportation Research Board, Washington, DC, 1997

Human Factors - see complete references in Appendix F

Advanced Traffic Accident Investigation Manual, Institute of Police Technology and Management, University of North Florida

Manual for Condition Rating of Flexible Pavements, SP-024, Ontario Ministry of Transportation, Toronto

Manual of Geometric Design Standards for Canadian Roads, Roads and Transportation Association of Canada, 1986 (RTAC 1986)

Manual of Uniform Traffic Control Devices for Canada, Transportation Association of Canada, 1998

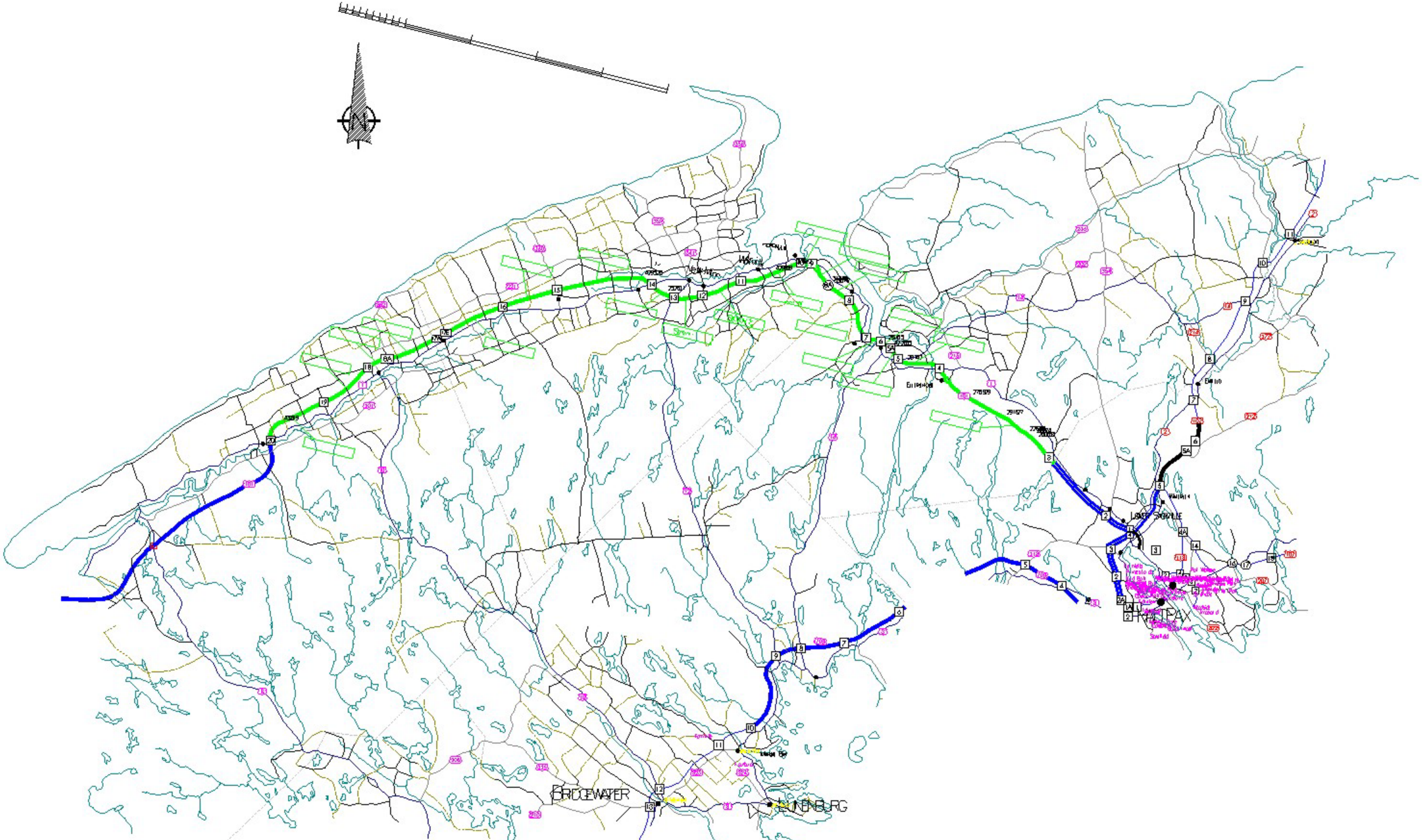
Morin, Donald A. *Application of Statistical Concepts to Accident Data.* Record 188, Highway Research Board, Washington, DC

Standard Specification, Highway Construction and Maintenance, Nova Scotia Department of Transportation and Public Works, 1997 and revised to 2000 (TPW 1997)

The Traffic Accident Investigation Manual, Northwestern University Traffic Institute

Traffic Accident Reconstruction Manual, Volume 2, Northwestern University Traffic Institute

Transportation and Traffic Engineering Handbook, Institute of Traffic Engineers, Washington, DC, 1976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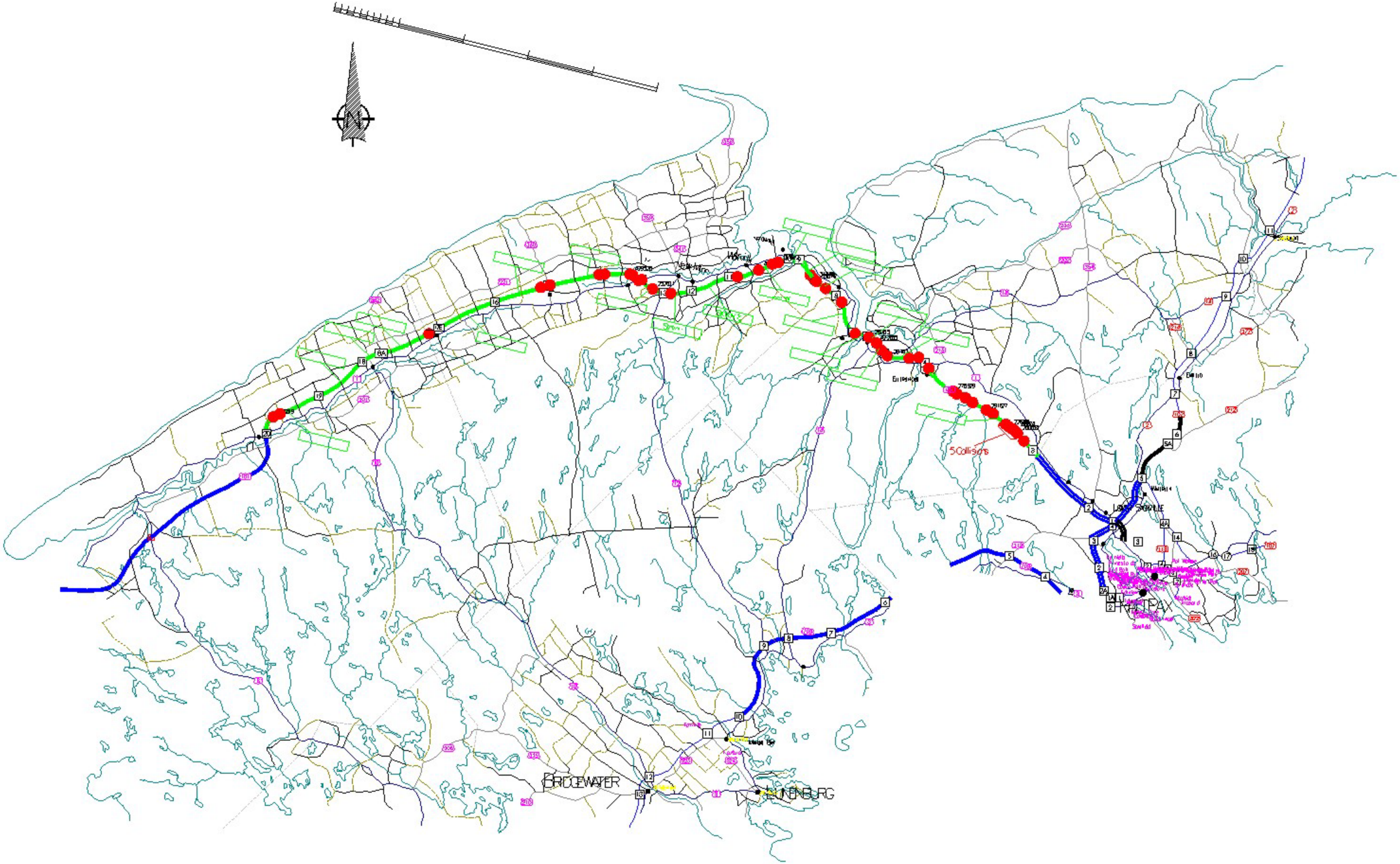

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