Greater Yellowstone Rural ITS Priority Corridor Project

Task 3. ITS-related Inventory: Regional Needs Assessment

Prepared for:

MONTANA DEPARTMENT OF TRANSPORTATION,

and

U.S. DEPARTMENT OF TRANSPORTATION,
FEDERAL HIGHWAY ADMINISTRATION,

In Cooperation with:

IDAHO TRANSPORTATION DEPARTMENT,

WYOMING DEPARTMENT OF TRANSPORTATION,

and

U.S. DEPARTMENT OF INTERIOR, YELLOWSTONE NATIONAL PARK

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IMPLEMENTATION STATEMENT

This study is sponsored by the Montana Department of Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration. The major objective of this study is to identify transportation challenges, prioritize those challenges, determine geographic areas of focus, and identify existing systems and planned infrastructure improvement projects in the Greater Yellowstone Corridor. Recommendations from this study will give researchers and the Project Steering Committee a better understanding of transportation in the Corridor. In addition, results will support future tasks that will ultimately identify Corridor demonstration projects.

DISCLAIMER

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Montana Department of Transportation or the U.S. Department of Transportation, Federal Highway Administration. Alternative accessible formats of this document will be provided upon request.

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Appreciation is also extended to Lisa Landenberger, GIS Engineer, Geographic Information and Analysis Center, Montana State University; and the Greater Yellowstone Rural ITS Priority Corridor Steering Committee members.

EXECUTIVE SUMMARY

The Greater Yellowstone Rural Intelligent Transportation System Priority Corridor, shown in Figure i, is a nationally significant rural corridor connecting Idaho Falls, Idaho and Bozeman, Montana. The purpose of analyzing this corridor is to ultimately demonstrate applications of Intelligent Transportation Systems (ITS) in a rural setting.

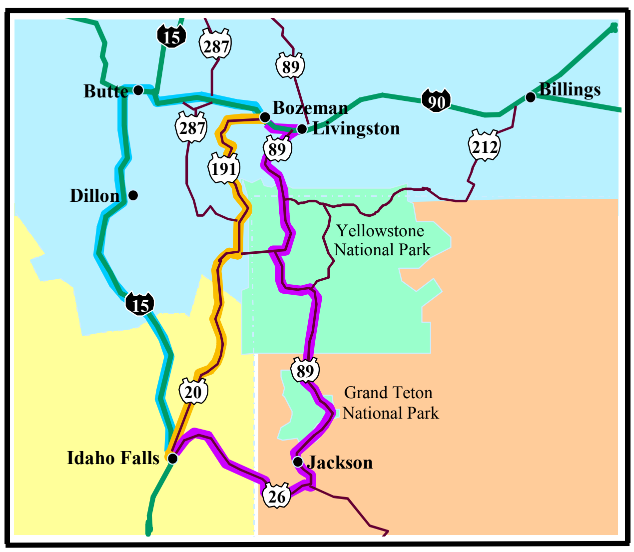

Figure i - GYRITS Study Area

This report summarizes the research findings of Task 3, ITS-related Inventory. The purpose of this task was to: (1) identify stakeholders' perceived transportation challenges within the Corridor, (2) quantify the challenges identified by stakeholders and research staff, (3) identify geographic areas of focus for these challenges, and (4) inventory existing legacy systems and planned transportation improvements.

To accomplish these activities, WTI conducted stakeholder workshops, collected extensive data on the Corridor, and analyzed data to quantify transportation challenges and locate geographic areas of focus.

Perceived transportation challenges identified through stakeholder workshops included safety impacts from:

- inclement weather;
- disparate vehicle speeds;
- mixed vehicle types, including farm equipment, commercial vehicles and snowmobiles;
- motorists unfamiliar with the area focusing more on directional information than driving;
- animal encroachments on the roadway;
- long emergency response times;
- poor horizontal and vertical alignment; and
- hazardous materials incidents;

in addition to:

- infrastructure damage caused by commercial vehicles;
- the need for partnerships and institutional cooperation;
- the lack of tourist/traveler information; and
- the dependence on tourism for economic sustainability of rural communities.

An intensive data collection and evaluation effort was made to determine if these and other challenges were quantifiable. Additionally, this data was used to locate the geographic area in which each problem was most severe. Table i shows the data used to quantify these challenges. To assist in this analysis, much of the data was spatially plotted using geographic information systems (Figures ii-xi).

Table i - Data Used to Quantify Challenges

Transportation challenges	**Data elements**
Safety problems and lengthy emergency Response times	Crash data
Commercial vehicle operations efficiency	Average daily truck traffic and interviews with weigh/inspection station operators
Lack of traveler/tourist information	Tourist destinations with annual visitation and tourist expenditures
Traveler mobility	1990 census data including countywide totals for mobility impaired, poverty level, citizens above 60 years in age
Congestion at Yellowstone National Park (YNP) entrances	Number of vehicles entering YNP
Congestion at construction/work zones	Planned construction improvements
Hazardous materials spills	Hazardous materials spill locations
Commercial vehicle safety	Crash data for crashes involving heavy trucks

Safety challenges quantifiable through crashes were analyzed through a detailed crash analysis. Crashes were analyzed on a micro and macro level. Microscopically, crash trends were identified at locations that exhibited a high number of crashes relative to the traffic volume. A macro level analysis was accomplished by identifying the frequency and location of crashes throughout the corridor that exhibited the microscopically identified trends. The safety challenges identified through this analysis include:

- icy road conditions and motorists driving too fast for these conditions,
- rear-end collisions,
- crashes resulting from failure to yield right of way or disregard for traffic control,
- crashes involving snowmobiles, and
- crashes involving animal conflicts.

Challenges thought to have a reasonable chance of yielding significant benefits from ITS applications are listed in Table ii along with their geographic area of focus. The body of this report contains detailed descriptions of the analysis methodology and results.

Data used in this analysis can serve as “before” data in future demonstration projects. Also, data collected on planned construction projects and legacy ITS systems (e.g., existing variable message signs) can be used to coordinate specific GYRITS projects with previously planned infrastructure improvement projects and legacy ITS components.

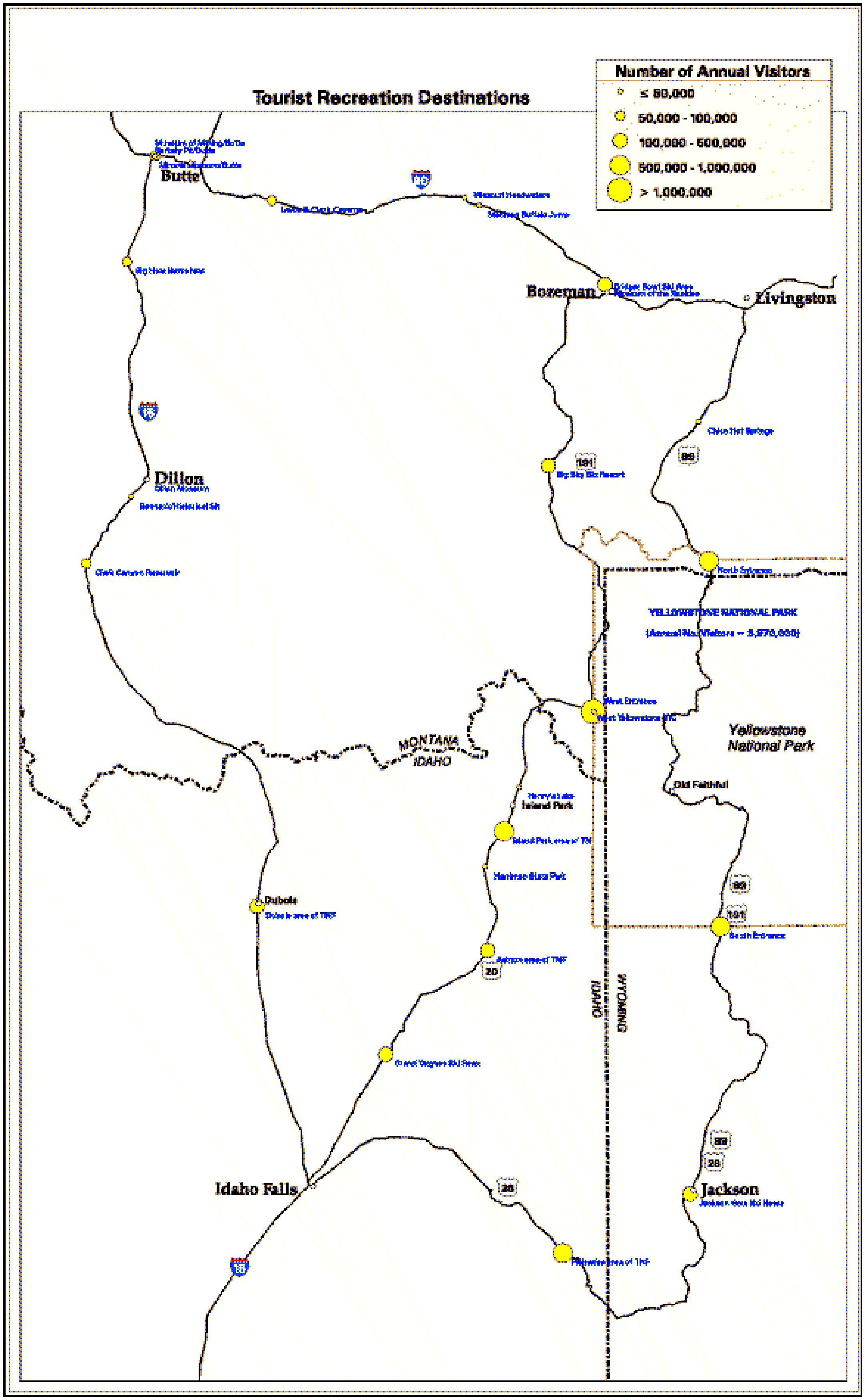

Figure ii - Tourist Destinations

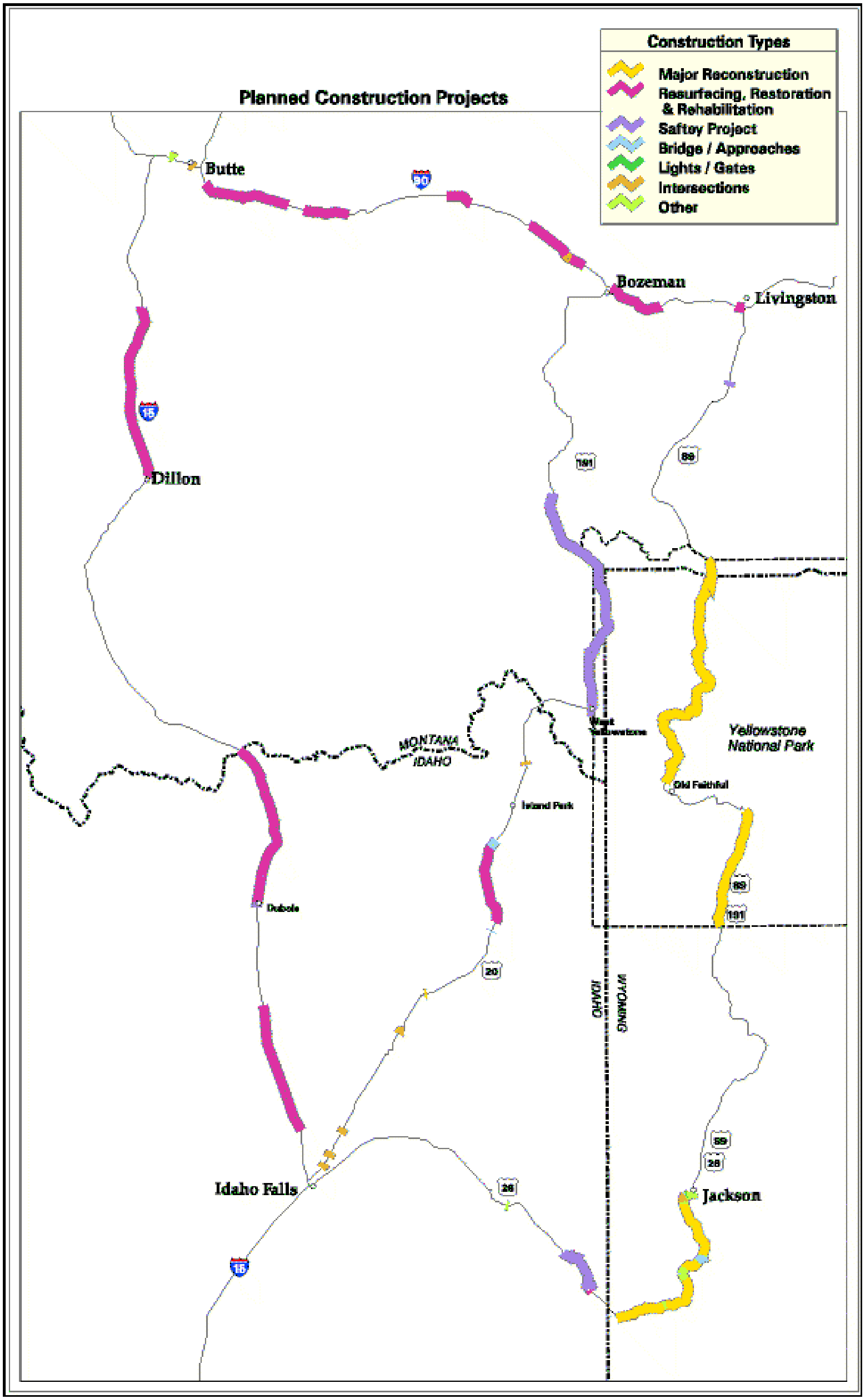

Figure iii - Planned Construction Projects

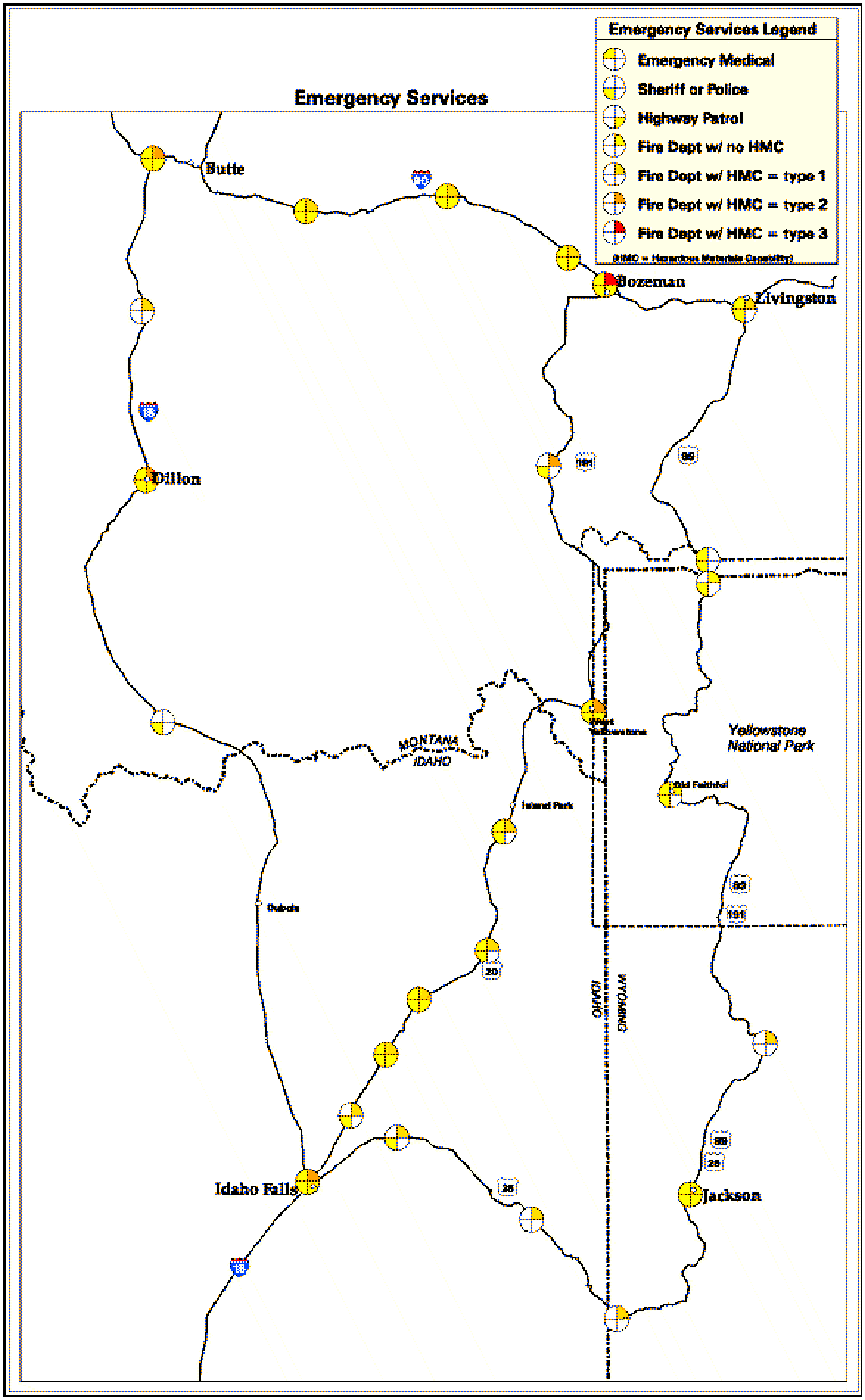

Figure iv - Emergency Services Locations

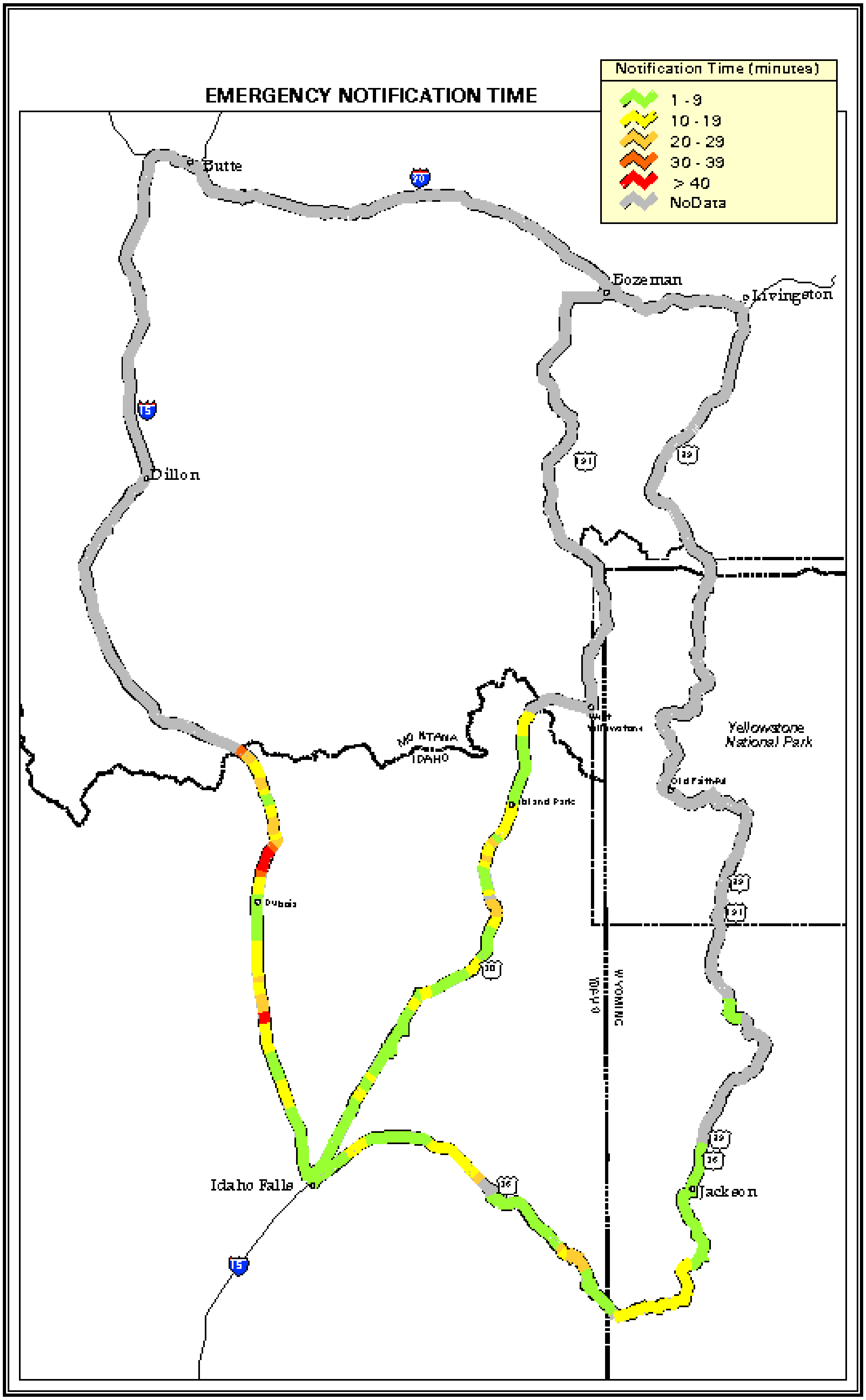

Figure v - Emergency Medical Notification Times

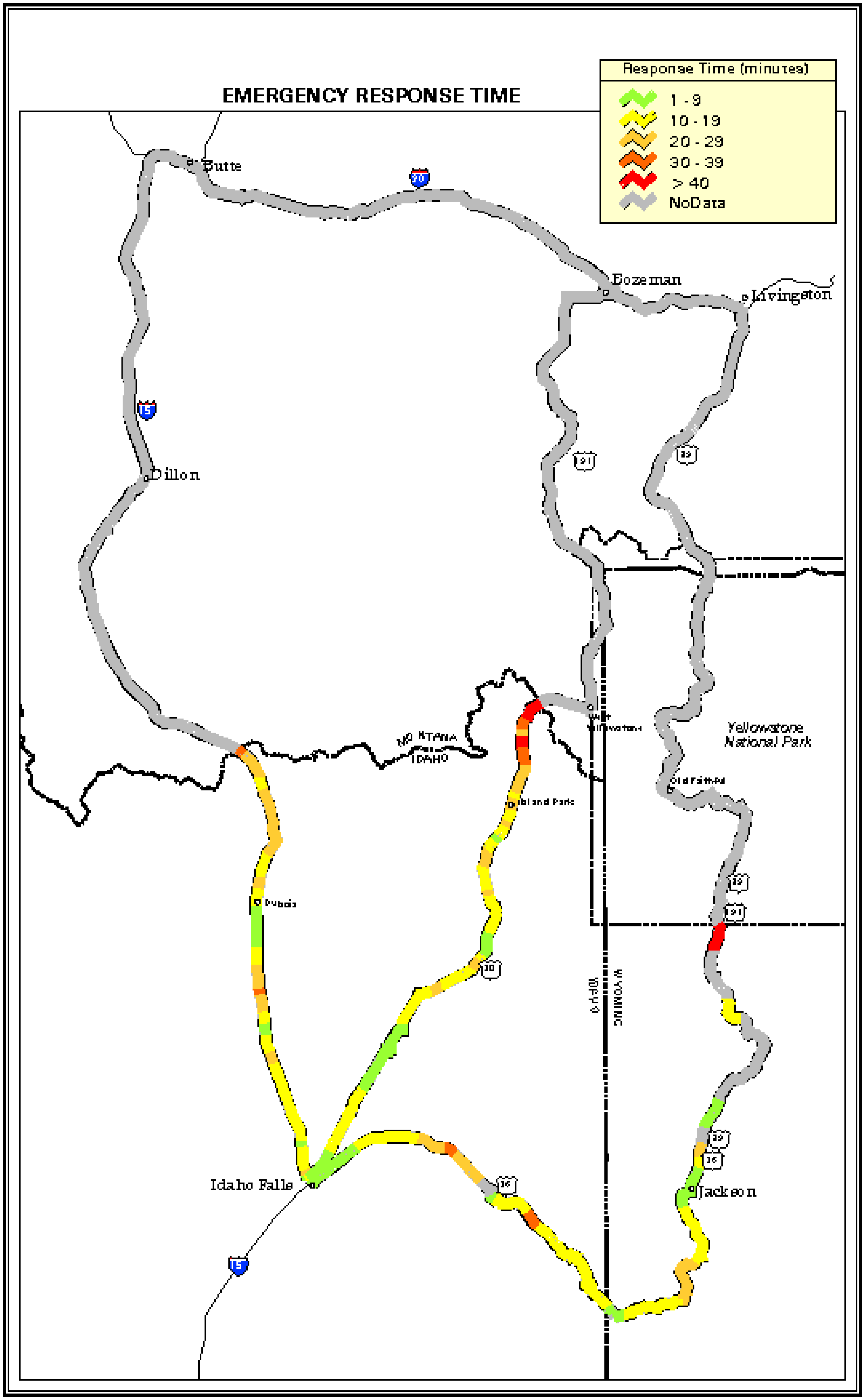

Figure vi - Emergency Medical Response Times

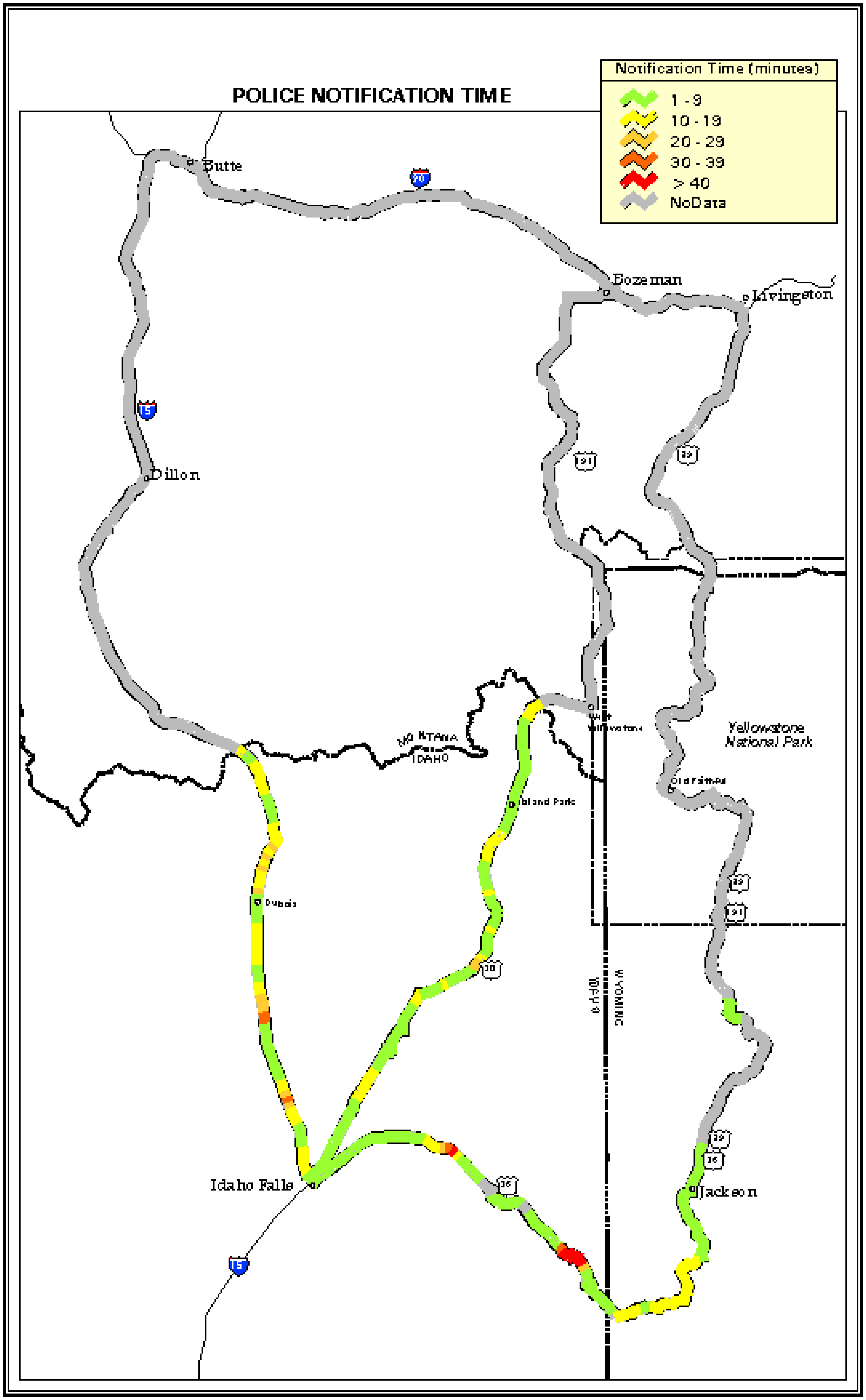

Figure vii - Police Notification Times

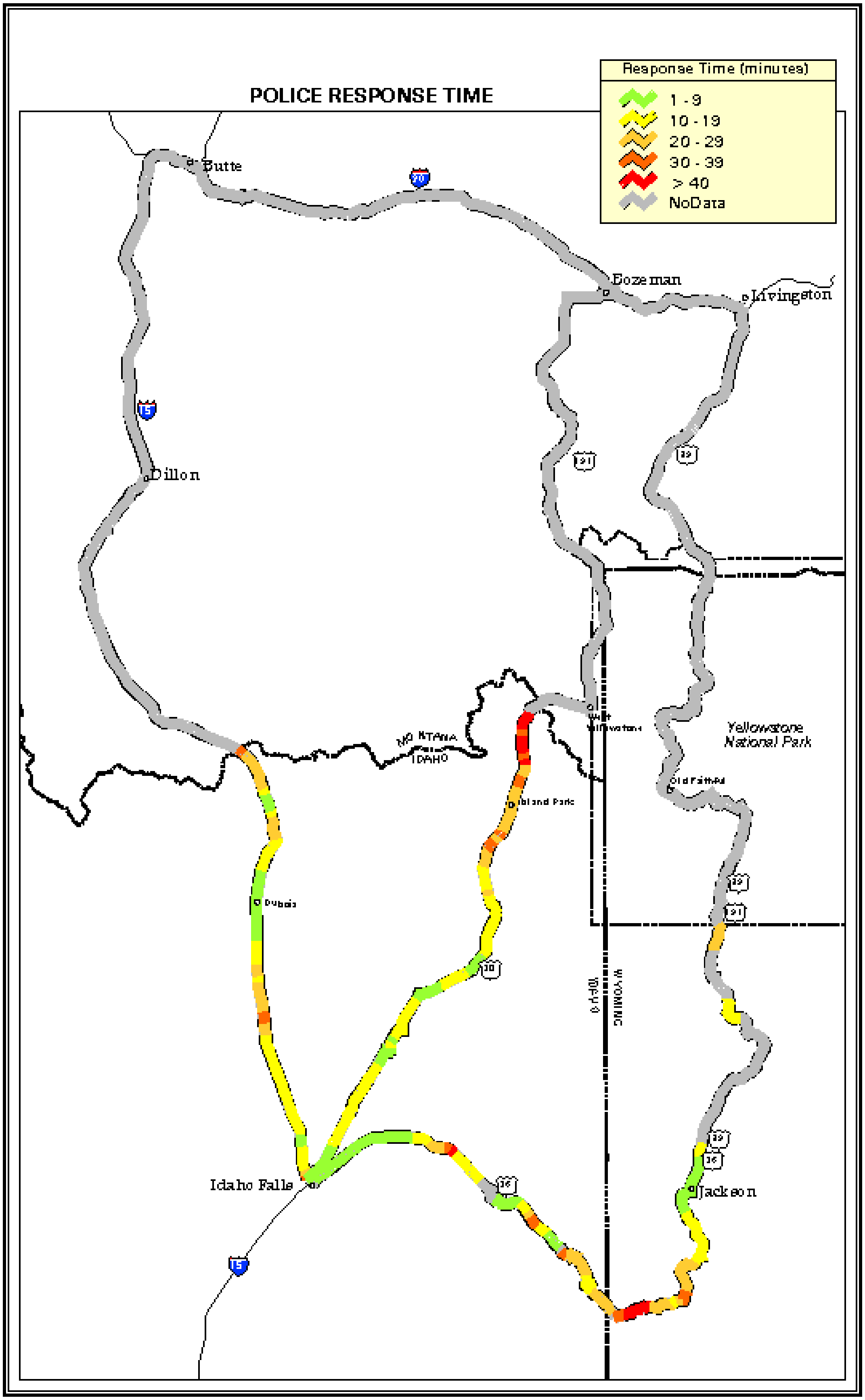

Figure viii - Police Response Times

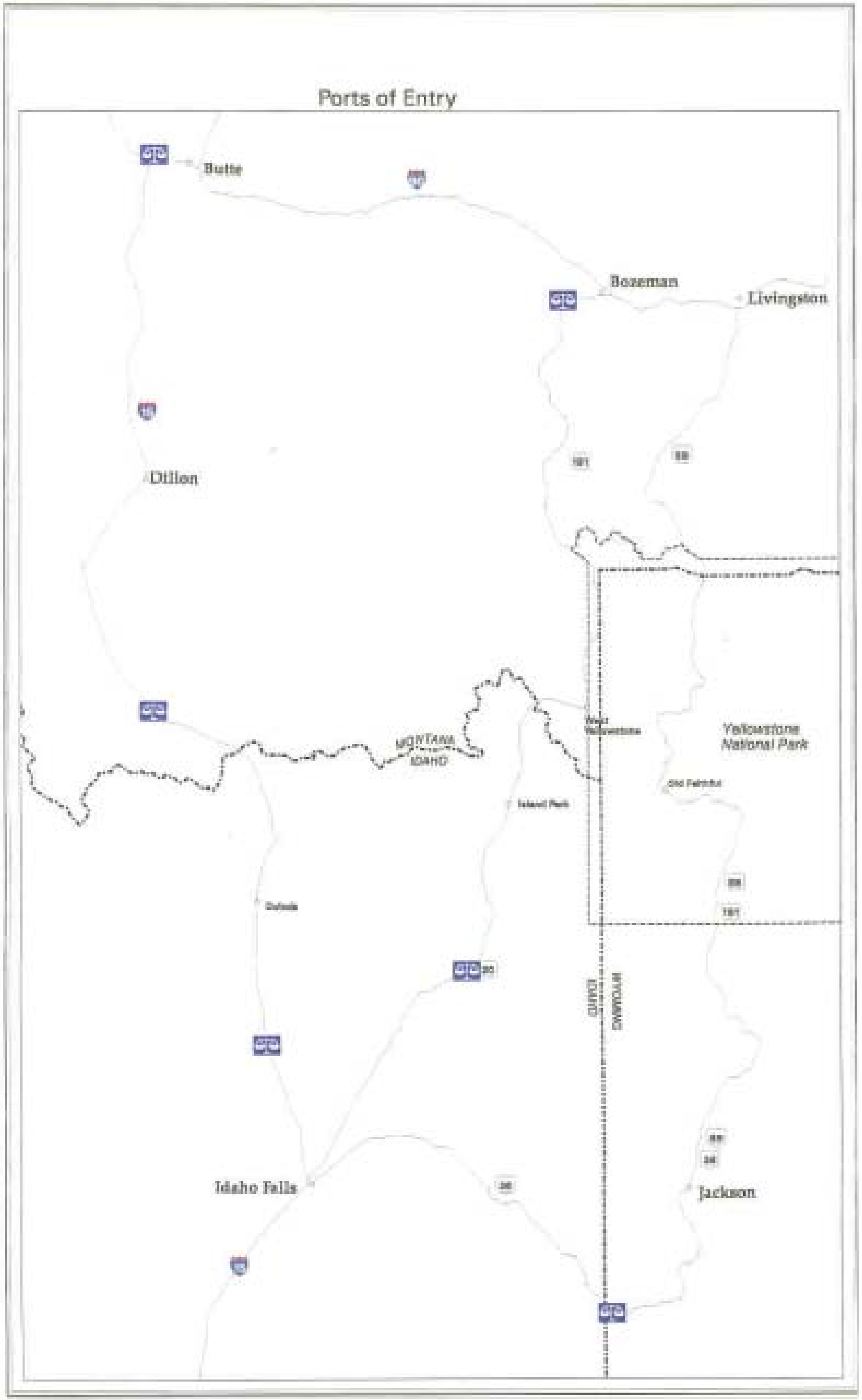

Figure ix - Weigh Station Locations

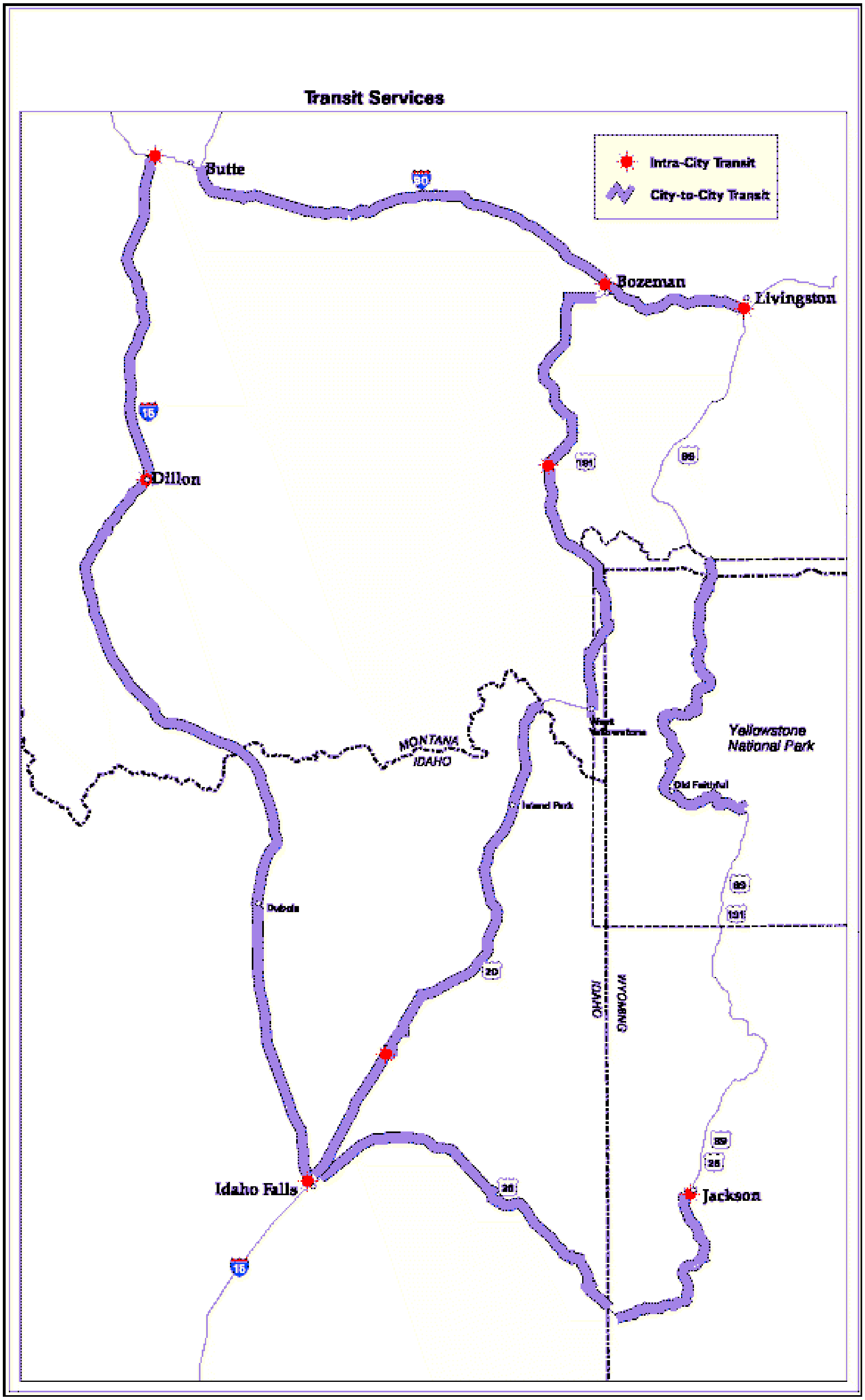

Figure x - Transit Service (Public and Private)

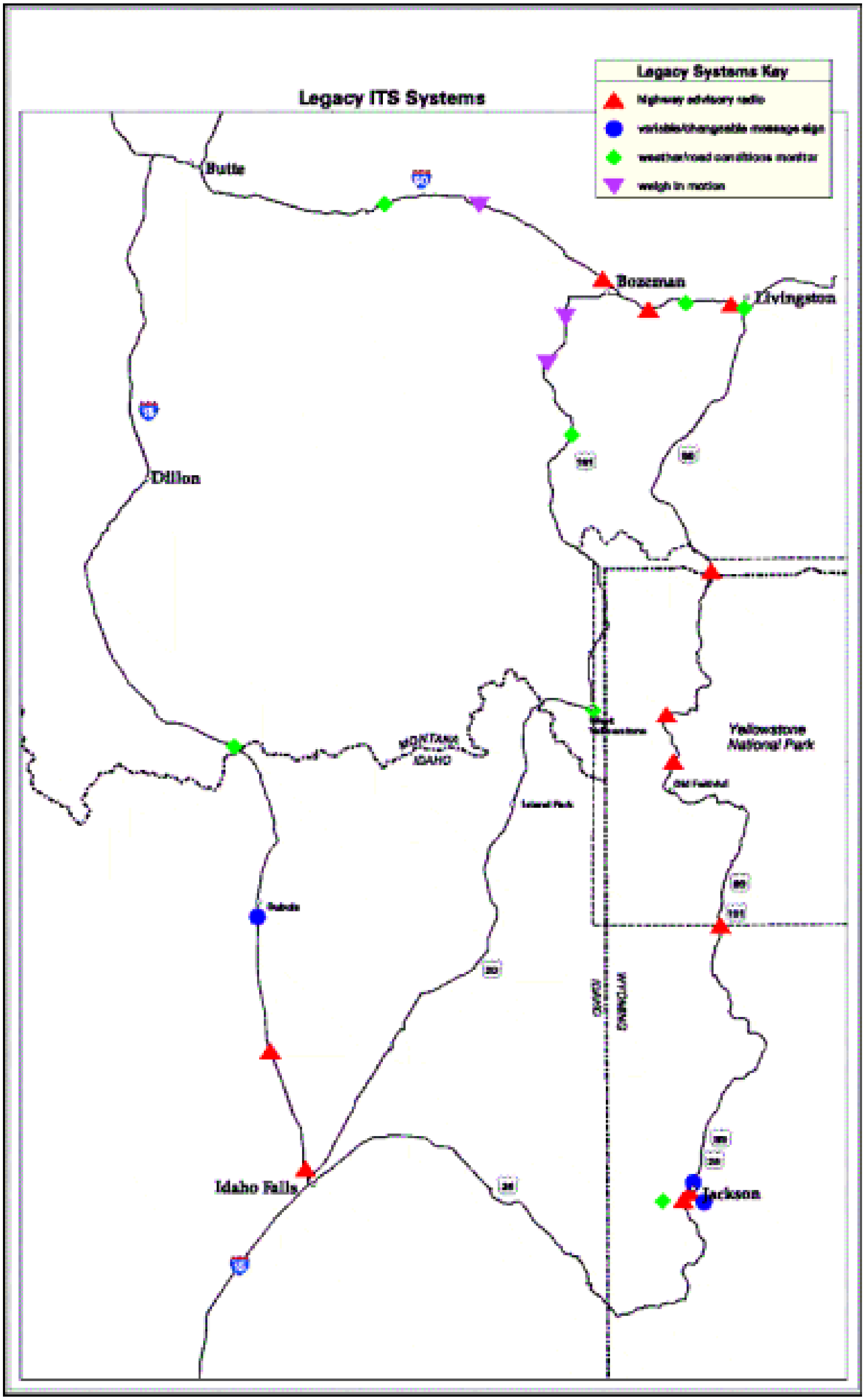

Figure xi - Legacy Systems

Table ii - Summary of Challenges and Recommended Geographic Areas of Focus

Corridor Challenge	**Specific Locations**	**Corridor Segments**
1. Inclement weather		Entire Corridor
2. Unsafe speed and slippery roads		Hwy 191 through Gallatin Canyon, portions of Idaho Hwy 20, Idaho Hwy 15 on Monida Pass and a majority of Interstate 90
3. Commercial vehicle crashes		Specifically relating to icy roads and animal conflicts along Montana Hwy 191
4. Hazardous materials		Entire Corridor
5. Lengthy emergency response time		*Response times:* Idaho Hwy 20 near Idaho/Montana border, Wyoming Hwy 89 near Idaho/Wyoming border *Notification times:* Idaho Interstate 15 not including Idaho Falls area
6. Lack of traveler/tourist Information	Approaches to Yellowstone National Park (Gardiner, MT; Jackson, WY; and West Yellowstone, MT)	Entire Corridor
7. Failure to yield right-of-way or disregard for traffic control	Intersections along Hwy 191 through Bozeman, MT; Wyoming Hwy 89 through Jackson, WY; and Hwys 20 and 26 just outside of Idaho Falls, ID	
8. Rear-end collisions	Intersections along Hwy 191 through Bozeman, MT and Hwy 89 through Jackson, WY	
9. Animal encroachment on the roadway		Portions of Hwy 191 and Hwy 89 from Jackson, Wyoming to Livingston, Montana
10. Snowmobile crashes		Hwy 89 through Yellowstone National Park
11. Commercial vehicle operations efficiency	Existing and planned ports of entry/ weigh stations	
12. Traveler mobility	One of the existing paratransit systems (to be determined)	
13. Congestion at YNP entrances	Three YNP entrances at Gardiner, MT; West Yellowstone, MT and north of Jackson, WY	
14. Congestion at construction zones		One or more of the planned construction sites (to be determined)

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INTRODUCTION

This report summarizes the research of Task 3, ITS-related Inventory: Regional Needs Assessment, for the Greater Yellowstone Rural Intelligent Transportation Systems (ITS) Priority Corridor. The purpose of this task is to identify stakeholders' perceived transportation challenges within the Corridor, quantify each challenge identified by stakeholders and research staff, identify geographic areas of focus for these challenges, and inventory existing legacy systems and planned transportation improvements.

Report Organization

This report contains five major sections:

1. Introduction: provides a background and description of the Corridor.
2. Methodology: describes the approach to complete this task, including how stakeholder input was obtained, what types of data were collected, how the data was collected, how the data was analyzed to quantify challenges, and how geographic areas of focus were determined.
3. Findings: includes the stakeholders' perceived transportation challenges, quantified operational and safety challenges, and geographic areas of focus.
4. Summary: summarizes the results of this task and the next steps in the project.
5. Appendices: include crash data attributes collected from each state and the data request survey sent to each state department of transportation.

Description of the Corridor

The Greater Yellowstone Rural Intelligent Transportation System Priority Corridor (GYRITS PC) is a 200-mile long, 100-mile wide, nationally significant rural transportation corridor between Bozeman, Montana and Idaho Falls, Idaho (Figure 1). This corridor includes:

- three states: Montana, Idaho and Wyoming;
- two national parks: Yellowstone and Grand Teton; and
- a variety of transportation facilities ranging from Interstate freeway to low-volume, two-lane rural highways.

Primary transportation facilities include:

- Interstate 90/15 from Bozeman, Montana to Idaho Falls, Idaho through Butte, Montana;
- U.S. Highway 191/20 from Bozeman, Montana to Idaho Falls, Idaho; and
- U.S. Highway 89/26 from Livingston, Montana through Jackson, Wyoming to Idaho Falls, Idaho.

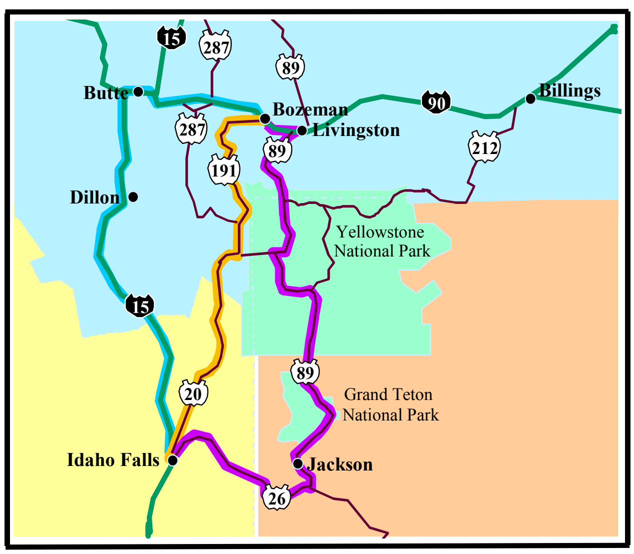

Figure 1 - Study Area

These routes represent vital transportation links for the economy and well-being of the three-state area of Montana, Wyoming and Idaho. They also serve the recreational and resource needs of a growing national constituency seeking to utilize the Greater Yellowstone ecosystem and Grand Teton National Park. The Corridor traverses a broad treasure of national resources. The national importance of the Corridor is further emphasized by its function as the connector for the trucking industry between the upper Midwest markets along Interstate 90 and the Intermountain and Southwest markets approachable by Interstate 15.

METHODOLOGY

The approach to this task, in which transportation challenges were identified and quantified, was threefold:

(1) Input from stakeholders was solicited to identify perceived travel and safety challenges.

(2) Quantifiable data was collected and assimilated to determine (a) the characteristics of safety and operational challenges within the study area and (b) existing and planned infrastructure and systems.

(3) Geographic areas of focus were determined using geographic information systems (GIS) to spatially display the quantified safety and operational information in combination with planned and existing infrastructure and systems.

Stakeholder Workshops

To date, two stakeholder workshops have been conducted: one on March 13, 1996, at Montana State University in Bozeman, Montana and a second on June 24, 1997 at the Best Western GranTree Inn in Bozeman, Montana. Workshop participants included people from several states, levels of government, diverse government agencies and private industries who helped identify specific transportation challenges within the Greater Yellowstone Corridor that could benefit from ITS technology.

Participants met in small breakout groups for approximately 1-1/2 hours to identify and discuss issues related to the Corridor. Efforts were made to ensure that each group (which consisted of a small number of participants, a facilitator and recorder) included individuals with different perspectives on Corridor issues. Facilitators directed discussion toward both macro and micro issues. Following the breakout discussions, each group presented their results to the entire assembly, followed by an additional period for open comments from the attendees. The issues raised by these groups are summarized later in this document.

Quantified Data Collection

Quantified data was collected on (1) the safety and operation of the Corridor roadways and (2) existing and planned infrastructure characteristics. This combination of data helped identify areas for improvement and will assist in evaluating future improvement benefits.

In October 1996, researchers sent a letter to GYRITS PC project partners describing the data needed to identify problem areas and evaluate advanced technology improvements. Safety-related and operational data requests included transportation data, traveler characteristics, weather data and animal migration and habitat areas. Specific data elements and their availability are summarized in Table 1.

Differences in the way the three states and Yellowstone National Park organized their data made combining the data challenging. In addition, much of the data requested arrived in hard copy format, requiring extensive computer data entry and database development to convert the data to a useable electronic format.

Table 1. Availability of Safety-related and Operational Data

	IDAHO	MONTANA	WYOMING	YELLOWSTONE
TRANSPORTATION- AND SAFETY-RELATED DATA				
Crash data including				
Milepost	Yes	Yes	Yes	Yes
Severity (fatality, injury, property-damage-only)	Yes	Yes	Yes	Yes
Contributing factors (road slippery/icy, poor visibility, animal)	Yes	Yes	Yes	Yes
Vehicle type (car, truck, truck w/ hazmat)	Yes	Yes	Yes	Yes
Collision type (rear-end, angle, single vehicle run-off-road)	Yes	Yes	Yes	Yes
First harmful event	Yes	Yes	Yes	Yes
Weather and road conditions at time of crash	Yes	Yes	Yes	Yes
Emergency response time	Yes	No	Yes	No
Average daily traffic and truck traffic	Yes	Yes	Yes	Only 1 year, no truck
Hazardous materials incidents	Some	Some	Some	Some
TRAVELER CHARACTERISTICS				
Tourist destinations and major attractions	Yes	Yes	Yes	Yes
Tourist dollars spent	Yes, but only on statewide or regional level			
WEATHER DATA				
Average annual rain and snowfall	Yes, but only in some spot locations			
Average annual temperature ranges	Yes, but only in some spot locations			
Areas of consistent ice and snowpack problems	No	No	No	No
ANIMAL MIGRATION AND HABITAT AREAS	Yes	Yes	Yes	Yes

Transportation- and Safety-related Data

The first step in the GYRITS PC project was to identify and define transportation- and safety-related challenges such as weather, objects in the roadway, driver inattention, roadway congestion, low transit ridership and inefficient freight movement or incidents. These challenges were defined based on quantitative data supplied by partner agencies and through limited field observations.

Following is a summary of transportation- and safety-related data collected from each of the GYRITS PC project partners, including:

- crash data,
- emergency response times,
- average daily traffic and truck traffic, and
- hazardous materials incidents.

Crash Data. Three years of crash data was collected from January 1, 1993 through December 31, 1995 for Idaho and Montana and from January 1, 1994 through December 31, 1996 for Wyoming and Yellowstone National Park (YNP). The data was provided directly through each state's department of transportation and, for Yellowstone, the National Park Service, Office of Field Operations and Technical Support Center - Highway Operations in Denver, Colorado. Crash data typically included road surface condition, road alignment, relation of crash location to roadway, relation of crash location to junction, vehicle type, driver intent and contributing circumstances. Appendix A summarizes the specific data elements provided by each state and Yellowstone National Park. Differences in data format and groupings complicated the development of a common database for analysis and spatial mapping. As such, researchers combined distinct data groupings into one generic code. This generic code and each corresponding state and national park code is illustrated in Appendix A. Project partners approved the coding methodology. In Yellowstone National Park, crash data is spatially referenced by a link-node system, rather than by mileposts like the three states. For the purpose of this study, YNP crash locations were converted to mileposts with the help of strip maps provided by Yellowstone National Park.

Emergency Response Times. The *emergency notification time* is defined as the amount of time it takes from the time of the crash for someone to notify the Emergency Medical Services (EMS) and police. The *emergency response time* is the time it takes for emergency vehicles to arrive at the scene of the crash once they have been notified. Emergency notification times and response times were determined from the crash data described above. However, this set of data was much smaller, as not all crashes require an emergency response. Emergency response times usually refer to medical emergency response (e.g. ambulance). However, some data was available on police response times. Emergency response time information was provided by the Idaho and Wyoming Departments of Transportation.

Average Daily Traffic /Average Daily Truck Traffic. Average daily traffic (ADT) and average daily truck traffic (ADTT) volumes were collected from the Idaho, Montana and Wyoming Departments of Transportation and Yellowstone National Park. Idaho supplied a *Rural Traffic Flow Map* (1) that helped determine the ADT for a given section of roadway. Idaho also supplied an *Estimated Commercial Vehicle Rural Traffic Flow Map* (2) on which the ADTT could be determined for a given section of roadway. The ADT and ADTT volumes on these maps were not linked to specific mileposts. Thus, researchers were required to estimate a milepost location for the various traffic and truck volumes. For Montana roadways, ADT and ADTT were contained in the *Traffic by Sections* (3) publication. These traffic and truck volumes were linked to specific mileposts, allowing for a more exact description of the traffic conditions. The Wyoming Department of Transportation - Planning Division supplied ADT and ADTT information corresponding to mileposts for the specific Corridor routes in Wyoming. Yellowstone National Park supplied a *1994 Traffic Counts* (4) document that listed ADT volumes on a map of Yellowstone National Park. Traffic volumes were linked to station numbers (the routes within Yellowstone National Park are referenced using a link-node system rather than mileposts, which made it more difficult to determine the exact location of the traffic and truck counts).

Hazardous Materials Incidents. Initially, incident information for the three states was obtained through the Marasco Newton Group, a consultant to the U.S. Department of Transportation (5). The hazardous materials incident data included incident location (route and nearest city), amount spilled and total damage. Researchers felt questioned the accuracy or completeness of the information, so state data sources were investigated.

At the state level, data was received from the Montana Department of Environmental Quality (6) and the Wyoming Department of Environmental Quality (which included Wyoming and Yellowstone National Park) (7). Data was not provided by the Idaho Department of Environmental Quality. This data was sorted by county and included such information as date of incident, responsible party, substance released, quantity released and the cause of the incident.

Traveler Characteristics

Annual visitation information to various recreation destinations was collected from a variety of sources, including chambers of commerce, state departments of commerce, Yellowstone National Park, state parks and the National Forest Service. These destinations included Yellowstone National Park, Targhee National Forest, state parks, museums, ski resorts, historical sites, reservoirs and visitor information centers.

Weather Data

Average annual values were collected for rainfall, snowfall and temperature range. These values were obtained from the Western Regional Climate Center (8). Data was only available at spot locations throughout the Corridor.

Using the *Uniform Building Code* (9), design wind speeds and seismic zones were determined at the same locations where the climatic data was collected. These values set the minimum design standards for structural design.

Road closure information was also collected based on interviews with personnel from highway maintenance and state police agencies. Information was collected on locations of existing closure gates, common locations of road closures, and frequency and duration of closures at these locations.

Animal Migration and Habitat Areas

Animal migration and habitat areas are not extensively documented, so data was obtained directly through interviews with officials at the U.S. Forest Service-Montana Fish, Wildlife and Parks and Yellowstone National Park. Interviewees, based on their personal experience, drew shapes on maps depicting the general areas of major animal habitat and migration. Hard copy information was not available. Even though migration and range area patterns were difficult to document, the safety-related aspects (e.g., animal-vehicle collisions) were not.

Existing and Planned Infrastructure

Information on existing and planned infrastructure was collected in each of the three states and Yellowstone National Park through a survey. The purpose of the survey was to inventory existing, planned and needed transportation improvements (both advanced and traditional) within the Corridor, so that any improvements identified from this study can build upon and add value to ongoing initiatives.

Specific information on existing and planned infrastructure is summarized in Table 2. Surveys were mailed to stakeholders with follow-up telephone contact as necessary. A copy of the survey instrument is contained in Appendix B. The survey contained questions related to:

- traffic data and information,
- visitor characteristics,
- existing and planned systems, and
- transportation improvement needs.

Geometric/Physical Roadway Characteristics. Roadway geometric data including shoulder and lane widths were obtained from the departments of transportation in Idaho, Montana and Wyoming. Curve radii and grades were not collected, as they would have to be determined from hard copies of as-built's, which would have taken a considerable effort. This effort was beyond the project resources. The departments of transportation also provided information on future changes to the roadway geometry in each of the three states..

Table 2. Availability of Existing and Planned Infrastructure Data

	IDAHO	MONTANA	WYOMING	YELLOWSTONE
TRANSPORTATION				
Geometric/physical characteristics and planned improvements	Yes	Yes	Yes	No
Maintenance facilities/operation centers	Yes	Yes	Yes	Yes
Airports	Yes	Yes	Yes	Yes
Rail lines and freight transfer centers	Yes	Yes	Yes	Yes
Transit service	Yes	Yes	Yes	Yes
RESIDENTIAL, BOUNDARY AND LAND USE INFORMATION				
Cities/towns locations and populations	Yes	Yes	Yes	Yes
Jurisdictional boundaries	Yes	Yes	Yes	Yes
Waterways	Yes	Yes	Yes	Yes
TRAVELER INFORMATION AND SERVICES				
Legacy systems (HAR, VMS, RWIS, WIM)	Yes	Yes	Yes	Yes
Hotels/Motels	Yes	Yes	Yes	Yes
Visitor centers/rest areas	Yes	Yes	Yes	Yes
EMERGENCY SERVICES				
Police department locations	Yes	Yes	Yes	Yes
Fire department locations	Yes	Yes	Yes	Yes
Hazardous materials response team locations	Yes	Yes	Yes	Yes
COMMUNICATION INFRASTRUCTURE				
Cellular coverage	Yes	Yes	Yes	Yes
Wire-line coverage(US West, Three Rivers Telephone Co-op)	No	No	No	No

The Wyoming Department of Transportation - Planning Division provided the planned roadway geometric changes for Wyoming. The Montana Department of Transportation (MDT) supplied the 1996-1998 *Statewide Transportation Improvement Program* (10). Because MDT's improvements are projected only through 1998, this information may become outdated during the course of this study. The Highway Program Manager from the Idaho Department of Transportation supplied documentation on the planned and proposed improvements throughout the Idaho portion of the Corridor.

Maintenance Facilities/Operations Centers. The locations of transportation maintenance or operations centers were obtained through the mail-out survey.

Airports. The locations of all major airports throughout the Corridor were found using the *Official 1997 Wyoming Highway Map*, the *Official 1997 Idaho Highway Map*, the *Official 1996-97 Montana Highway Map* and the *American Map Corporation – Idaho, Montana, Wyoming Road Map*.

Rail Lines and Freight Transfer Facilities. Locations of rail lines and freight transfer facilities were obtained from U.S. Census Bureau TIGER line data (11).

Transit Service. Information on existing or planned transit services was obtained through the mail-out survey.

Legacy Systems. The use and locations of highway advisory radio (HAR), variable message signs (VMS), road-weather information systems (RWIS) and weigh-in-motion (WIM) systems were obtained through the mail-out survey.

Cities/Towns Locations and Populations. Population data for cities along the Corridor came from multiple sources. First, the *1990 Census of Population and Housing* from the U.S. Bureau of Census (12) was used. This data source provided population data for incorporated cities/towns containing at least 1000 people, and cities/towns that are within an Indian reservation. For other cities and towns in Montana, the *Official 1990 Montana Highway Map* was used. Unfortunately, this source did not depict all of the cities/towns. County block maps (13) were used as supplementary data sources although only maps for Park, Gallatin, and Madison Counties were available. In Idaho, a combination of the *1990 Census of Population and Housing* and the *Official 1990 Idaho Highway Map* proved successful in gathering the necessary population data. Populations for Wyoming cities/towns were more difficult to locate; only two Wyoming cities/towns are listed in the *1990 Census of Population and Housing.* The *Official 1990 Wyoming State Map* provided populations for several more cities and towns.

In addition to total populations, other residential statistics collected for the counties surrounding the Greater Yellowstone Corridor included the number of people:

- over the age of 60,
- below the poverty level, and
- with mobility limitations.

The poverty threshold used in the *1990 Census of Population and Housing* was set by the Department of Health and Human Services as $6,280 for the first person in a family and $2,140 for each additional person. Families were considered below the poverty level if their annual income was below this threshold (12).

Mobility limitations include any person aged 16 or older who uses crutches, a wheelchair or has any form of mobile disability that requires the use of another walking aid on a regular basis.

Traveler Services. Traveler services generally included major gas station/convenience store areas, lodging or food. Traveler services throughout the Corridor were located using a Global Positioning System (GPS). Coordinates were obtained by driving the Corridor and manually collecting the data using a hand-held Magellan GPS 4000 Satellite Navigator. Based on the errors inherent with this unit, accuracy is expected to be within 100 meters of the actual position 95 percent of the time (14).

Cities and towns where numerous traveler services were located are classified as *all services present*, and one reading was taken. Services that are not near a populated area and are located along the roadway were documented, and GPS coordinates were obtained for each location.

Visitor Centers/Rest Areas. Visitor centers and rest areas were located using the same technique described above. A GPS reading was taken at every major visitor center and rest area along the Corridor using a hand-held Magellan GPS 4000 Satellite Navigator.

Police Departments. Police departments were located via telephone directories for cities/towns throughout the Corridor.

Fire Department Locations and Hazardous Materials Response Capabilities. Fire departments were also located via telephone directories for cities and towns throughout the Corridor. Hazardous materials response capabilities were determined by contacting the a representative from the Bozeman Fire Department that was also knowledgeable on the hazardous materials response capabilities throughout Idaho and Wyoming.

Communication Infrastructure. Initially, cellular coverage was determined using maps provided by cellular phone providers. Because these maps use a small scale and were developed for marketing, researchers felt their accuracy was questionable; known cellular "black" areas where various geographic features prevent cellular coverage were shown to have service on the maps. As an alternative, researchers drove the Corridor carrying a standard 0.6W cellular phone and documented the ability to maintain an adequate cellular signal. Wire-line locations were also documented as part of this process.

Safety Analysis

To identify which transportation challenges may benefit from ITS applications, researchers examined safety-related data to determine the magnitude of each problem. This section describes the data analysis process.

Safety is of paramount concern in the rural driving environment. By focusing this study on safety applications of ITS technologies, the project may achieve a greater acceptance from the rural stakeholders. Crash rates helped identify segments along the Corridor that had potentially atypical crash challenges, meaning locations that experienced unusually high occurrences of crashes relative to the volume of traffic traversing that segment of road. Typically, crash rates are good indicators of areas where crashes occur as the result of recurring contributing circumstances, called crash trends. Each of the atypical crash locations identified was analyzed for a crash trend. The crash analysis and Corridor description will aid in prioritizing the challenges and establishing geographic areas of focus.

A total of 4,918 crashes were analyzed for a three-year period from 1993-1995 for Montana and Idaho and 1994-1996 for Wyoming. The severity of these crashes is shown in Figure 2. For this study, crash rates were determined for each half-mile segment along the Corridor. Additionally, crash rates weighted by their severity were determined for each half-mile segment. Based on these rates, potential atypical crash locations were determined. These locations were then analyzed to determine what, if any, crash trends existed. These segments were thought to have the best chance of realizing the greatest benefits from ITS safety countermeasures.

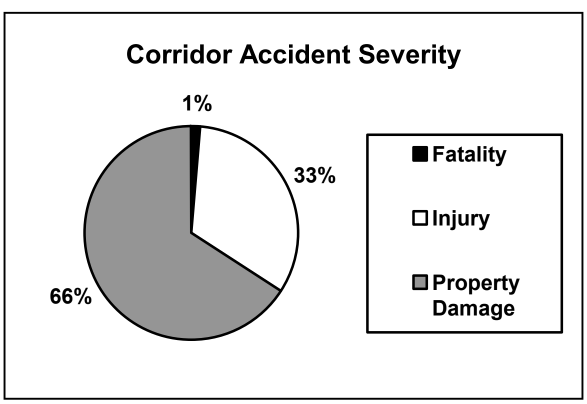

Figure 2 - Crash Severity in Corridor

Crash Rates

Potential atypical crash locations were identified based on a statistical overrepresentation of crashes. Crash rates were determined for each half-mile segment using a rate per million vehicle-miles traveled (R/MVMT), determined by the equation below (15). Average annual daily traffic (AADT) was estimated by averaging the AADT for the three years. The crash rates for all the segments were compared along each route. A half-mile segment was identified as a possible atypical crash site if its crash rate was greater than one standard deviation above the average (mean) for that route.

$$\boxed{R / MVMT = \frac{\#\ \ accidents * 1{,}000{,}000}{AADT * 0.5\ \ mile * 365\ \ days * 3\ \ years}}$$

Severity Rates

Severity rates were calculated in the same manner as the crash rates, but in addition to counting the crashes, each crash was also weighted based on its severity. Fatalities were weighted by a factor of eight, injuries were weighted by a factor of three and property-damage-only crashes were weighted as one. Typically a factor of 12 is used for weighting fatal crashes. However, it is acceptable in cases such as this to use a factor of eight to keep random singular fatalities from skewing the severity rates in a particular half-mile segment (15).

Trend Identification

Each half-mile segment determined as a potential atypical crash location was analyzed for a crash trend. Typically, areas with low rates should have random type crashes, but this is not always true. For the purpose of this study, a trend was defined as having over 25 percent of the same type of crash but not less than four total crashes. The trends identified include crashes involving:

- snowmobiles,
- unsafe speeds during icy/slushy road conditions,
- rear-ends,
- failure to yield right-of-way and/or disregard for traffic control,
- animal conflicts,
- driver under the influence of alcohol or drugs, and

- head-on collisions.

Emergency Response Times

In addition to the crash analysis that yielded the trends above, the crash data was used to analyze emergency response times to crashes. This data was only available for Idaho and Wyoming; thus Montana and Yellowstone National Park were excluded from analysis of response times. The response times were averaged for five-mile segments that overlapped every mile. Five-mile segments were used to increase the number of data points.

Identification of Operational Challenges

Although the main focus of this study was safety, many operational issues were also investigated. Table 3 displays the data elements used to quantify each of the transportation challenges identified by stakeholders and researchers. How data was used for each challenge is discussed in the findings.

Table 3 - Data Used to Quantify Challenges

Transportation challenge identified	**Data elements used to quantify**
Commercial vehicle operations efficiency	Average daily truck traffic and interviews with weigh/inspection station operators
Lack of traveler/tourist information	Annual visitation and tourist expenditures at tourist destinations
Traveler mobility	1990 census data including countywide totals for mobility-impaired, poverty level and citizens above 65 years in age
Congestion at Yellowstone National Park entrances	Number of vehicles entering Yellowstone National Park
Congestion at construction/work zones	Planned construction improvements
Hazardous materials spills	Hazardous materials spill locations

Identification of Geographic Areas of Focus

Geographic areas of focus were determined for each of the safety and operational challenges identified. This section discusses the methodology for determining the geographic areas of focus.

Safety-related Challenges

Crash data was used to determine geographic areas of focus. Before using the crash data to determine geographic areas of focus, the Corridor was broken up into 35 major segments based on changes in geometry, city limits, mountainous areas and state lines (Figure 3). Although state lines were assumed to be transparent, segments were broken along state lines for ease of analysis. If similar challenges occurred on either side of a state line, segments would have been later joined. The segment types included rural level, rural mountainous, urban (within city limits), suburban (directly outside city limits until change in cross section), and park. Yellowstone National Park was separated because of its lower design speeds; typical speed limits are between 35 and 45 miles per hour. Yellowstone National Park was also unique in the number of animals, the number of tourists and the dense trees that encroach on the clear zone. The number of crashes for each crash trend, identified previously for half-mile locations, was determined for each of the 35 major segments. A geographic area of focus was selected if the area met two of the following three criteria:

- a high percentage of the crashes in the area had a common trend,
- a high number of the crashes in the area had the same common trend, and/or
- half-mile atypical locations showed the same trend.

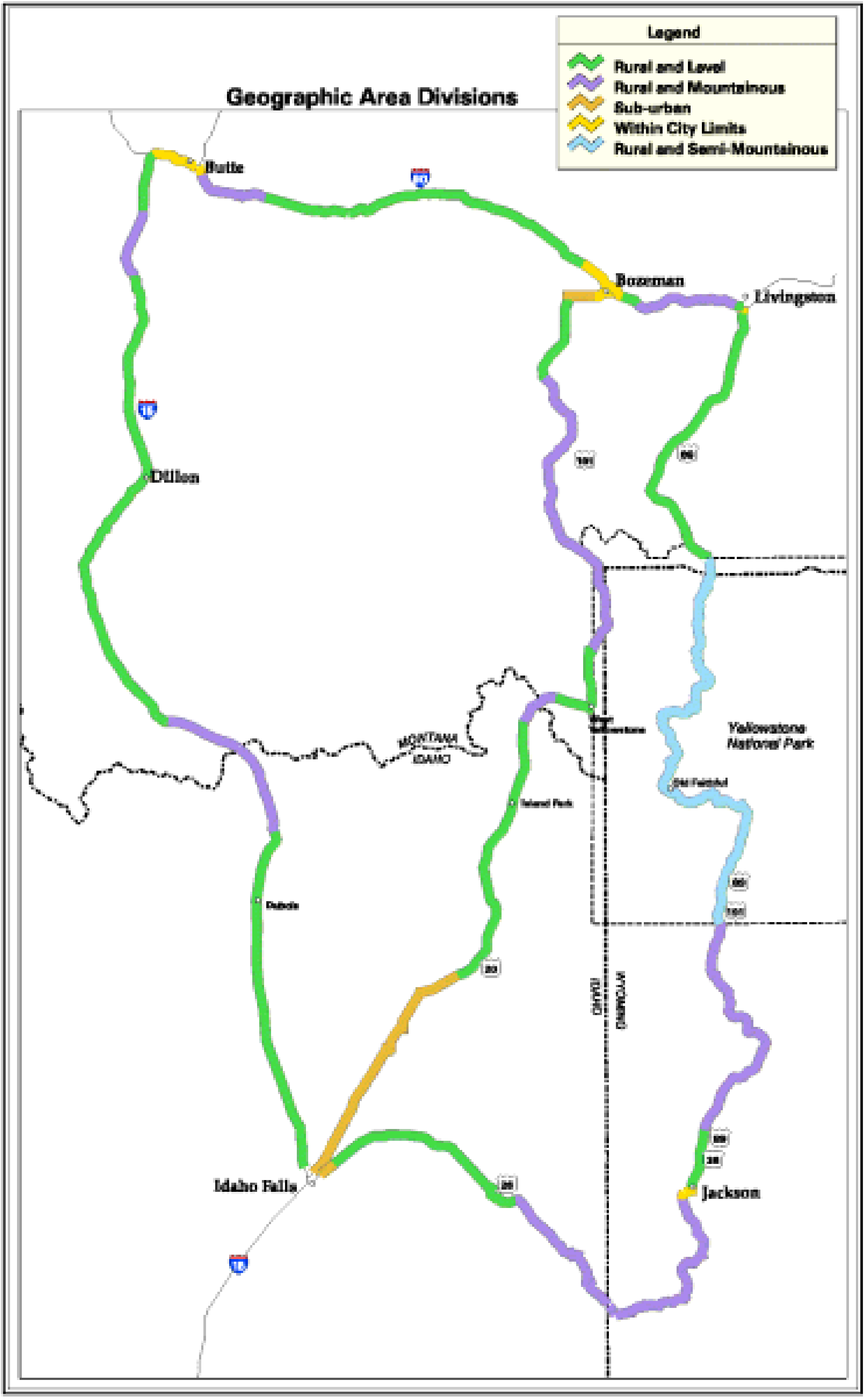

Figure 3 - Geographic Area Divisions

Operational Challenges

Operational data was spatially displayed using geographic information systems (GIS) to identify improvement areas along the Corridor. In addition, data on existing and planned infrastructure was spatially displayed. The combination of these two types of data will allow for better "added value" benefits by building solutions onto existing or planned infrastructure. Figure 4 depicts the general concept.

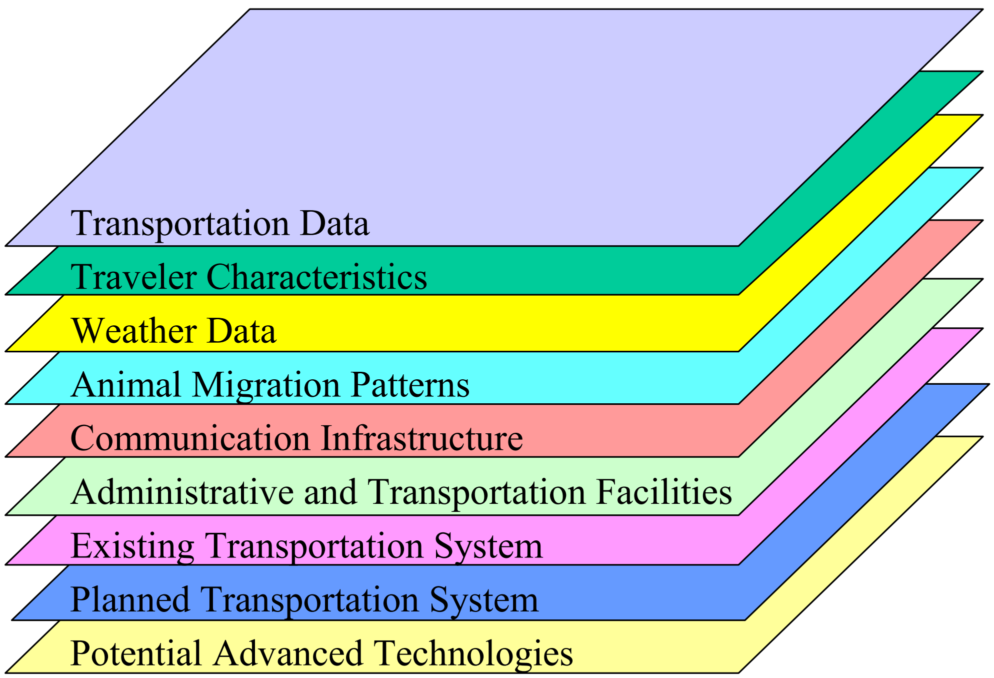

Figure 4. Geographical Information Systems Layers

Attributes are depicted either at spot locations on the map or continuously along the roadway. For example, lodging accommodations are best depicted at spot locations, whereas average daily traffic (ADT) is best depicted as a continuous range along the length of the roadway.

FINDINGS

This section details stakeholders' perceived transportation challenges, quantification of those challenges and recommended geographic areas of focus.

Stakeholder Perspectives

Stakeholder perspectives on Corridor challenges and potential ITS solutions were obtained through meetings held in Bozeman, Montana on March 13, 1996 and June 24, 1997. This section details the results of these two meetings, although a majority of the comments resulted from the first meeting. The perceived transportation challenges presented here may not be those of all stakeholders.

Rural Corridor Concept

One of the fundamental issues challenging this effort is the justification for developing and deploying ITS technologies in a rural environment. The primary benefits stakeholders expect from ITS technology included improved safety and better emergency response. Participants also anticipated tourists and new residents would benefit from better and more accurate information on a variety of subjects, including weather conditions, road conditions, dangerous highway features and vacation route information. Concerns were raised, however, that it might be difficult to convince taxpayers of the benefits of these new technologies.

The participants noted the appropriateness of the Greater Yellowstone Corridor for studying rural ITS applications as the area encompasses two national parks (Yellowstone and Grand Teton) and three states (Idaho, Montana, and Wyoming). The presence of the parks may generate national, rather than merely regional, interest in the Corridor.

Some commented on the choice of specific routes for ITS projects within the Corridor. Some participants stated that the central route in the Corridor (U.S. 191 from Bozeman running through Gallatin Canyon across U.S. 20 to Idaho Falls) offers the broadest and best opportunities to develop/demonstrate ITS technologies. They stated the two-lane primary road system has diverse types of vehicles (large truck to bicycle), uses (logging trucks to tourists) and geometrics (sharp curves and steep grades to long, level, straight stretches) that make it especially attractive for ITS projects. As such, various features on these routes may be representative of many highways in rural areas throughout the nation. The comment was made that the southern part of the Livingston, Montana to Idaho Falls, Idaho route on U.S. 89/26 is closed for several months of the year through Yellowstone National Park and Grand Teton National Park.

The prevailing opinion on routes, however, was that all three routes are equally important, in that each route offers unique features of interest for ITS applications. The heavy traffic and seasonal congestion inside the national parks, for example, were believed to offer some interesting and unusual conditions for testing ITS technologies. Successful ideas could then be extended to other national parks.

Specific Highway Challenges and Possible Solutions

Much of the stakeholder discussion was devoted to identifying challenges along Corridor routes that could be addressed with ITS technologies. Showing slides taken sequentially along the U.S. 191/20 route from Bozeman, Montana to Idaho Falls, Idaho stimulated discussion of these challenges. Most of the participant comments focused on safety-related issues; some comments were made on methods to satisfy traveler/tourist needs. Most of the technologies mentioned by the participants were roadside rather than in-vehicle (onboard) systems. While in-vehicle systems may be very effective, they were also thought to be very expensive compared to roadside systems.

The most common safety challenges cited by the workshop participants related to: (1) adverse weather conditions, (2) disparate travel speeds of various highway users and (3) animals on the roadway. Adverse weather conditions along the Corridor routes consist primarily of high winds, poor visibility and slippery roadways due to blowing and drifting snow.

Many participants were aware of ITS technologies that are being used in some fashion to alert motorists to these conditions: road weather information systems to monitor conditions along roadways are already in use at several locations in Montana. Highway department personnel presently use this information to compile public road reports and to direct plowing and sanding operations. Sensors that directly monitor road surface and visibility conditions have also been investigated. Further experimentation, evaluation and development of technologies like these may be appropriate along the Corridor routes.

Presuming adverse weather-related conditions are in effect, considerable attention was directed to the manner in which motorists are alerted to these conditions. The fastest response to changing conditions is realized by allowing the sensor system to directly inform motorists of dangerous conditions immediately upon their detection. Due to liability concerns and other issues, however, some decisions on posting warnings, and particularly on closing routes, are made only after the sensor data has been reviewed by a human being. Travel warnings and road closures can be particularly upsetting to businesses dependent on motorists and to time sensitive commercial vehicle operators. Motorists, themselves, may ignore warnings if they believe systems are overly cautious in issuing warnings. Some questioned whether advanced technologies or improved information dissemination would reduce crashes resulting from human error.

Changeable message signs and local area radio broadcasts were the most commonly stated approaches for transmitting weather hazard warnings to motorists. In Montana, road reports are updated at 7 a.m. and 2 p.m. or immediately when an unsafe situation arises. Much of the weather-related information is provided through employee reports. Several participants believed that these technologies are very appropriate in a rural setting, and that they are currently underutilized in this setting. Participants suggested that changeable message signs or highway advisory radio could be used for general tourist information when not used for a safety-related need. Some participants voiced concerns with the quality of the radio message systems (background static, weak signal, etc.), and expressed interest in exploring technologies to improve the quality of the delivery of these messages. They mentioned that weather hazard warnings might also be issued at information kiosks along the Corridor routes.

Many workshop participants indicated that the disparity in the type and speed of vehicles using two-lane Corridor routes is a major safety challenge. Slow-moving vehicles include recreational, farm and commercial vehicles. Fast-moving vehicles include both private vehicles and commercial vehicles. The composition of the traffic stream varies considerably with the season of the year: slow-moving recreational vehicles and other tourist traffic is common in the summer, while winter traffic includes skiers and snowmobilers (in some areas, snowmobiles are run on the highways). While the challenges caused by the disparities in the speeds of these vehicles were universally recognized, the solutions to these challenges were unclear. Some participants indicated that this problem may be appropriate for research and development of new ITS technologies under the Corridor initiative.

One idea proposed by participants to mitigate the hazards associated with speed disparities was installation of sensors to detect slow moving vehicles entering the traffic stream (at frequently used pullouts and side roads) integrated with message signs to warn mainstream travelers of the presence of these vehicles. In-vehicle systems were also mentioned for mitigating hazards of slow-moving vehicles in the traffic stream. Widespread availability and use of in-vehicle devices, however, was not expected in the near future.

Confounding the challenge associated with disparate vehicle speeds in the traffic stream is the mixture of highway users on the Corridor routes, notably the somewhat conflicting use of the two-lane routes by recreation and commercial vehicles. Further conflicts may arise between local travelers and tourists. Once again, definitive solutions to this challenge were elusive. Use of weigh-in-motion (WIM) and automatic vehicle identification (AVI) systems were recommended as approaches to control overweight and illegal truck operation. Commercial vehicles carrying hazardous materials were of particular concern both from a safety standpoint as well as politically because of the high public visibility and coverage in the event of an incident. One idea mentioned was mandatory in-vehicle crash avoidance technologies for commercial vehicles on these routes. Hazard warning systems specific to heavy vehicle operation may also be appropriate at some locations. Such systems might, for example, monitor vehicle speed and configuration on steep grades. Safe speed would be computed based on vehicle configuration with a warning issued if that speed were exceeded. Some non-ITS approaches mentioned included adding turn bays, eliminating unsafe pull-outs, adding passing lanes, increasing enforcement, controlling platooning (several large vehicles traveling as a group) and limiting truck traffic (as has already been done for hazardous materials on U.S. 191 through Gallatin Canyon). These suggestions led to the observation that ITS technologies will not solve all challenges, and that an integrated approach to addressing these types of challenges will probably yield the optimum results.

Many participants mentioned animal-vehicle conflicts as a safety challenge along the Corridor routes. A commonly proposed solution was some sort of roadside detection system located at known problem areas. Links to a message sign would warn motorists of animal presence. Some participants indicated that in-vehicle systems may serve this purpose and could offer more complete coverage than fixed roadside systems. Once again, however, participants believed that such systems would not be widely available or used in the near future.

The Corridor routes have a variety of additional hazardous conditions that may be addressed with ITS technologies. Participants consistently mentioned active message signs that would warn speeding motorists of conditions that require reduced speed, such as hazardous weather, sharp curves, blind entrances, congested areas, etc.

In addition to crash avoidance technologies, the workshop participants were interested in exploring how ITS technologies can improve emergency response when crashes do occur. While many commented that Mayday (a satellite-based emergency notification device for contacting emergency response personnel) should be investigated, they observed that the proliferation of cellular phones might make a separate communication system for this specific purpose unnecessary. It was further noted, however, that cellular phone service may not be available in all areas, and that dedicated Mayday systems do offer real advantages over reliance on phone service. Concerns were raised regarding the ability of emergency services to respond quickly enough to meet motorists' expectations given limited resources. False alarm rates were also raised as a concern with Mayday systems.

Stakeholders expressed interest in exploring ITS-based traveler information systems, primarily due to the large number of tourists that descend on the Corridor area for several months each year. It was suggested that travelers might endanger themselves and others by "overdriving" to reach lodging or other services. Kiosks were mentioned as one avenue to provide information to travelers. The kiosks could be used to provide general vacation/tourist information and also real-time information on weather and road conditions. Radio broadcasts could also provide tourist information to motorists.

The workshop participants were concerned with possible jurisdictional/institutional barriers to deploying and operating the various ITS technologies described above. While the involvement of several governmental jurisdictions in the program is certainly desirable, coordinating both planning and everyday operation of the system becomes complicated. Researchers suggest efforts should be made in the deployment process (as is practical) to share communication lines and facilities between applications. Consideration should also be given when deploying these technologies to seek opportunities to collect traffic data and other information important to facility planning and design. These kinds of information may already be collected by the various ITS applications, or it may be possible to use ITS communication lines with separate equipment to obtain this information.

While all the comments made by the workshop participants positively endorsed the use of ITS technologies to address Corridor transportation challenges, several participants did mention that possible liability problems exist when these technologies are employed. The value of using state-of-the-art technology to provide motorists with real-time warnings of possible highway hazards seems obvious. However, any crashes or lost business revenues that may result from malfunctions of this technology could expose the state departments of transportation to considerable liability.

Participants in the stakeholder meetings on the Greater Yellowstone Rural ITS Priority Corridor provided useful insights on why rural applications of ITS technologies should be developed and why the Greater Yellowstone area is a good location for developing and demonstrating these applications. The participants indicated that partnering between the many organizations interested in and affected by proposed solutions in the Corridor would be essential to its success. The three routes located in the Corridor were believed to each offer unique and useful opportunities to research ITS applications. Participants identified many examples of rural transportation challenges that ITS technologies may help to mitigate. These challenges were generally related to highway safety, although discussion also centered on the potential of ITS technologies to improve emergency response and provide better general information to travelers. The challenges that were identified offer opportunities to both evaluate existing technologies and to possibly develop new technologies. The major issues identified by stakeholders and described in detail above include safety impacts from:

- inclement weather;
- disparate vehicle speeds;
- mixed vehicle types, including farm equipment, commercial vehicles and snowmobiles;
- motorists unfamiliar with the area focusing more on directional information than driving;
- animal encroachments on the roadway;
- long emergency response times;
- poor horizontal and vertical alignment; and
- hazardous materials incidents;

in addition to:

- infrastructure damage caused by commercial vehicles;
- the need for partnerships and institutional cooperation;
- the lack of tourist/traveler information; and
- the dependence on tourism for economic sustainability of rural communities.

Traveler Needs Survey

In addition to the task that this document details, the GYRITS PC project included a traveler needs survey. Although this survey is detailed in a separate document, some results are summarized here, as they further identify transportation challenges within the Corridor.

The traveler needs survey was administered to travelers at 14 locations along the Corridor with a total of 481 respondents. Survey questions were designed to determine the following:

- what information rural travelers need and want,
- which medium would be best for presenting this information to travelers, and
- where travelers would want this information presented.

The last two types of information were important for identifying the best ITS solutions but were not necessary to identify and quantify problems. Therefore, the only survey results discussed in this document are those related to the information rural travelers need and want. Results showed travelers were most worried about:

- road conditions like ice and snow;
- passing trucks and other heavy vehicles;
- animals on the roadway;
- where to get assistance for vehicle breakdown, crash or emergency medical aid;
- locations of and directions to parks; and
- scenic routes and historical sites.

Quantified Safety Challenges

As described previously, analysis of crashes within the Corridor yielded several specific safety challenges. Each of these challenges was analyzed both on a Corridor-wide level and within the more specific geographic areas of focus (discussed in more detail later). Using this safety analysis, several major trends were found to account for a majority of crashes along the Corridor. Figure 5 shows these trends to include: animal encroachments on the roadway, snowmobile conflicts, icy road conditions/excessive speed, rear-end collisions and failure to yield right-of-way. “Multiple trends” and “no trends” are also shown in the figure. Head-on collisions and alcohol- and drug-related crashes were initially investigated because some half-mile segments with high severity rates had these crash types. However, they were excluded from further analysis because of the low number of crashes and lack of correlation to a specific geographic area. For the entire Corridor, alcohol- and drug-related crashes accounted for 81 property damage-only crashes, 117 injury crashes and nine fatal crashes. Head-on collisions accounted for 30 property damage-only crashes, 35 injury crashes and 10 fatal crashes.

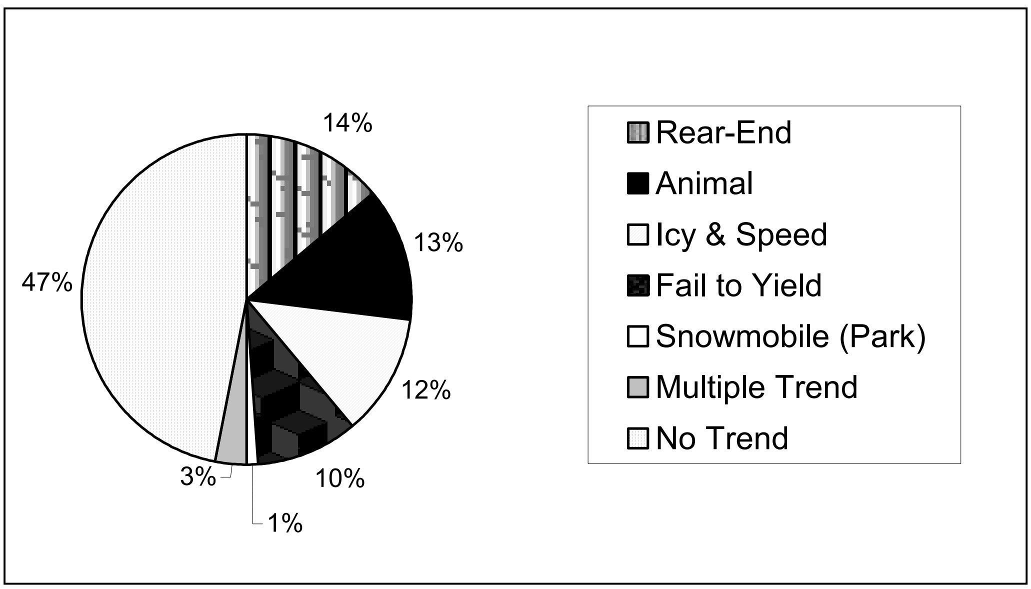

Figure 5 - Crash Trend Breakdown for Entire Corridor

Failure to Yield Right-of-way Collisions

“Failure to yield right-of-way” collisions include the contributing circumstances of failure to yield right-of-way and disregard for traffic control. These types of crashes generally occurred at an intersection where the highway passed through a city or town. A majority of the crashes in this category were angle crashes caused by failure to yield right-of-way, typical at city intersections.

Rear-end Collisions

Another crash trend that occurred mostly at intersections was rear-end collisions. The ability of ITS solutions to reduce these crashes would depend on whether these trends occurred within a city or town or on a high-speed highway.

Unsafe Operating Speed and Icy/Slushy Road Crashes

Unsafe operating speeds were a contributing factor to many crashes. Most of these crashes were also attributed to icy or slippery roads. In most cases, the drivers were not exceeding the posted speed limit, but were driving too fast for safe operation at the existing surface conditions.

Animal–vehicle Collisions

This Corridor contains many animal migration and habitat areas. Animal-vehicle conflicts are a major safety challenge.

Snowmobile Crashes

In many areas within the Corridor, a large number of the crashes involved “other” vehicle types, especially within Yellowstone National Park. Upon further investigation, these crashes occurred between the third Wednesday in December and the first Monday in March (about 2-½ months) when the YNP roadways are closed to all vehicles except snowmobiles. There are slight groupings around the Old Faithful and West Thumb areas, but the crashes are mostly spread throughout Park. Of these crashes involving snowmobiles in the Park, about two-thirds are single snowmobile crashes. The severity of these crashes was similar to the Corridor averages with a third injury crashes and one-percent fatal crashes. Most occurred on clear days, snowpacked road surfaces and straight level roads.

Emergency Response Times

Several measures are recorded in regards to assistance for crash victims. The *emergency notification time* is the amount of time taken from the time of the crash (or as shortly after as possible) to when someone contacts the Emergency Medical Services (EMS) and the police to inform them of the crash. The *emergency response time* is the time it takes for emergency vehicles to arrive at the scene of the crash once they have been notified. The combination of the notification and the response times was analyzed to determine how long it took for aid to reach a crash victim. Some crash data was excluded due to inaccuracy or inaccessibility. Emergency notification/response time data was taken from the crash data collected. However, this set of data was much smaller, as not all crashes required an emergency response. Emergency response time information was provided by the Idaho and Wyoming Departments of Transportation. From 1993 to 1996, 24 percent of the total EMS arrival times were over 30 minutes and four percent were over one hour. The average time was 23 minutes. The total police notification and response times were approximately the same as emergency notification and response times. The crashes with longer response times were found to be further away from a major city (i.e., Idaho Falls, Idaho). The longer the travel distance for emergency vehicles; the longer the wait for victims and the longer duration to leave the crash scene and arrive at the hospital. These delays could increase the severity of crash victims' injuries.

Commercial Vehicle Crashes

To identify commercial vehicle safety issues, these crashes were analyzed separately, as they are a smaller data set and commercial vehicles, as a group, have unique opportunities for ITS deployment. Commercial vehicles accounted for approximately 15 percent of the vehicle-miles traveled in the Corridor and were involved in about 11 percent of the crashes.

First, to determine how commercial vehicle safety compares with national averages, crash rates were determined for the whole Corridor, separating fatal crashes, injury crashes and property-damage-only crashes (PDO). Rates were calculated based on crashes per hundred million vehicle-miles traveled.

Table 4 -Commercial Vehicle Crash Rates in the Corridor

Crash Type	Total Crashes in Corridor (3 years)	Crash Rate[1]: Corridor	Crash Rate[1]: National(16)
Property-damage-only	335	67 R/HVMT	75 R/HVMT
Injury crash	150	30 R/HVMT	47 R/HVMT
Fatal crash	14	3 R/HVMT	3 R/HVMT

[1] R/HVMT crashes per hundred-million vehicle-miles traveled

As shown in Table 4, property damage and injury crashes occurred with slightly less frequency than national averages. Fatal crashes, though, occurred with higher frequency. None of these rates differed significantly from national averages.

To identify specific safety challenges for commercial vehicles, potentially atypical half-mile segments were identified based on crash rates. As mentioned above, the sample of crashes involving commercial vehicles was only 11 percent of the total crash sample. With such a small data set, it was difficult to identify trends in half-mile segments; researchers found no significant trends.

Table 5 displays prominent commercial vehicle crash attributes throughout the Corridor. Major trends identified include inattentive driving, driving too fast for conditions, icy roads and animal conflicts.

Table 5 - Contributing Circumstances for Commercial Vehicle Crashes

Contributing Circumstance	Percent of Crashes
Inattentive driving	29
Speed too fast for conditions	21
Icy road conditions	15
Animal conflict	9
Failure to yield right-of-way	5
Failure to have vehicle under control	7
Following too closely	2
Improper passing maneuver	3
Vehicle defects	4

Many of the ITS applications envisioned to improve commercial vehicle safety are based on improving the accuracy and efficiency of commercial vehicle safety inspections. However, Table 5 shows that only a small number of crashes (4 percent) were attributed to vehicle defects, which these safety inspections could prevent. Therefore, these types of ITS applications may not yield a significant benefit. However, commercial vehicle drivers experience many of the same safety problems as passenger car drivers, such as inattentive driving, icy roads and animal conflicts. Commercial vehicles could be considered as a test fleet of vehicles for combating some of these safety problems, especially those that may require in-vehicle components.

Quantified Operational Challenges

The operational challenges identified by research staff and stakeholder interviews were quantified to determine how much benefit would result from the application of ITS technologies. This section summarizes the quantification of those challenges.

Commercial Vehicle Operations Efficiency and Infrastructure Damage

Commercial vehicle operations (CVO) efficiency as well as infrastructure damage are difficult to quantify. However, by improving weigh station operation, we may effectively improve both. A more efficient weigh station may reduce delay times and improve efficiency for commercial vehicle operations. Also, more effective screening of commercial vehicle weights may reduce the infrastructure damage caused by overweight vehicles. There are already plans to improve operations at several weigh stations by implementing the HELP, Incorporated Prepass$_{tm}$ system. Trucks that have applied to and been approved by HELP, Incorporated would be able to bypass equipped weigh stations while their weight and permitting information is determined electronically at or near mainline speeds. Although some information was collected on truck traffic volumes and freight movement, the major focus of this section is on weigh station operations.

Average daily truck traffic within the Corridor ranged from 80 to 2,100 vehicles per day, totaling 450,000 commercial vehicle-miles traveled per day (not including Yellowstone National Park). No data was available on the quantity of freight moved within and through this Corridor. However, statewide values of freight movement are shown in Tables 6 and 7. Approximately $230 billion dollars in freight is moved totaling 38 billion ton-miles within and through the entirety of the three states each year.

Table 6 - 1993 Statewide Totals for Value of Freight Movement (Millions of Dollars)(17)

State	Total	Within	To	From	Through
Idaho	$84,157	$7,362	$8,219	$7,251	$61,324
Montana	$37,586	$5,960	$4,873	$2,049	$24,704
Wyoming	$108,292	$2,337	$4,969	$1,178	$99,808

Table 7 - 1993 Statewide Totals of Freight Movements (Millions of Ton-Miles)

State	Total	Within	To	From	Through
Idaho	9,973	2,360	927	886	5,800
Montana	10,028	2,821	862	1,524	4,820
Wyoming	17,901	3,585	472	862	12,982

Officials in Montana, Wyoming and Idaho were interviewed by phone about the six commercial vehicle weigh stations that are adjacent to the Corridor. No weigh station along the Corridor lies within Yellowstone National Park. The following officials were asked about weigh station operational information: Drew Livesay, Montana Department of Transportation - Motor Carrier Services (18), Reymundo Rodriguez, Idaho Department of Transportation - Port of Entry Authority (19), and Liz Clark, Wyoming Department of Transportation - Port of Entry Authority (20). Details of these phone conversations are discussed below.

Montana. *The Four Corners Weigh Station* (west of Bozeman at the intersection of Montana Highway 84 and U.S. Highway 191) is staffed with four officers and is open a minimum of 493 hours per month (approximately 16 hours a day). In response to Gallatin Canyon safety concerns raised by local residents, staff was increased from three to four officers in late 1994 to provide better commercial vehicle enforcement coverage. Both commercial and private vehicle volumes have significantly increased over the past five years, particularly since the recent completion of a four-lane reconstruction project between Bozeman and the Four Corners intersection. The Motor Carrier Services Division is very concerned about the impact of increasing traffic and congestion on weigh station operations and has initiated a traffic and safety analysis of the Four Corners area. Pending the results of this analysis, the options appear to be limited; closing the Four Corners weigh station altogether or relocating to another less congested location. Montana and Idaho are discussing a “joint” port of entry weigh station facility project that could relocate the service and enforcement activities currently provided at Four Corners to a new facility within the Henry’s Lake area of Idaho. Idaho and Montana currently operate a joint facility at Haugan, Montana, and both states are interested in expanding this partnership. The Four Corners Weigh Station is not a proposed HELP, Incorporated PrePass site.

The Butte Weigh Station (near the intersection of Interstate 90 and Interstate 15 west of Butte) is comprised of an eastbound and a westbound facility. The westbound facility is permanently staffed with four officers and is operational a minimum of 493 hours per month (approximately 16 hours a day). The eastbound facility is intermittently staffed. Both buildings were constructed in the early 1960s. Because of its strategic location near the intersection of Montana's two Interstate highways, Butte westbound is an important commercial vehicle compliance and enforcement facility. Congestion is an ongoing problem at both Butte facilities. Butte westbound is a proposed HELP, Incorporated PrePass site.

The Lima Weigh Station (on Interstate 15 approximately 18 miles north of the Montana/Idaho border) is a northbound-only weigh station facility located east of Interstate 15. The original 1950s facility was replaced with a new building and re-engineered truck ramps in 1993. The Lima Weigh Station is staffed with four officers and is in operation a minimum of 493 hours per month (approximately 16 hours a day). Although Lima is a busy and important Interstate facility, congestion is not a problem due to the 1993 improvements. Lima is expected to become a fully operational HELP, Incorporated PrePass site by September 1998.

All Montana weigh stations issue computer-generated oversize/overweight commercial vehicle permits and collect Gross Vehicle Weight fees. SummitNet, Montana's dedicated statewide communications network, links all weigh station computers with one another and with the Montana Department of Transportation's mainframe computer in Helena. In conjunction with the Montana Highway Patrol (the lead commercial vehicle safety agency in Montana), ASPEN safety inspection software is also being installed on each weigh station computer. Upon completion of the ASPEN installation process, each Montana weigh station will be capable of conducting a roadside commercial vehicle safety inspection via the weigh station computer and uploading the resulting inspection information into the Highway Patrol's safety database in Helena. With ASPEN, each weigh station will also be able to identify carriers with a poor safety history and target those carriers for safety inspections.

Idaho. *The Sage Junction Weigh Station* (near the intersection of Interstate 15 and Highway 33) is approximately 1700 feet off the Interstate. Seven personnel operate the facility for about 20 hours per day, seven days a week. It was built in 1988.

The Ashton Weigh Station (near Ashton on Route 20) was built in 1968. It is a satellite facility, meaning no permanent personnel operate the scales on a regular basis. The scale is operated by roving personnel and is open approximately one to three days per week. Plans are underway for a future satellite scale at Thornton (approximate milepost 330) with a pad but no housing for personnel.

Both weigh stations do not generally have a problem with delays caused by queuing of vehicles. It was noted that traffic volumes typically reduce after the scales are open about an hour, probably due to vehicles rerouting to avoid the facilities.

Wyoming. *The Alpine Junction Weigh Station* (at the junction of Route 89 and 26), built in 1981, is open from 5 a.m. to 9 p.m. seven days a week. Four personnel staff it with occasional roving personnel from Idaho. Delays are generally low, and no vehicle goes by the scale without a paperwork check. Delays are higher in the summer due to higher traffic volumes; it is assumed winter drivers generally take less mountainous routes.

Tourist/Traveler Information and Economic Vitality

Many communities within the Corridor rely on tourism for economic sustainability. Figure 6 shows many recreational destinations within the area, including major ski areas, state and national parks, museums, historic sites and other recreational areas. These locations receive over six million visitors per year. To determine how dependent this region is on tourism expenditures and the potential benefit of ITS applications for disseminating tourist information, data was collected on the revenues from tourists visiting the areas in and around the Corridor. Except for Idaho, data was only available on a statewide basis, so it is uncertain which portion of the statewide totals accounts for those in the Corridor area. In 1996, Wyoming saw 4,191,000 travelers spend just over $1.0 billion in direct expenses, which created $55,153,000 in state and local tax revenue (21). In Montana, 7.9 million people visited in 1995, spending $1.2 billion

(22). In 1993, nonresident motor vehicle travel parties visiting Idaho totaled 9,400,000 with expenditures of an estimated $1.3 billion. Travel in Region 6 of Idaho (which includes most of the Corridor area within Idaho) accounted for 2,060,000 (22 percent) of these visitors, who spent $184,500,000 (23). These revenues might be increased by providing more tourist information to out-of-state travelers, which, in turn, should grant them a more comfortable and enjoyable trip and entice them to stay longer. In addition, better traveler information might yield additional benefits, such as increased safety from more knowledgeable drivers.

Traveler Mobility

Within the counties through which the Corridor passes, 10.4 percent of the population is 65+ years in age (12 percent is the national average), 15 percent is below the poverty level (13 percent is the national average), and three percent has mobility limitations (4 percent is the national average). Many of these citizens depend on public transportation for health care, shopping and other activities important to the quality of life. Most of the public transit along the Corridor is paratransit targeted to the transportation-dependent. ITS applications could allow existing paratransit agencies to increase the number of rides provided with minimal to no increase in operation costs. Additionally, improved ridership on the tour buses of Yellowstone National Park could reduce traffic congestion, improve safety and reduce the impact to this pristine area.

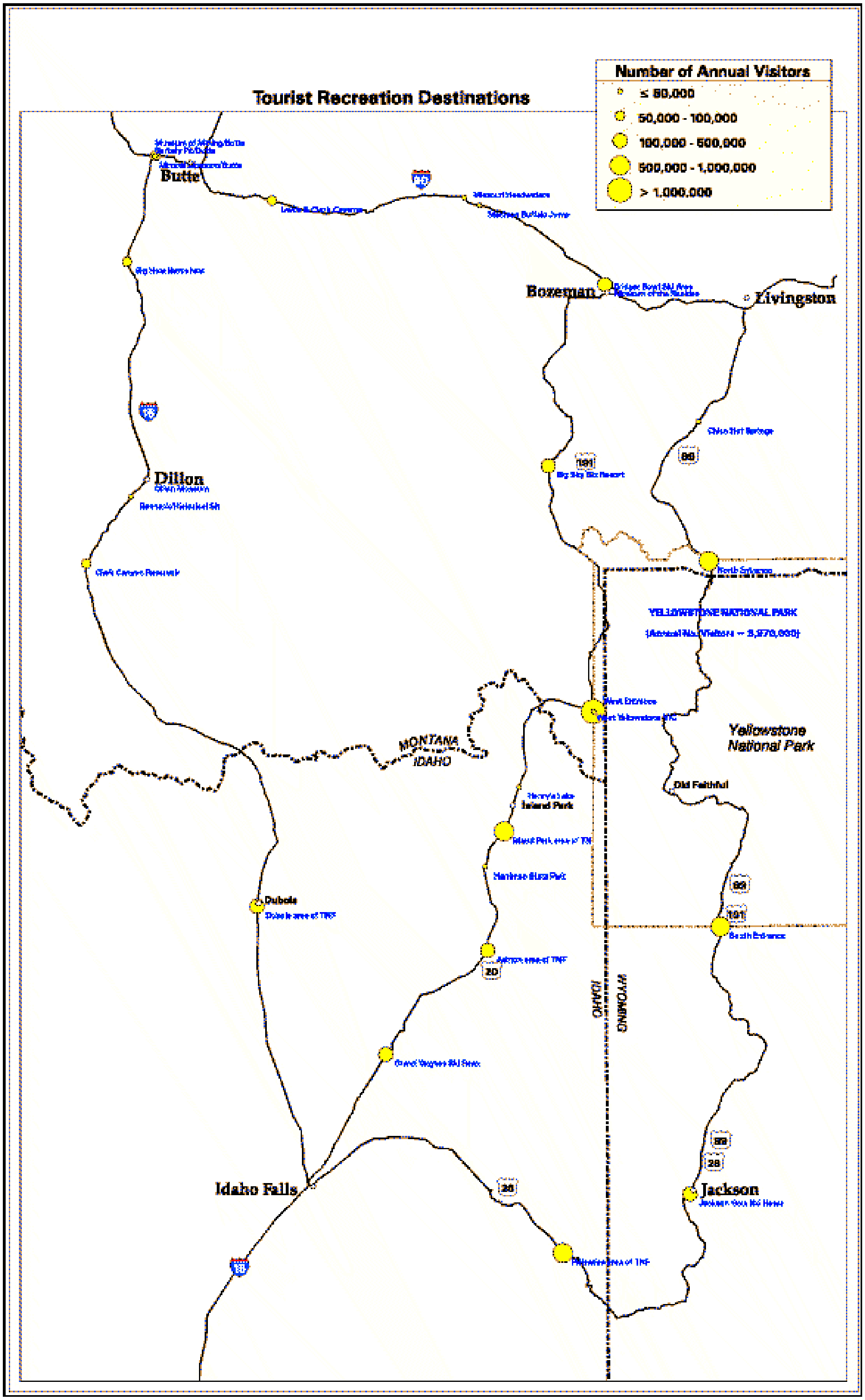

Figure 6 - Tourist Destinations

Congestion

Seventy-four percent of the nearly 3 million vehicles that enter Yellowstone National Park each year travel through one of the three gates in the GYRITS Corridor: (1) West Yellowstone, Montana, (2) Gardiner, Montana and (3) Jackson, Wyoming. Delays occur frequently, as each vehicle is stopped to show passes, pay fees or recieve information on the park.

In addition, traffic delays occur due to road construction and maintenance. Figure 7 shows planned construction and maintenance projects within the Corridor. Some projects are already underway. Future projects, though, could be supplemented with ITS applications that may reduce construction zone delays.

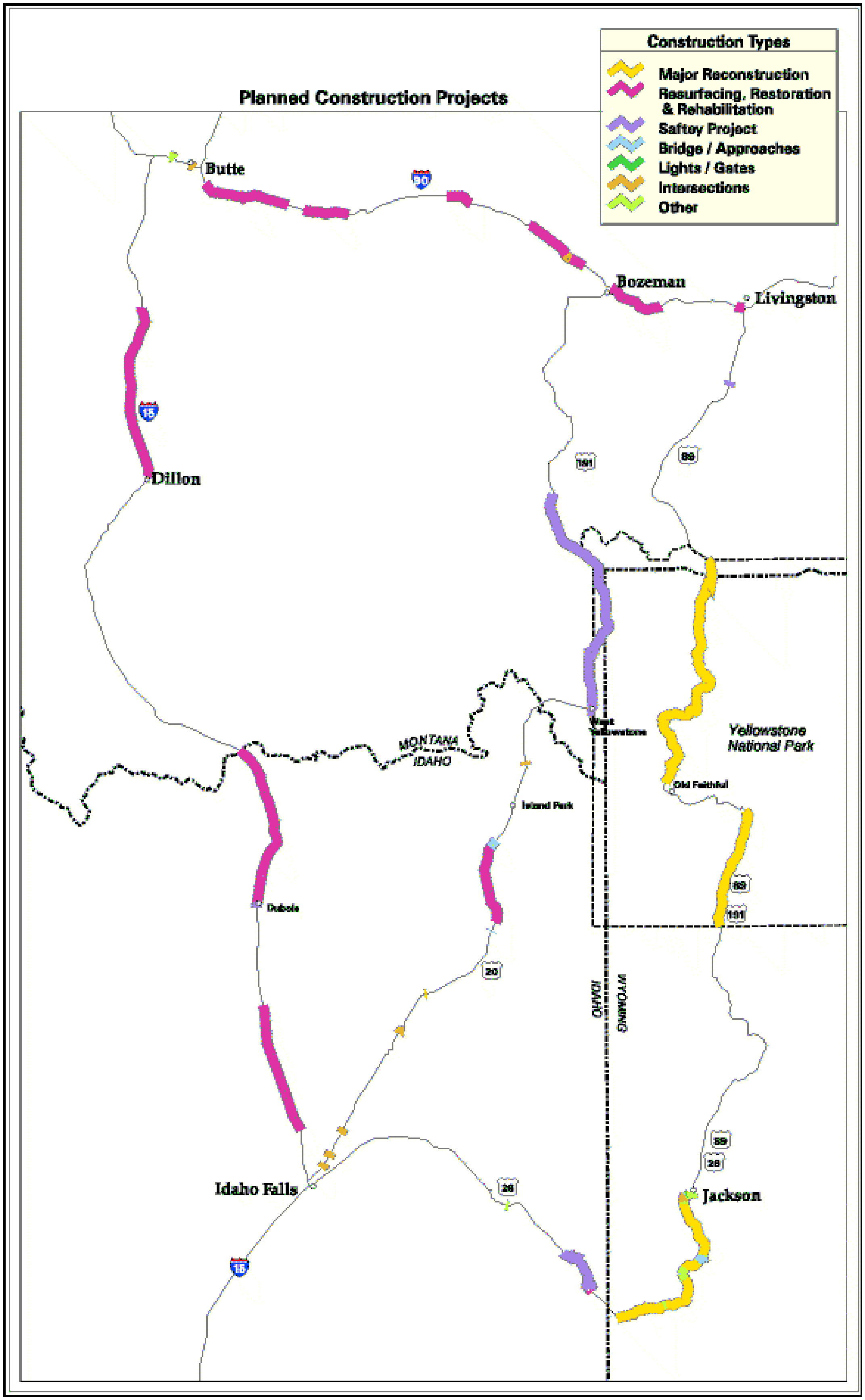

Figure 7 - Planned Construction Projects

Hazardous Materials Movement and Environmental Impact

Two sources of data were used to assess the impact of hazardous materials movement. The U.S. Department of Transportation - Office of Hazardous Materials showed 22 hazardous material spills along the Corridor during the three-year period of 1994 to 1996. These spills cost $1,770,000 in damages from product loss, carrier damages, property damage and decontamination. Decontamination only accounted for $8000 of these damages.

The second data source was the Department of Environmental Quality for each of the three states through which the Corridor passes. The information received from Montana and Wyoming (Wyoming included data for Yellowstone National Park) identified locations only by county. Information was never received from the Idaho Department of Environmental Quality. For the three-year period (1994 to 1996), 171 hazardous materials spills occurred within the Montana and Wyoming counties in the Corridor; and over 120,000 gallons of hazardous materials were spilled. However, most of these incidents involved pipe or storage tank leaks, rather than transported hazardous materials. Though some of the records are not clear, 52 incidents seemed to involve trucks and rail cars with 32,448 gallons of hazardous materials spilled, including diesel fuel, fertilizer and asphalt. No information was available on cleanup costs or property damage.

To better emphasize the magnitude of impact resulting from hazardous material spills, consider the following incident. The *Bozeman* (Montana) *Daily Chronicle* (24) reported a 1995 crash closed Montana Highway 191 for 12 hours. This area has no alternate routes, and average daily traffic at this location was about 2,000 vehicles. As a rough calculation, if half of these vehicles were delayed for six hours, and the value of a person's time approximated at $10 per hour, total cost of the delay in lost person hours was $60,000.

The accuracy of both national and state data sources was questioned by researchers. When comparing a data record of that same crash with the newspaper article (Table 8). Discrepancies were noted in amount spilled, the date, and even the highway number.

Table 8 - Comparison of Data Sources

	Newspaper	Montana DEQ	USDOT
Location of Incident	Highway 191 near Greek Creek	Gallatin County	Highway 19 milepost 21 near Big Sky
Incident Date	1/10/95	11/6/95	11/5/95
Material Spilled	Asphalt	Asphalt	Asphalt
Amount Spilled	7,000 gallons	200 gallons	1,398 gallons

Such inaccuracies make it difficult to determine the exact magnitude of this problem. However, available information indicates hazardous materials spills are a challenge in the Corridor. The difficulties in obtaining this data also point to the need for a more coordinated and accurate method of collecting information and monitoring hazardous material spills.

Road Closures

There are several challenges associated with road closures and the problems causing the closure. Roads are closed for several reasons. Some are closed to clear a physical blockage such as drifting snow, avalanche/rock slide or a vehicle crash, while others are closed to let a storm pass through the area or visibility to improve before permitting travel. There are many challenges associated with road closures. An effective, timely road closure may require much coordination between agencies and large amounts of manpower. Agencies involved may include: state departments of transportation, county road maintenance, state police, local emergency medical services, fire departments, and towing services. Another issue is liability. Many agencies are apprehensive to close a roadway not only because of mobility and delay but because it puts extra responsibility on that agency to ensure that no motorists are stranded on the roadway once it is closed. Providing information upstream to motorists of closure is another important challenge. Some road closures are planned in order to complete road construction, maintenance activities or avalanche work. For planned road closures officials must deal with finding an alternate route and informing the public. The following is a summary of the road closure locations, types, frequency and duration.

Montana. Road closures are coordinated with the Montana Department of Transportation and Montana Highway Patrol. They are closed through portable signing, permanent gates (if available) and highway patrol vehicles. Based on interviews with Doug Moeller and Martin Martin with the Montana Department of Transportation - Maintenance and Sergeant Burt Obrert with the Montana Highway Patrol common road closure locations in Montana include:

- Bozeman Pass: Interstate 90 between Bozeman and Livingston

Cause	Extremely poor visibility or to clear a major crash
Frequency	Two to three times per year
Duration	A few hours. Once the road is closed Montana Department of Transportation will not reopen it until they have sufficiently cleared the road of snow. This is done because it is easier to clear the road when it is closed and upon reopening there are typically high traffic volumes.

- Interstate 90 from West Livingston Interchange to East Livingston Interchange

Cause	Visibility due to blowing snow
Frequency	Few times per year
Duration	Until visibility improves, usually a few hours
Detour	Traffic is detoured through the town of Livingston

- Gallatin Canyon: Highway 191 from Four Corners to West Yellowstone

Cause	A major crash blocking one or both lanes
Frequency	Once per year
Duration	Until crash is cleared, usually a few hours
Signing	Closed only to through traffic by signing

- Monida Pass: Interstate 15 at Idaho Border

Cause	Snow accumulation and safety problems from wind, blowing snow and icy roads
Frequency	Every other year
Duration	Until the road is cleared, from a few hours to a day
Signing	Signs placed in Butte and along Interstate 15. Closed at the border only at the request of Idaho when closed in Idaho

- Homestake Pass: Interstate 90 East of Butte

Cause	Overturned or jackknifed truck
Frequency	Four times per year
Duration	Until the wreck is cleared, usually a few hours

Idaho. Road closures are coordinated with Idaho State Police and Idaho Department of Transportation. Portable road closure gates and signing are used. Based on interviews with Patrick McDonald with the Idaho State Police, common road closure locations in Idaho include:

- Interstate 15 between Idaho Falls and Roberts

Cause	Blowing dust and visibility problems
Frequency	A few times every spring
Duration	Until visibility improves, usually a couple hours and sometimes overnight
Detour	Lewisville Highway

- Monida Pass: Interstate 15 between Dubois and Montana State Line

Cause	Snow accumulation and safety problems from wind, blowing snow and icy roads
Frequency	Every other year
Duration	Until the road is cleared, from a few hours to a day

- Highway 20 between Ashton and West Yellowstone, Montana

Cause	Snow accumulation or heavy truck crashes blocking roadway
Frequency	5-6 times per season
Duration	Until highway is cleared, usually 4-5 hours

- Highway 26 between Swan Valley or Palisade and Alpine Junction, Wyoming

Cause	Solid ice causing safety problem
Frequency	5-6 times per year
Duration	Until ice is cleared, usually 2-3 hours

Wyoming. Wyoming Department of Transportation-Maintenance manages road closures. When a road is closed, crews work around the clock to clear the road. Roads are closed by permanent gates, permanent signs with flashers and portable signs. Based on interviews with Jim Montuoro, and Ernie Potter, Wyoming Department of Transportation and Dave Schofield, Wyoming Highway Patrol common road closure locations in Wyoming include:

- Highway 89 between Alpine Junction and Hoback Junction

Cause	Over 30 active avalanche sites
Frequency	Depending on snowpack and weather conditions, at least twice per year
Duration	Until road is cleared ranging from 1 to 24 hours

- Highway 89 between Hoback Junction and Jackson

Cause	Active avalanche at approximate milepost 151
Frequency	Twice per year
Duration	Typically one hour
Detour	South park loop road (county road)

Grand Teton National Park. Road closures in Grand Teton National Park are coordinated with the Road Maintenance Office and Ranger Division. Based on interviews with Richard Spalmer with the Grand Teton National Park, South District Ranger Station, a common site for road closures in Grand Teton National Park is:

- Highway 89 between Blacktail Ponds (just north of Moose) and Teton Point Turnout

Cause	Poor visibility and plows can not keep up with snow accumulation
Frequency	One to two times per year
Duration	A day or less

Yellowstone National Park. Yellowstone National Park is closed at the entrance gates annually to rubber tired vehicles from the first Monday in November to the first Friday in May. During this time period, the park is open to snowmobiles from the third Wednesday in December to the first Monday in March. Because of the annual closure, the park does not deal with intermittent weather-related closures to regular vehicles. However, segments of the park are typically closed to snowmobiles. Snowmobile closures are due to high winds, avalanche work and drifting snow. Permanent gates located at park entrances and several locations throughout the park are used for these closures.

Perceived Challenges

Stakeholders identified many issues as major transportation challenges. However, examination of the data proved that some of these were perceived rather than real challenges. These challenges will not be included in future analysis, because of their low probability of return in benefits.

Motorists Unfamiliar with the Area

Stakeholders believed motorists from outside the Corridor area were involved in crashes more frequently because they were more focused on directions rather than safety. Ideally, the magnitude of this problem could be determined by comparing crash rates of in-state versus out-of-state vehicles. A breakdown of traffic by in-state versus out-of-state vehicles was unavailable, however a comparison of the portion of out-of-state vehicle for different crash types was made. It was hypothesized that motorists unfamiliar with the area would be more involved in certain types of crashes. The portion of crashes in the corridor involving out-of-state vehicles was determined from the three years of crash data from Idaho (1993 to 1995) and Wyoming (1994 to 1996). Crash data from Montana did not include registered vehicle state information. As shown in Table 9, out-of-state vehicles accounted for 50 to 60 percent of the crashes regardless of the type of crash. The only inconsistency between in-state and out-of-state vehicles was within and around larger cities, where a higher percentage of crashes involved in-state vehicles. These crashes were typical intersection crashes involving angle collisions and failure to yield right-of-way. This inconsistency is probably attributed to the fact that more of the traffic in these areas is due to daily commuters, and thus a higher percentage of the traffic is in-state vehicles.

Table 9 - Portion of Out-of-State Vehicles by Crash Type in the Corridor

Crash type	Total crashes	% Involving out-of-state vehicle
All crashes	1,804	54
Light condition dark	492	48
Light condition day	1,196	56
Weather clear	1,095	56
Weather snow	201	50
Road condition dry	1,060	55
Road condition icy	449	53
Severity injury	639	52
On curve and grade	163	55
Driver action left turn	191	57
Driver action pass	79	65
Collision type angle	351	18
Failure to yield right-of-way	246	38
Animal collision	244	56
Speed too fast for conditions	385	55

Vehicle Mix and Speed Disparities

Disparate vehicle speeds, mainly caused by mixed vehicle types, was a difficult safety challenge to quantify. Many stakeholders cited instances when they were personally frustrated traveling behind a slow-moving vehicle, with the safety challenge arising when faster vehicles passed the slower-moving vehicles. Researchers deemed this challenge as questionable based on the fact that the crash attribute “improper passing maneuver” did not arise as a significant challenge in the crash analysis.

Geographic Areas of Focus

For each challenge identified, geographic areas of focus were determined. These focus areas will help narrow down potential locations for future ITS projects. Additionally, geographic focus areas can demonstrate the interrelationships of various issues. Sections of the Corridor were categorized as:

Urban	(1) two-lane highways within the city limits of a city having a population greater than 1,000 or (2) controlled access four-lane highways (Interstate and Route 20 outside Idaho Falls) having more than two exits within a city
Suburban	from the edge of the city limits until the geometry of the roadway resumes to two-lane rural
Rural Mountains	does not fall within the urban or suburban areas and has major elevation changes
Rural Level	does not fall within urban or suburban areas and is a relatively flat grade
Park	Yellowstone National Park was kept separate, although it probably most emulates the rural level category. The park has lower design speeds, with typical speed limits between 35 and 45 miles per hour. This segment is also unique in the number of animals, the number of tourist travelers and the dense trees that encroach on the clear zone

The breakdown of these sections is shown in Figure 8. For each particular challenge, geographic areas were chosen based on the type of challenge and the quantifiable data available.

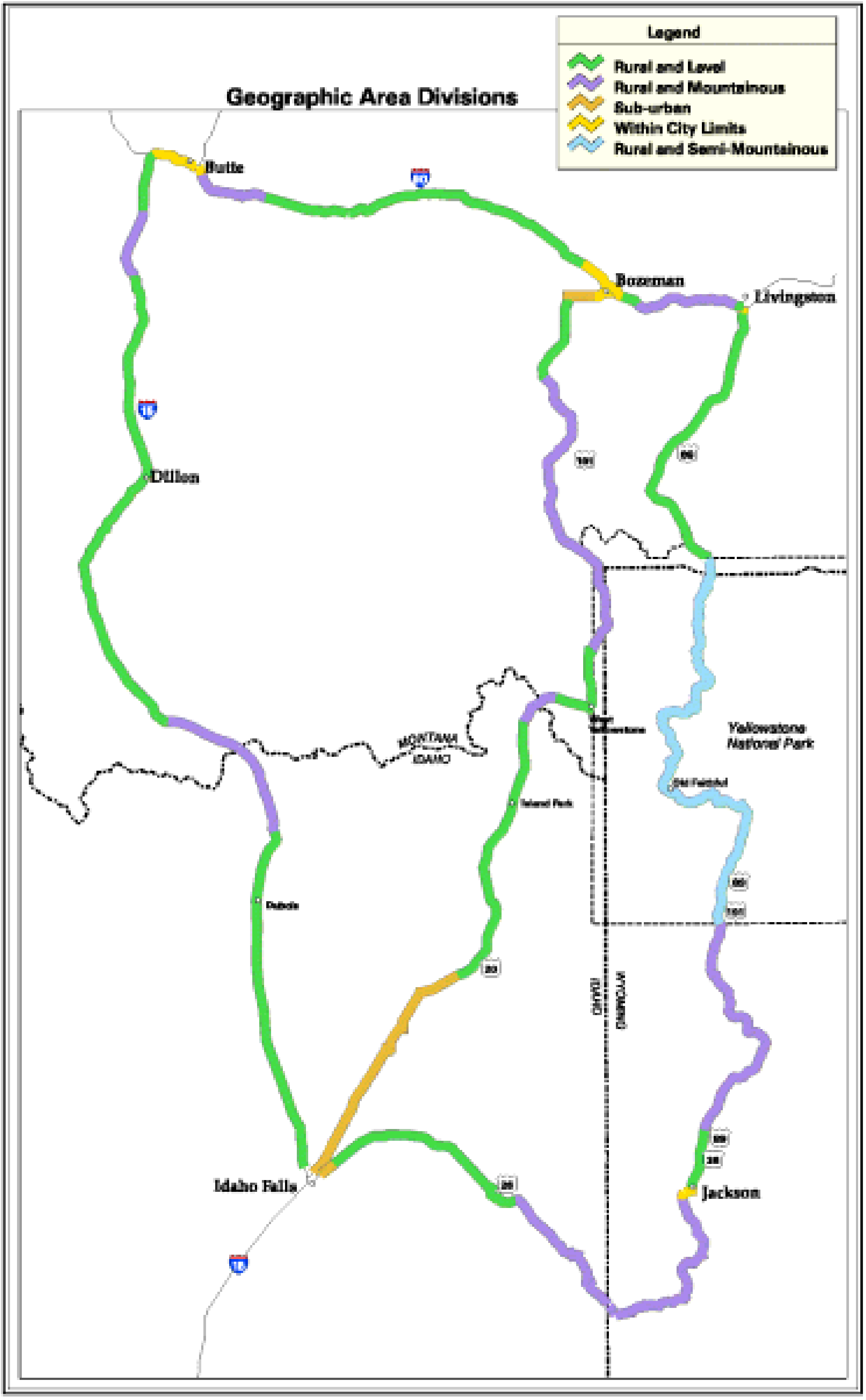

Figure 8 - Geographic Area Divisions

Generally, a geographic areas of focus was selected if:

- The area experienced a crash trend potentially alleviated with a technological solution. These area trends were determined based on analysis of the collected data.
- The area could successfully support data collection efforts allowing for a valid before/after statistical evaluation. The area must experience a sufficient number of crashes or adequate traffic volumes to obtain a statistically valid sample before and after the implementation of the technological solution.
- The area has existing infrastructure in place to minimize implementation costs and maximize the "added value" benefits of the technological solution.

Geographic Areas With Safety-related Challenges

When looking at the crash analysis for all vehicles and for commercial vehicles, a geographic area of focus was chosen for a particular safety challenge if it met two of three criteria:

- the geographic area contained atypical crash locations that had an identifiable crash trend for the particular safety challenge,
- over 20 percent of all the crashes in the geographic area had a particular safety challenge, or
- a high number (over 50) of all the crashes in the geographic area had a particular safety challenge.

Table 10 shows which sections of the Corridor experienced above-average crash rates. Sections with commercial vehicle crash rates higher than the national average were identified as commercial vehicle safety problem areas. One lengthy segment (including most of Highway 191) was identified as having two major safety challenges for commercial vehicles: (1) driving too fast for icy conditions and (2) animal conflicts. While these two challenges present a problem for both commercial vehicles and other vehicles, commercial vehicles will be included in future consideration of these two challenges because they may provide a better potential test market for deployment of applications requiring in-vehicle components. These segments are identified with a "C" in Table 10.

Table 10 - Geographic Areas of Focus for Safety Challenges

Seg #	Type	State	Route	From milepost	To milepost	Failure to yield	Speed and icy	Rear ends	Snowmobile	Animal
1	Ft	MT/YP	191	0	11					
2	Mt	MT/YP	191	11	67		1-C			1-C
3	Ft	MT	191	67	82					
4	Su	MT	191	82	87			1		
5	Ub	MT	191	87	91	1		1		
6	Mt	MT	20	0	3					
7	Ft	MT	20	3	9					
8	Su	ID	20	309	353	1				
9	Ft	ID	20	353	401		1			
10	Mt	ID	20	401	406					
11	Su	ID	26	335	338	1				
12	Ft	ID	26	338	376					
13	Mt	ID	26	376	403					
14	Mt	WY	26	0	2					
15	Mt	WY	89	118	152					
16	Ub	WY	89	152	155	1		1		
17	Ft	WY	89	155	165					
18	Mt	WY	89	165	212					1
19	Sm	YP	89	0	93				1	1
20	Ft	MT	89	0	52					1
21	Ub	MT	89	52	53					
22	Ft	ID	15	121	180					
23	Mt	ID	15	180	196		1			
24	Mt	MT	15	0	13					
25	Ft	MT	15	13	99					
26	Mt	MT	15	99	111					
27	Ft	MT	15	111	121					
28	Ub	MT	15	121	129					
29	Ub	MT	90	227	229					
30	Mt	MT	90	229	242		1			
31	Ft	MT	90	242	301		1			
32	Ub	MT	90	301	310					
33	Ft	MT	90	310	313					
34	Mt	MT	90	313	331		1			
35	Ft	MT	90	331	333					

C = Commercial Vehicle; Ft = Rural Flat; Mt = Rural Mountainous; Su = Suburban; Ub = Urban; Sm = Park

Long Emergency Response Times. Areas with long emergency response times to crashes were determined by plotting notification/response times and the locations of existing emergency services. Emergency service locations are shown in Figure 9. Figures 10-13 show notification and response times for emergency medical vehicles and police.

Interestingly, emergency response times were typically longer (30 minutes or more) near the state borders. Near the Idaho/Montana border on Idaho Route 20, response times were longer, even though an array of emergency services are close by to the north at West Yellowstone, Montana and to the south near Island Park, Idaho. Some police response times were longer near the Wyoming/Idaho border on Wyoming Highway 89. These situations may be remedied by coordinating multi-state emergency response.

Outside the Idaho Falls, Idaho area, Idaho Interstate 15 had longer notification times. This is to be expected because of the remote nature of the area.

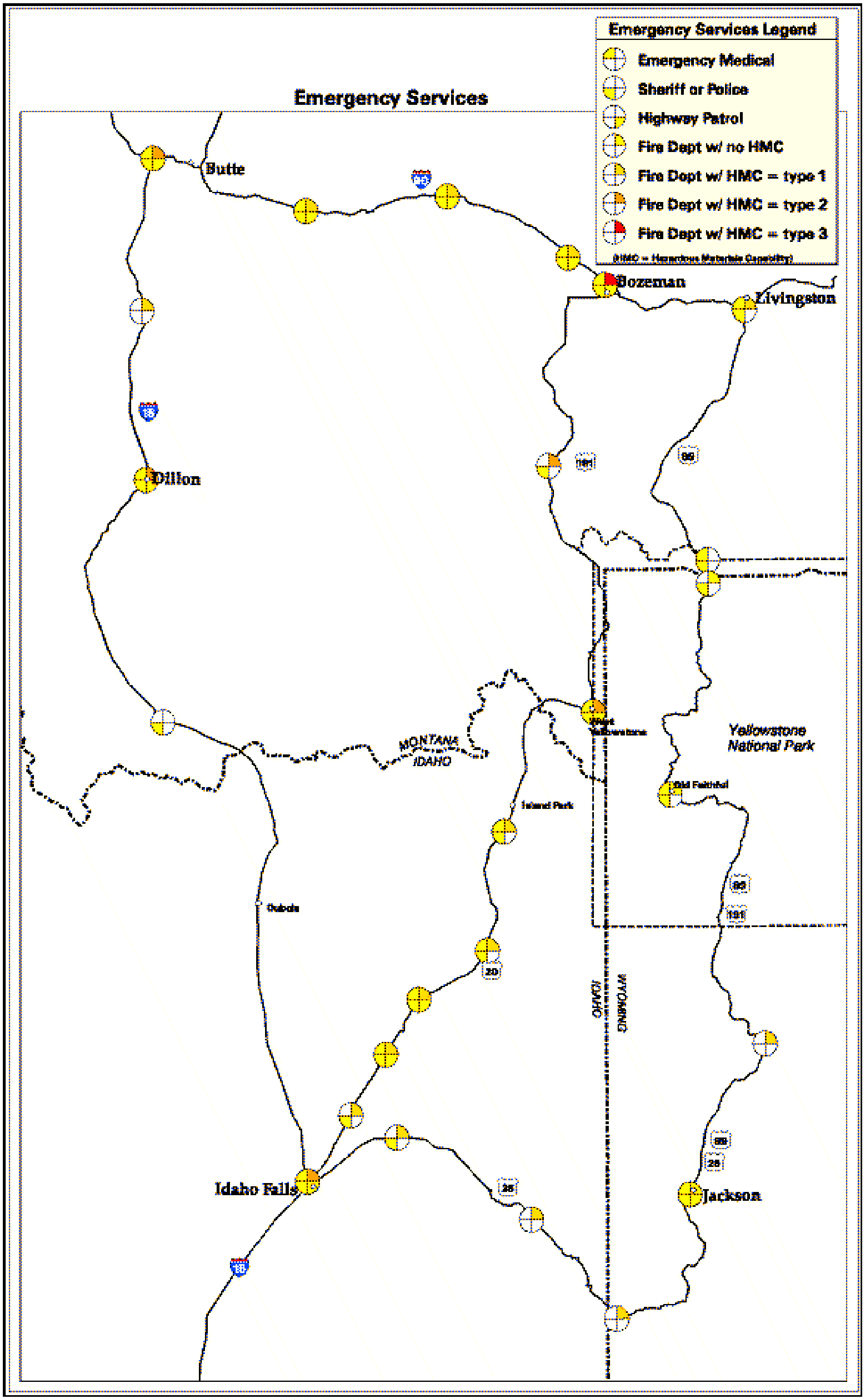

Figure 9 - Emergency Service Locations

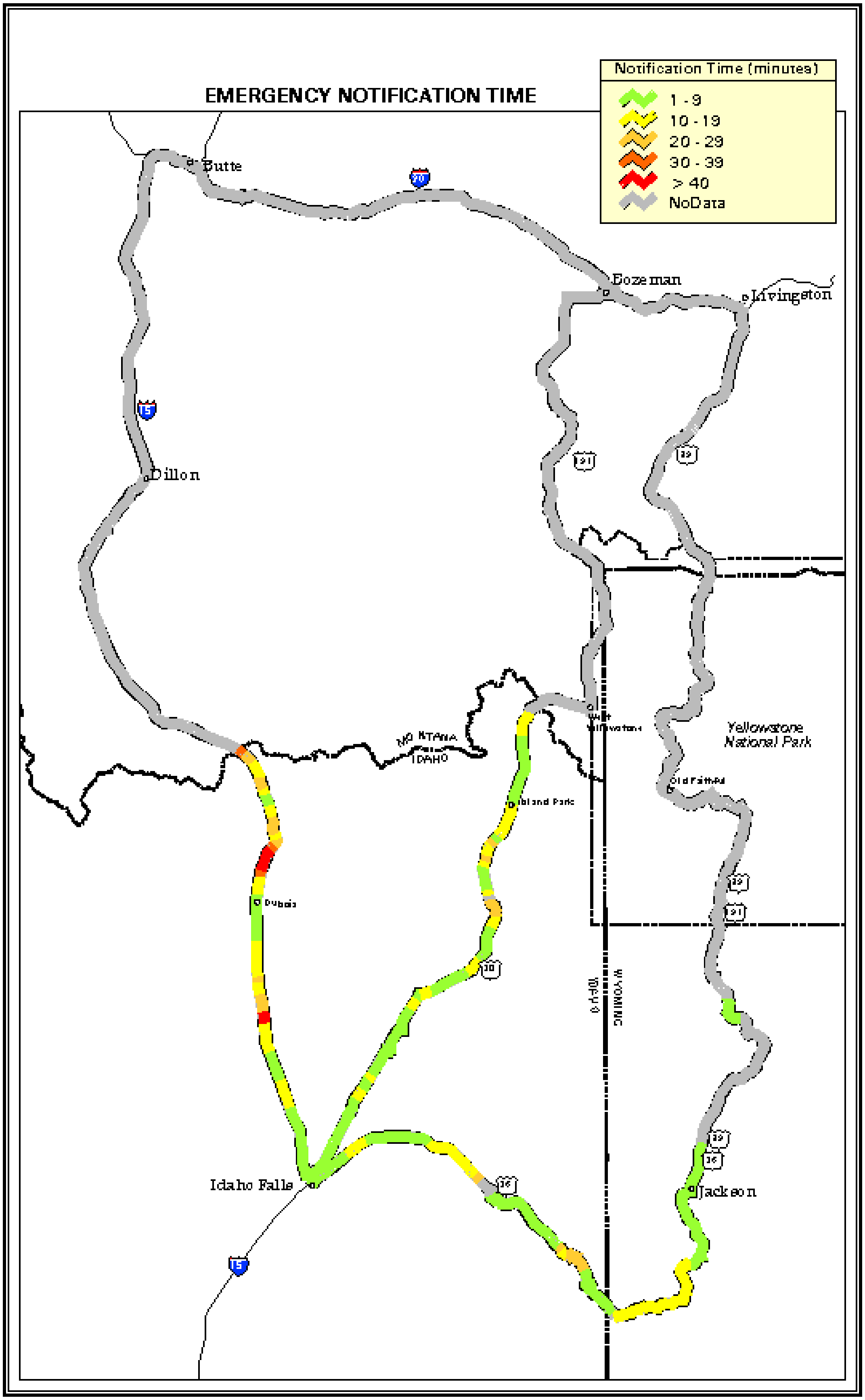

Figure 10 - Emergency Medical Notification Times

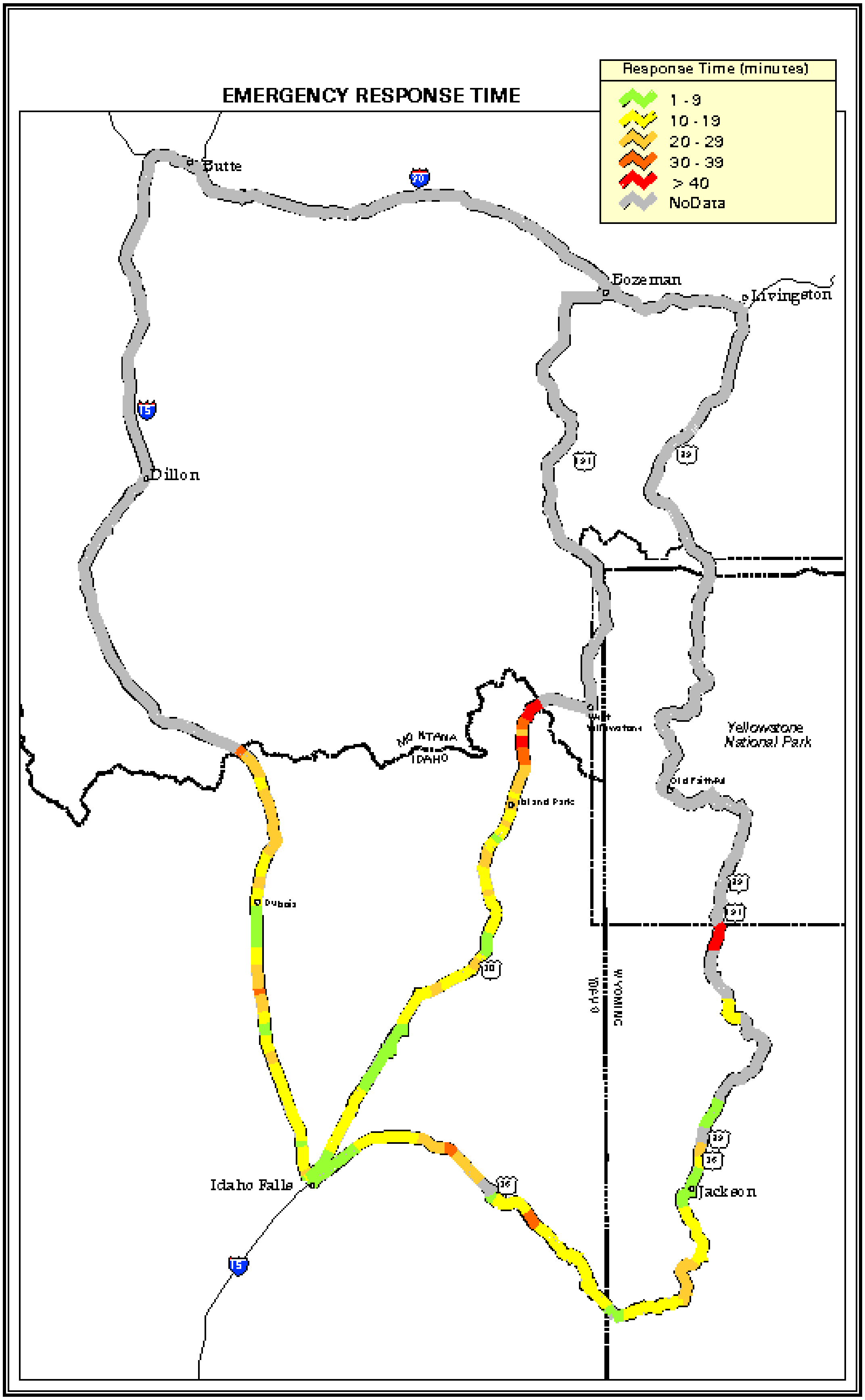

Figure 11 - Emergency Medical Response Times

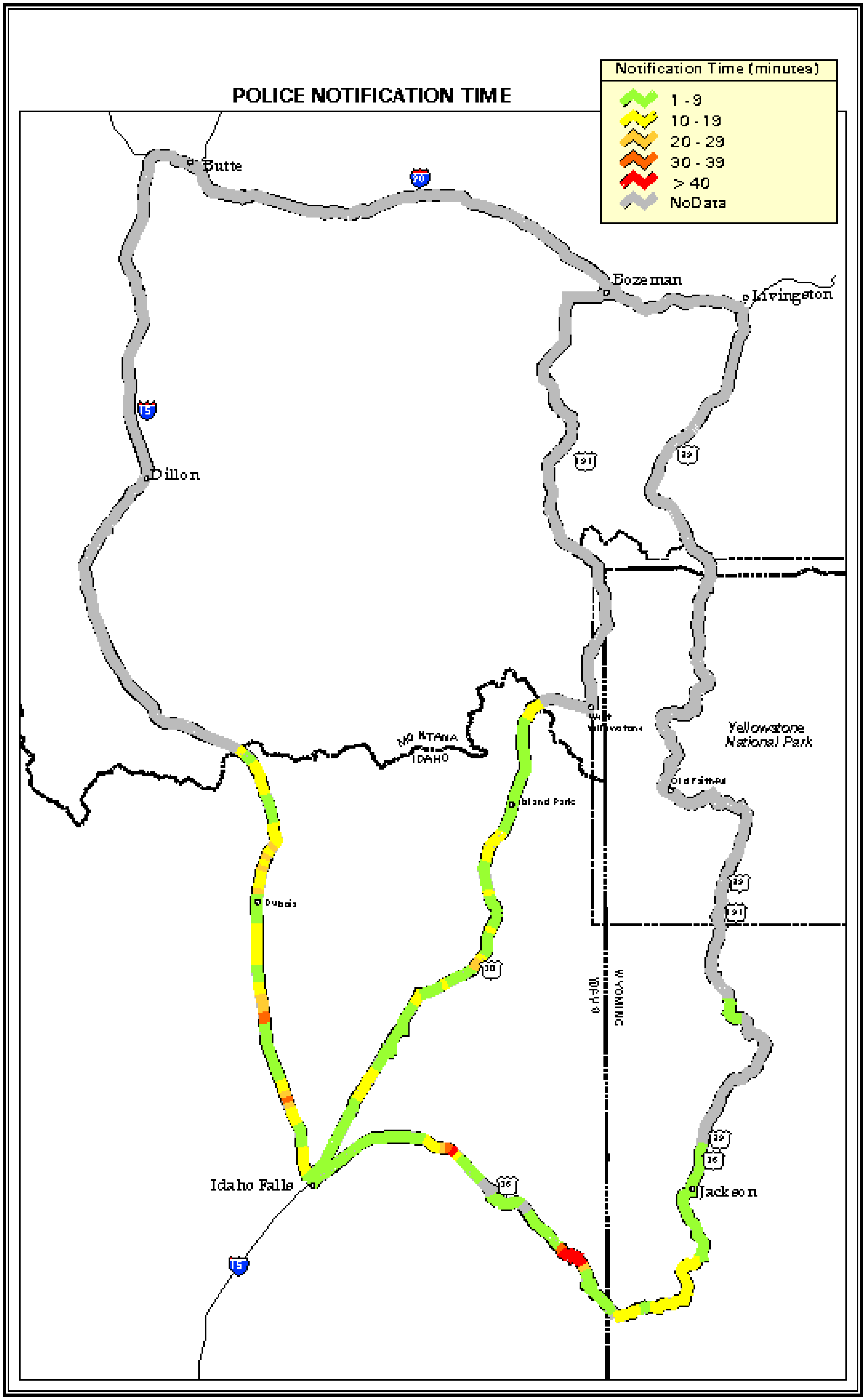

Figure 12 - Police Notification Times

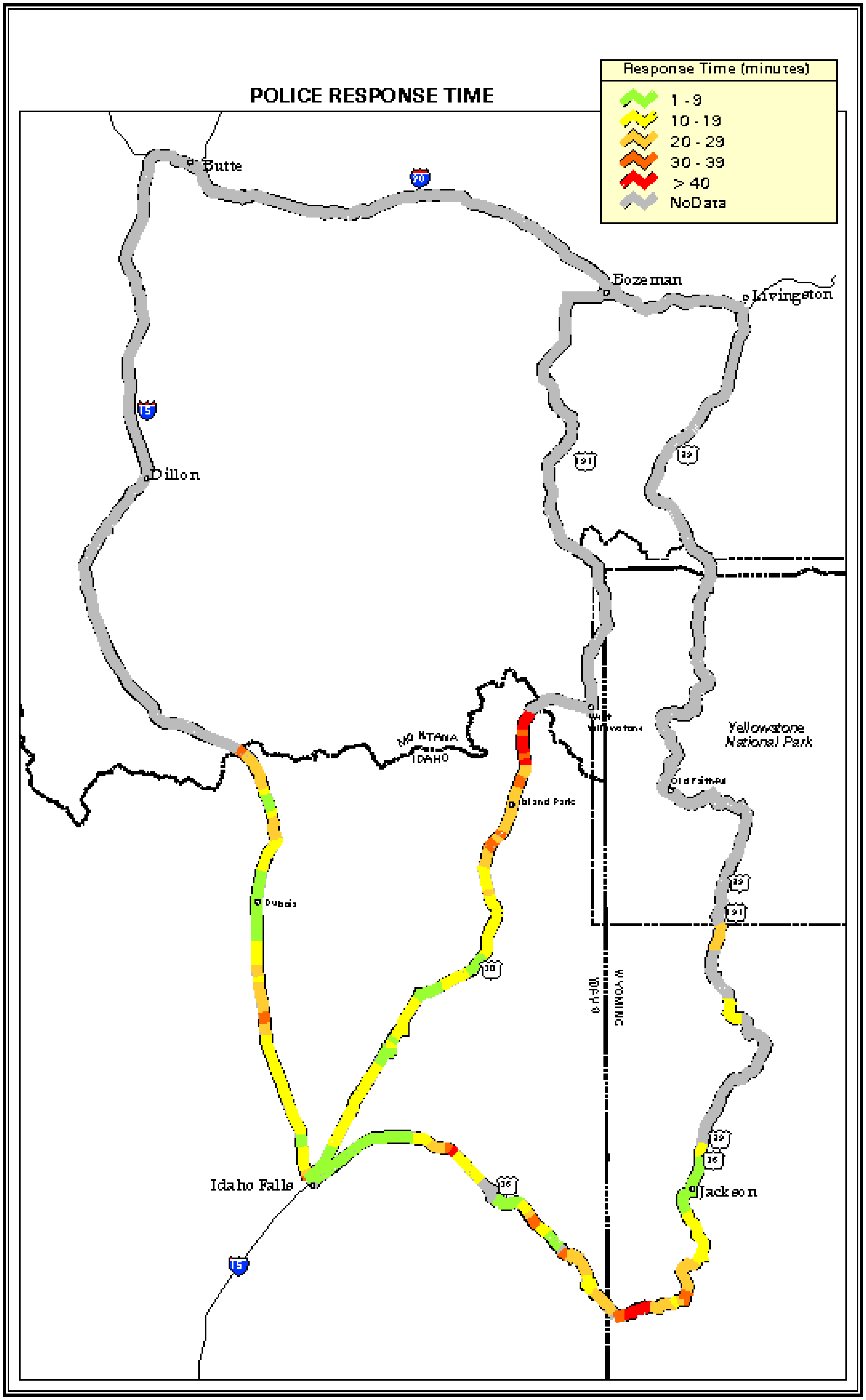

Figure 13 - Police Response Times

Geographic Areas with Operational Challenges

Commercial vehicle operations efficiency can be improved at the weigh stations. Six weigh stations are spread throughout the Corridor as shown in Figure 14. Some weigh stations were built in the early 1960's and do not have adequate entrance and egress ramps; trucks queue and incur delays.

Although a majority of tourist travel is focused around Yellowstone National Park, tourist destinations are spread throughout the Corridor as shown in Figure 6. Tourism and traveler information applications should be considered on an area-wide basis with supporting spot information dissemination improvements.

Congestion occurs at the three Yellowstone National Park entrances and in construction and work zones. Congestion mitigation efforts should focus on the park entrances or one of the selected construction projects shown in Figure 7.

Public mobility applications should be considered for existing paratransit agencies. Transit agencies (both public and private) are shown in Figure 15. Selection of a specific paratransit agency and location will require further analysis.

Inconsistencies in the available hazardous materials spills data preclude any determination of a geographic area of focus for this challenge. Hazardous material spills appear to be prevalent throughout the Corridor, and researchers recommend this challenge be analyzed on a Corridor-wide level.

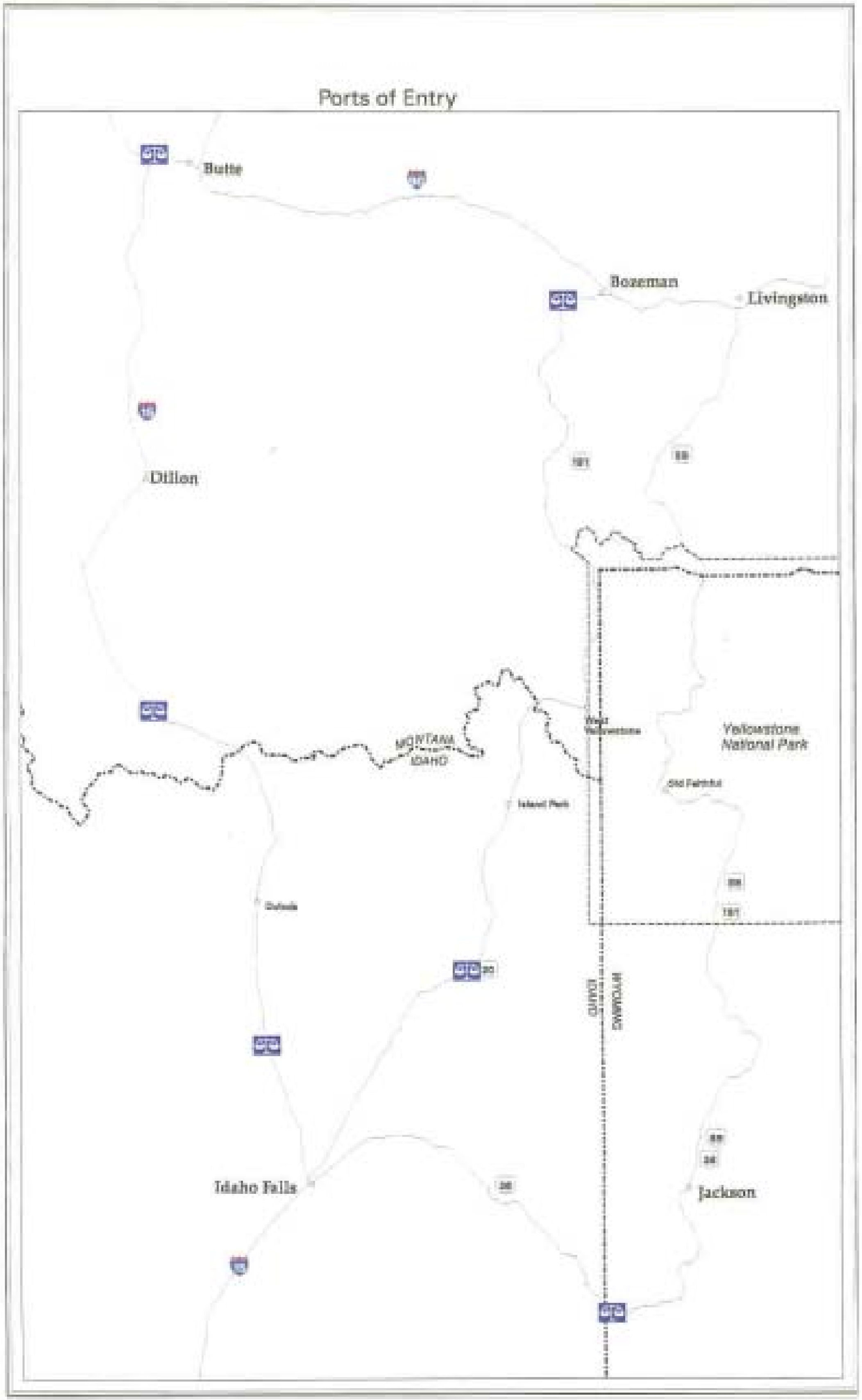

Figure 14 - Weigh Station Locations

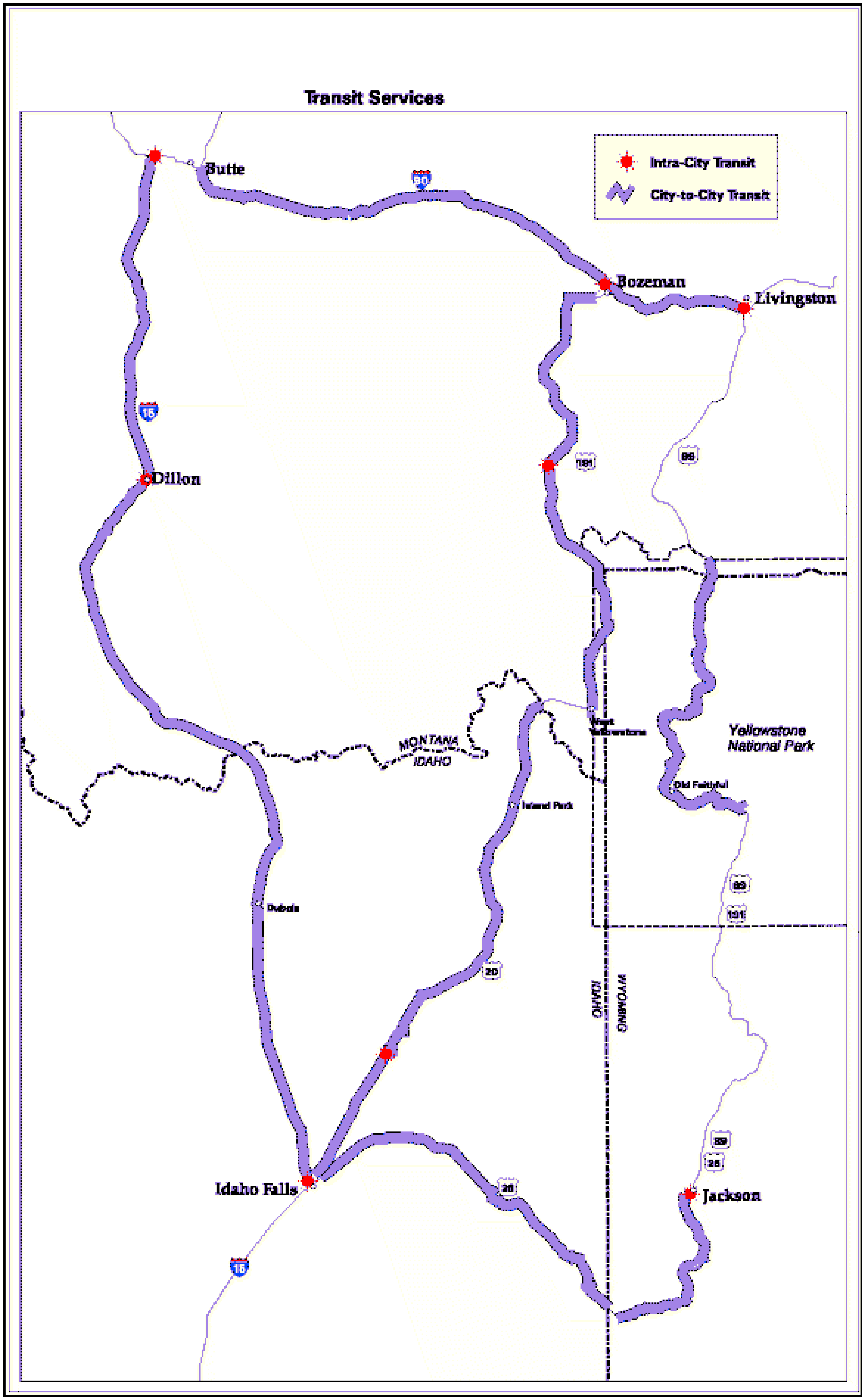

Figure 15 - Transit Service (Public and Private)

Existing and Planned Infrastructure

In addition to the above suggestions, project locations should be selected to include existing components such as variable message signs, highway advisory radio and road weather information systems. These legacy systems are shown in Figure 16. Additionally, ITS deployment projects should be coordinated with planned construction projects to reduce deployment costs (Figure 7).

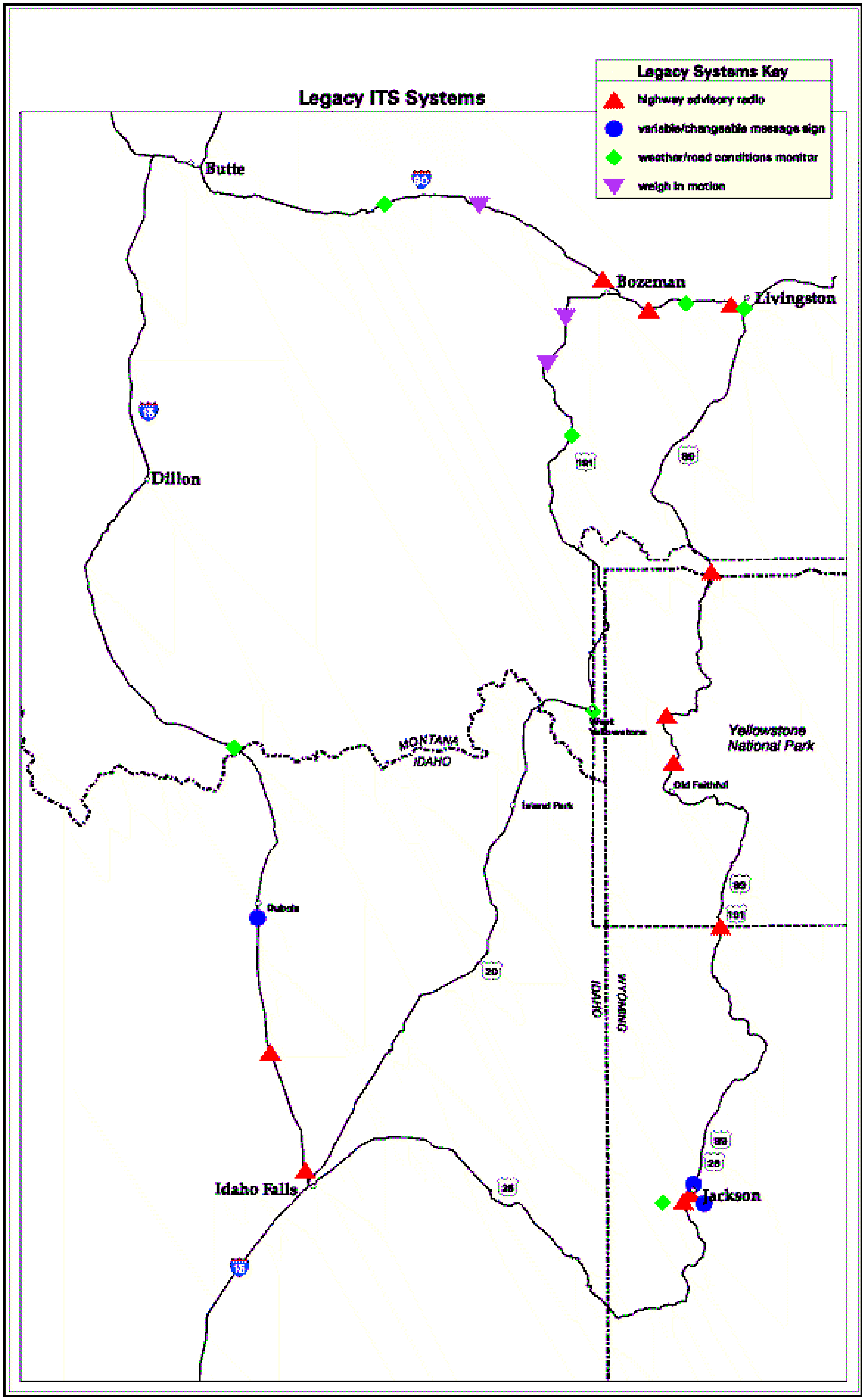

Figure 16 - Legacy Systems

SUMMARY

This task identified transportation challenges in the Greater Yellowstone Rural ITS Priority Corridor, quantified those challenges, determined geographic areas of focus and inventoried existing and planned infrastructure. Stakeholders were interviewed during several meetings. Major transportation-related issues identified by them include safety impacts from:

- inclement weather;
- disparate vehicle speeds;
- mixed vehicle types, including farm equipment, commercial vehicles and snowmobiles;
- motorists unfamiliar with the area focusing more on directional information than driving;
- animal encroachments on the roadway;
- long emergency response times;
- poor horizontal and vertical alignment; and
- hazardous materials incidents;

in addition to:

- infrastructure damage caused by commercial vehicles;
- the need for partnerships and institutional cooperation;
- the lack of tourist/traveler information; and
- the dependence on tourism for economic sustainability of rural communities.

These challenges and others identified through previous efforts were quantified to determine which challenges might benefit most from ITS technology. For each challenge, and based on available data, a suggested geographic area of focus was determined. The challenges identified and their corresponding geographic areas of focus are shown in Table 11.

The results of this task will support other tasks by helping determine appropriate ITS applications and project locations.

Table 11 Summary of Transportation Challenges and Recommended Areas of Focus

Corridor Challenge	Specific Locations	Corridor Segments
1. Inclement weather		Entire corridor
2. Unsafe speed and slippery roads		Hwy 191 through Gallatin Canyon, portions of Idaho Hwy 20, Idaho 15 on Monida Pass and a majority of Interstate 90
3. Safety problems relating to commercial vehicles		Specifically relating to Icy roads and animal conflicts along Montana Hwy 191
4. Hazardous materials		Entire corridor
5. Emergency response times		*Response times:* Idaho Hwy 20 near Idaho/Montana Border, Wyoming Hwy 89 near Idaho/Wyoming Border *Notification times:* Idaho Interstate 15 not including Idaho Falls area.
6. Lack of traveler/tourist information	Approaches to Yellowstone National Park (Gardiner, MT; Jackson, WY; and West Yellowstone, MT)	Entire corridor
7. Failure to yield right-of-way or disregard for traffic control	Intersections along Hwy 191 through Bozeman, Wyoming Hwy 89 through Jackson and Idaho Hwys 20 and 26 just outside of Idaho Falls	
8. Rear-end collisions	Intersections along Hwy 191 through Bozeman and Wyoming Hwy 89 through Jackson	
9. Animal encroachment on the roadway		Portions of Hwy 191 and Hwy 89 from Jackson, WY to Livingston, Montana
10. Snowmobile crashes		Hwy 89 through Yellowstone National Park
11. Commercial vehicle efficiency	Existing and planned ports of entry	
12. Traveler mobility	One of the existing paratransit systems (to be determined)	
13. Congestion at Yellowstone entrances	Three park entrances at Gardiner, MT; West Yellowstone, MT and north of Jackson, WY	
14. Congestion at construction zones		One or more of the planned construction sites (to be determined)

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APPENDIX A: CRASH ATTRIBUTES

Crash data was collected for the three-state area and Yellowstone National Park. The following table lists the crash attributes provided by each state. To allow crashes to be compared on a Corridor-wide level, similar attributes from different state databases were grouped together to form a generic code. The left column of this table gives the generic code description.

Combination of Crash Attributes Provided by Each State

Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
year when accident took place	year when accident took place	tear when accident took place	year when accident took place	year when accident took place
state where accident took place	state where accident took place	state where accident took place		state where accident took place
accident milepost locations rounded down	accident occurred within this mile	accident occurred within this mile	accident occurred within this mile	NA
exact decimal milepost location	exact decimal milepost location	exact decimal milepost location	exact decimal milepost location	NA
accident time (military)	accident time (military)	accident time (military)	time of accident	time of accident
accident date (month/day/year)	accident date (month/day/year)	date accident occurred	date of accident	date of accident
distance of accident location from node	NA	NA	NA	distance from node
direction of accident location from node	NA	NA	NA	direction from node
node nearest accident location	NA	NA	NA	node nearest to accident
light condition: darkness	light condition: darkness (unlighted or lighted)	light: dark	light cond: dark unlighted or lighted	dark-lighted or not lighted
light condition: darkness (lighted)	light condition: darkness (lighted)	NA	light cond: dark lighted	dark-lighted
light condition: darkness (unlighted)	light condition: darkness (unlighted)	NA	light cond: dark unlighted	dark-not lighted
light condition: dawn/dusk	light condition: dawn/dusk	light: twilight	light cond: dawn or dusk	dawn or dusk
light condition: dawn	NA	NA	NA	dawn
light condition: dusk	NA	NA	NA	dusk
light condition: daylight	light condition: daylight	light: daylight	light cond: daylight	daylight
light condition: unknown	NA	NA	NA	unknown

Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
weather condition: clear	weather condition: clear	weath: clear	weather cond: clear	clear
weather condition: overcast/cloudy	weather condition: overcast/cloudy	weath: cloudy	weather cond: cloudy	cloudy
weather condition: fog	weather condition: fog	weath: fog	weather cond: fog	fog, smog, smoke
weather condition: raining	weather condition: raining	weath: rain	weather cond: raining	rain
weather condition: snowing	weather condition: snowing	weath: snow	weather cond: snowing	snow
weather condition: hail	NA	weath: hail	weather cond: sleet/hail	sleet, hail, freezing rain
weather condition: wind	NA	weath: wind	weather cond: strong wind	severe crosswinds
weather condition: blowing snow	accident analysis codes: blowing snow	NA	weather cond: ground blizzard	NA
weather condition: dust	NA	weath: dust	NA	blowing and/soil/etc.
weather condition: slush	NA	weath: slush	NA	NA
weather condition: smog	NA	weath: smog	NA	NA
weather condition: other	NA	NA	NA	other
weather condition: unknown	NA	NA	NA	unknown
road condition: dry	road condition: dry	srf: dry	road cond: dry	dry
road condition: icy/slushy	either of the following 2	either of the following 2	either of the following 4	icy/slushy
road condition: icy	road condition: icy	srf: icy	road cond: icy	NA
road condition: slushy	road condition: slushy	srf: slushy	road cond: slush	NA
road condition: snowy	road condition: snowy	srf: snowy	road cond: snowy	snowy
road condition: wet	road condition: wet	srf: wet	road cond: wet	wet
road condition: natural debris	road condition: natural debris	NA	NA	debris
road condition: muddy	NA	NA	road cond: muddy	muddy
road condition: other	NA	NA	NA	other
road condition: unknown	NA	NA	NA	unknown

Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
at least one death	injury severity: fatal	1 if fatalities is > 0	num kil >0	if fatals > 0
at least one injury but no death	Any of the three following injuries	1 if injuries is > 0 and fatalities = 0	num inj >0 and num kil =0	if injuries > 0 and fatals = 0
incapacitating injury (cannot perform normally)	injury severity: incapacitating injury (cannot perform normally)	NA	NA	NA
non-incapacitating injury (evidence of injury)	injury severity: non-incapacitating injury (evidence of injury)	NA	NA	NA
possible injury (apparent symptoms	injury severity: possible injury (apparent symptoms	NA	NA	NA
no injury or death	injury severity: no injury	1 if injuries=0 and fatalities=0	num inj =0 and num kil =0	if fatals = 0 and injuries = 0
number of fatalities	NA	fatalities	num kil	number of deaths caused by accident
number of injuries	NA	injuries	num inj	number of injuries caused by accident
alignment: curved and level	grade and horiz alignment: curves and level	alignment: curved and level	road alignment: curve and level	curved level
alignment: curved and on grade	grade and horiz alignment: curves and grade	any of the following three alignments	any of the following three alignments	curved on grade
alignment: curved and on downgrade	NA	alignment: curved and on downgrade	road alignment: curved downgrade	NA
alignment: curved and on hill crest	NA	alignment: curved and on hill crest	road alignment: curved hill crest	NA

Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
alignment: curved and on upgrade	NA	alignment: curved and on upgrade	road alignment: curved upgrade	NA
alignment: straight and level	grade and horiz alignment: straight and level	alignment: straight and level	road alignment: straight level	straight level
alignment: straight and on grade	grade and horiz alignment: straight and grade	any of the following three alignments	any of the following three alignments	straight on grade
alignment: straight and on downgrade	NA	alignment: straight and on downgrade	road alignment: straight downgrade	NA
alignment: straight and on hill crest	NA	alignment: straight and on hill crest	road alignment: straight hill crest	NA
alignment: straight and on upgrade	NA	alignment: straight and on upgrade	road alignment: straight upgrade	NA
relation to road: Access	NA	NA	NA	on roadway - parking/driveway access
relation to road: Median	NA	relation to rdwy: median	location of fhe: median	off roadway - median
relation to road: off road	roadway related location: off road	relation to rdwy: off road	location of fhe: off roadway	off roadway
relation to road: on road	roadway related location: on road	relation to rdwy: on road	location of fhe: on roadway	on roadway
relation to road: Out of R/W	NA	NA	location of fhe: outside ROW	NA
relation to road: parking lot access-road	NA	relation to rdwy: P-lot-access-Rd	NA	off roadway - parking lot
relation to road: Private	NA	NA	NA	NA

Property				
relation to road: roadside	NA	relation to rdwy: roadside	NA	off roadway - roadside
relation to road: Shoulder	NA	relation to rdwy: shoulder	location of fhe: shoulder	off roadway - roadside
relation to road: Other	NA	relation to rdwy: other	NA	NA
Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
relation to road: gore	NA	relation to rdwy: gore	NA	NA
relation to junction: no junction	relation to junction: non junction	relation to jct: non-junction	NA	Relation to junction - non-junction
relation to junction: intersection	relation to junction: at intersection	relation to jct: at intersection	NA	relation to junction - intersection
relation to junction: intersection related	relation to junction: intersection related	relation to jct: intersection related	NA	NA
relation to junction: driveway or alley	relation to junction: driveway access	relation to jct: dr/alley	NA	relation to junction - driveway access
relation to junction: other	NA	relation to jct: Other	NA	relation to junction - other
relation to junction: not applicable	NA	relation to jct: N/A	NA	NA
relation to junction: ramp	NA	relation to jct: at ramp	NA	relation to junction - interchange
vehicle type: passenger car, pickup truck, van	veh body: passenger car; minibus/van; pickup; motorcycle; bicycle; snowmobile; compact car; midsized car; large passenger car; small, mid-sized, and large station wagons; moped	veh: car; pkup; pu/c;	vehicle type: passenger car; pickup w/ camper; pickup; van; motorcycle; truck; snowmobile	vehicle type - automobile w/ or w/o trailer, van, pickup truck
vehicle type: truck/truck-tractor	veh body: truck/truck-tractor	NA	vehicle type: tractor/trailer	NA
vehicle type: semi truck	NA	veh: semi-truck	NA	vehicle type - tractor-

				trailer(s)
vehicle type: truck and trailer	NA	veh: truck/trailer; truck	NA	Vehicle type - truck and trailer(s)
vehicle type: 2 axle truck	NA	veh: 2-axle	NA	vehicle type - truck (su)
Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
vehicle type: 3 axle truck	NA	veh: 3-axle	NA	NA
vehicle type: triple trailer truck	NA	veh: triple trailer	NA	NA
vehicle type: double trailer truck	NA	veh: double trailer	NA	NA
vehicle type: motor home	veh body: motor home	veh: motor home	vehicle type: motor home	Vehicle type - Camper/RV
vehicle type: unknown	NA	veh: unknown; miss	vehicle type: unknown	NA
vehicle type: ambulance	veh body: ambulance; firetruck	NA	vehicle type: emergency vehicle	NA
vehicle type: other	veh body: bicycle; snowmobile; other; farm tractor/machinery	veh: motorcycle; ATV; farm	vehicle type: bicycle	vehicle type - snowmobile, motorcycle, ATV, other
vehicle type: construction vehicle	veh body: construction equipment	veh: construction	vehicle type: construction machine	NA
vehicle type: bus	veh body: bus; school bus	veh: bus	vehicle type: bus; school bus	vehicle type - cross country bus/school bus
driver action prior/during: back	vehicle intent: back	driver action: backing	activity prior: backing	backing
driver action prior/during: go straight ahead	vehicle intent: go straight ahead	driver action: go-straight	activity prior: straight ahead	straight ahead
driver action prior/during: lane change	vehicle intent: lane change	driver action: change lane	activity prior: changing lanes	changing lanes
driver action prior/during: make left turn	vehicle intent: make left turn	driver action: turn-lt	activity prior: left turn	left turn

driver action prior/during: make right turn	vehicle intent: make right turn	driver action: turn-rt	activity prior: right turn	right turn
driver action prior/during: overtake	vehicle intent: overtake	driver action: passing	activity prior: passing	overtaking (passing)
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
driver action prior/during: parking maneuver	vehicle intent: parking maneuver	driver action: Legal-Par	activity prior: parking	parking
driver action prior/during: remain parked	vehicle intent: remain parked	NA	activity prior: parked	parked
driver action prior/during: start in traffic lane	vehicle intent: start in traffic lane	driver action: start-in	activity prior: starting out	entering traffic lane
driver action prior/during: slow/stop	vehicle intent: slow/stop	driver action: slowing	activity prior: slowing	NA
driver action prior/during: remain stopped in traffic lane	vehicle intent: remain stopped in traffic lane	driver action: stop in traffic	activity prior: stopped in Traffic	stopped in traffic
driver action prior/during: make u-turn	vehicle intent: make U-turn	driver action: U-Turn	activity prior: U-turn	U-turn
driver action prior/during: start from parked position	vehicle intent: start from parked position	NA	NA	NA
driver action prior/during: make avoiding maneuver	any of the following 4	any of the following 4	any of the following 4	avoiding maneuver
driver action prior/during: avoid vehicle parked	NA	driver action: avoid-vehicle/pedestrian	NA	NA
driver action prior/during: avoid obstacle	NA	driver action: avoid obstruction	activity prior: avoiding object	NA
driver action prior/during: avoid another vehicle [aa]	accident analysis codes: avoid another vehicle	NA	NA	NA
driver action prior/during: avoid pedestrian -	accident analysis codes: avoid pedestrian -	NA	NA	NA

unexpected action [aa]	unexpected action			
driver action prior/during: enter alley	NA	driver action: enter alley	NA	NA
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
driver action prior/during: leave alley	NA	driver action: leave alley	NA	NA
driver action prior/during: Merging	NA	driver action: merging	NA	merging
driver action prior/during: Missing	NA	driver action: missing	NA	NA
driver action prior/during: Negotiate	NA	driver action: negotiate	NA	NA
driver action prior/during: Not on road	NA	driver action: not on rd	NA	NA
driver action prior/during: Other	NA	driver action: Other	NA	other
driver action prior/during: Work on road	NA	driver action: work on road	NA	NA
driver action prior/during: unknown	NA	NA	activity prior: other	unknown
driver action prior/during: leaving traffic lane	NA	NA	NA	leaving traffic lane
driver action prior/during: stopped/wait to turn	NA	NA	NA	stopped/wait to turn
Pedestrian intent: pedestrian not in road	pedestrian intent: pedestrian not in road	NA	NA	location of pedestrian - off roadway/on trail or bikeway
Pedestrian intent: pedestrian crossing at	pedestrian intent: pedestrian crossing at	driver action: X-ing/inter	NA	location of pedestrian - on roadway/ in X-walk

intersection or in crosswalk	intersection or in crosswalk			
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
Pedestrian intent: pedestrian crossing not at intersection or in crosswalk	pedestrian intent: pedestrian crossing not at intersection or in crosswalk	NA	NA	location of pedestrian - on roadway/ not in X-walk
collision type: angle	collision type: angle	event 1: angle	collision type: angle collision	angle
collision type: backed into	collision type: backed into	event 1: backed into	NA	NA
collision type: head on	collision type: head on	event 1: head on	collision type: head on	head on
collision type: Head on Lt	NA	event 1: head on lt	NA	NA
collision type: Head-on RT	NA	event 1: head-on rt	NA	NA
collision type: other	other	event 1: other	collision type: other	other
collision type: parking maneuver	collision type: parking maneuver	NA	NA	NA
collision type: 2-Vehicle Turn	NA	event 1: 2-Veh Turn	NA	NA
collision type: rear end	collision type: rear end	event 1: rear-end	collision type: rear end	rear end
collision type: sideswipe meeting	collision type: sideswipe meeting	event 1: SS opposite	collision type: sideswipe meeting	sideswipe-opposing
collision type: sideswipe passing	collision type: sideswipe passing	event 1: SS Same	collision type: sideswipe passing	sideswipe-overtaking
collision type: Left Turn	NA	NA	collision type: left turn	NA
collision type: Right Turn	NA	NA	collision type: right turn	NA

collision type: not applicable	NA	NA	NA	not applicable
collision type: unknown	NA	NA	NA	unknown
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
first harmful event: striking or avoiding domestic or wild animal	first harmful event: collision with animal; accident analysis codes: striking or avoiding domestic animal in roadway; accident analysis codes: striking or avoiding wild animal in roadway	event 1: wild animal; event 1: domestic animal	1st harmful event: deer; moose; elk	collision with animal
first harmful event: collision with fixed object	first harmful event: collision with fixed object	NA	NA	collision with fixed object
first harmful event: collision with motor vehicle in other roadway	first harmful event: collision with motor vehicle in other roadway	NA	NA	NA
first harmful event: other vehicle in transport	first harmful event: other vehicle in transport	NA	1st harmful event: MV-MV	collision with other motor vehicle
first harmful event: other non collision	first harmful event: other non collision	event 1: other-non-co	1st harmful event: other non-collision	non-collision
first harmful event: collision with other object (not fixed)	first harmful event: collision with other object	NA	1st harmful event: other object	collision with other object
first harmful event: overturned	first harmful event: overturned	event 1: overturn	1st harmful event: overturn	NA
first harmful event:	first harmful event:	event 1: parked car	1st harmful event: Parked	collision with parked

collision with parked motor vehicle	collision with parked motor vehicle		MV	motor vehicle
first harmful event: collision with pedacycle	first harmful event: collision with pedacycle	NA	1st harmful event: pedacycle	collision with pedacycle (bicycle)
first harmful event: collision with pedestrian	first harmful event: collision with pedestrian	event 1: pedestrian	1st harmful event: pedestrian	collision with pedestrian
Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
first harmful event: collision with railway train	first harmful event: collision with railway train	NA	NA	collision with railway train
first harmful event: unknown	NA	NA	NA	collision (unknown)
first harmful event: Fell/Jump	NA	event 1: fell/jump	NA	NA
first harmful event: Ran off road	NA	event 1: ran off rd	NA	NA
first object hit: building or other structure	first object hit off roadway: building or other structure	NA	NA	NA
first object hit: cut slope	first object hit off roadway: cut slope	NA	1st harmful event: cut slope	NA
first object hit: delineator	first object hit off roadway: delineator	NA	1st harmful event: delineator post	NA
first object hit: end of drainpipe	first object hit off roadway: end of drainpipe	NA	NA	culvert end structure
first object hit: drainage structure	NA	NA	NA	drainage structure
first object hit: guardrail	NA	NA	NA	guardrail/barrier
first object hit: Guardrail face	NA	event 1: grdrl face	NA	NA

first object hit: end of guardrail	first object hit off roadway: end of guardrail	event 1: grdrl End	1st harmful event: guardrail end	NA
first object hit: guardrail along fill	first object hit off roadway: guardrail along fill	NA	1st harmful event: guardrail by fill	NA
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
first object hit: guardrail protecting overpass structure	first object hit off roadway: guardrail protecting overpass structure	NA	NA	NA
first object hit: guardrail protecting lighting or power pole	first object hit off roadway: guardrail protecting lighting or power pole	NA	NA	NA
first object hit: median guardrail	first object hit off roadway: median guardrail	NA	NA	NA
first object hit: other guardrail	first object hit off roadway: other guardrail	NA	1st harmful event: guardrail other	NA
first object hit: guardrail protecting underpass	first object hit off roadway: guardrail protecting underpass	NA	NA	NA
first object hit: guardrail protecting sign	first object hit off roadway: guardrail protecting sign	NA	NA	NA
first object hit: fence	first object hit off roadway: fence	event 1: fence	NA	NA
first object hit: fill slope	first object hit off	event 1: embankment	NA	backslope

	roadway: fill slope			
first object hit: mailbox	first object hit off roadway: mailbox	NA	NA	NA
first object hit: raised median or curb	first object hit off roadway: raised median or curb	event 1: median/barrier	NA	NA
first object hit: no object hit	first object hit off roadway: no object hit	NA	NA	not applicable
Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
first object hit: other fixed object	first object hit off roadway: other object	NA	1st harmful event: other fixed	other fixed object
first object hit: overpass railing or side of overpass	first object hit off roadway: overpass railing or side of overpass	NA	1st harmful event: bridge rail	NA
first object hit: lighting, power or signal pole	first object hit off roadway: lighting, power or signal pole	event 1: utility pole	NA	pole
first object hit: road approach	first object hit off roadway: road approach	NA	NA	NA
first object hit: rock/boulder	first object hit off roadway: rock/boulder	NA	1st harmful event: boulder/rock	boulder
first object hit: rock/stone wall	NA	NA	NA	rock/stone wall
first object hit: tree/shrub	first object hit off roadway: tree	NA	1st harmful event: shrub/tree	tree/shrub
first object hit: unknown	first object hit off roadway: unknown	NA	NA	NA
first object hit: Bridge or overpass Structure	NA	event 1: bridge/overpass	1st harmful event: bridge structure	bridge structure
first object hit: sign	first object hit off	any of the following three	any of the following three	sign

	roadway: sign			
first object hit: Overhead Sign	NA	event 1: overhead sign	NA	NA
first object hit: Stop Sign	NA	NA	1st harmful event: stop sign	NA
first object hit: Other Sign	NA	NA	1st harmful event: other sign	NA
first object hit: barricade	NA	NA	NA	barricade
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
first object hit: Ditch	NA	event 1: ditch	1st harmful event: bearm/ditch	ditch
first object hit: Curb	NA	event 1: curb	NA	NA
first object hit: Other Pole/post	NA	event 1: other pole	1st harmful event: post	NA
first object hit: snow Embankment	NA	NA	1st harmful event: snow embankment	NA
contributing circumstance: Driver under influence of alcohol or drugs	either of the following two	contributing circumstance: alc/drug use	either of the following two	either of the following two
contributing circumstance: Driver under influence of alcohol	contributing factors (driver related): had been drinking	NA	human factor: alcohol related	alcohol
contributing circumstance: Driver under influence of drugs	NA	NA	human factor: illegal drugs	drugs
contributing circumstance: Disregard Traffic control	NA	either of the following two	human factor: disregard traffic control	disregard for signs signals or markings
contributing	NA	contributing	NA	NA

circumstance: Disregard for Signal		circumstance: disregard signal		
contributing circumstance: Disregard for stop sign	NA	contributing circumstance: pass stop sign	NA	NA
contributing circumstance: Distraction	either of the following two	contributing circumstance: distraction	human factor: distraction	NA
contributing circumstance: distraction within vehicle	accident analysis codes: distraction within vehicle	NA	NA	NA
contributing circumstance: distraction outside vehicle	accident analysis codes: distraction outside vehicle	NA	NA	NA
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
circumstance: failure to yield right of way	contributing factors (driver related): failure to yield right of way	contributing circumstance: fail to yield	human factor: failure to grant ROW	failure to yield right-of-way
contributing circumstance: fail to signal	contributing factors (driver related): fail to signal	contributing circumstance: fail to signal	human factor: no/improper signal	improper signal
contributing circumstance: fell asleep	accident analysis codes: fell asleep	contributing circumstance: sleep/drowsy	human factor: fell asleep	fell asleep, fainted
contributing circumstance: exceeded posted speed limit	contributing factors (driver related): exceeded posted speed limit	contributing circumstance: exceed posted speed	NA	exceeded posted speed limit
contributing	contributing factors	contributing	human factor: unsafe	too fast for conditions

circumstance: speed too fast for conditions	(driver related): speed too fast for conditions	circumstance: too fast for conditions	speed	
contributing circumstance: Following Too Closely	NA	contributing circumstance: follow to close	human factor: following too closely	followed too closely
contributing circumstance: improper backing	contributing factors (driver related): improper backing	contributing circumstance: improper backing	human factor: unsafe backing up	improper backing
contributing circumstance: improper lane change	contributing factors (driver related): improper lane change	contributing circumstance: improper lane change	human factor: improper lane use	improper lane change
contributing circumstance: improper parking	contributing factors (driver related): improper parking	contributing circumstance: improper parking	NA	improper parking
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
contributing circumstance: improper passing	contributing factors (driver related): improper passing	contributing circumstance: improper overtake	NA	improper passing
contributing circumstance: improper turn	contributing factors (driver related): improper turn	contributing circumstance: improper turn	human factor: improper turning	made improper turn
contributing circumstance: inattentive driving	accident analysis codes: inattentive driving	contributing circumstance: inattentive	human factor: inattentive driver	failed to give full time and attention
contributing circumstance: inexperience	accident analysis codes: inexperience	NA	human factor: inexperienced driver	NA
contributing	NA	NA	no driver	NA

circumstance: No Driver				
contributing circumstance: Other	contributing factors (driver related): other	contributing circumstance: other	human factor: other	other
contributing circumstance: Pedestrian confusion	NA	NA	human factor: pedestrian confusion	NA
contributing circumstance: Unknown	NA	NA	human factor: unknown	NA
contributing circumstance: Hit and Run	NA	contributing circumstance: hit and run	NA	NA
contributing circumstance: fail to drive to right of roadway	contributing factors (driver related): fail to drive to right of roadway	contributing circumstance: left of center	NA	wrong side or wrong way
contributing circumstance: Missing	NA	contributing circumstance: missing	NA	NA
contributing circumstance: Over Corrected	NA	contributing circumstance: over correction	NA	NA
contributing circumstance: Previous Accident	NA	contributing circumstance: previous accident	NA	NA
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
contributing circumstance: Right of Center	NA	NA	NA	NA
contributing circumstance: Sick	NA	contributing circumstance: sick	NA	NA
contributing circumstance:	accident analysis codes: unwarranted slowing	contributing circumstance: too slow	NA	NA

unwarranted slowing		for traffic		
contributing circumstance: vehicle problem	NA	contributing circumstance: Vehicle defects; tire-defect	NA	NA
contributing circumstance: improper hitch	accident analysis codes: improper hitch	event 1: Sep-of-uni	NA	NA
contributing circumstance: vision obscurements	accident analysis codes: temporary vision impairment (eyes dilated for exam, patch, etc)	contributing circumstance: vision-obstruction	NA	NA
contributing circumstance: bikeway or bike route not used	accident analysis codes: bikeway or bike route not used	NA	NA	NA
contributing circumstance: blackout/heart/stroke/etc	accident analysis codes: blackout/heart/stroke/etc	NA	NA	NA
contributing circumstance: blowout	accident analysis codes: blow-out	NA	NA	NA
contributing circumstance: carbon monoxide poisoning	accident analysis codes: carbon monoxide poisoning	NA	1st harmful event: Inhale CO	NA
contributing circumstance: blinded by glaring lights other than vehicle	accident analysis codes: blinded by glaring lights other than vehicle	NA	NA	NA
(used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
contributing circumstance: jack-knife	accident analysis codes: jack-knife	event 1: jackknifed	NA	NA

contributing circumstance: load shifted	accident analysis codes: load shifted	event 1: cargo loss	NA	NA
contributing circumstance: load was too high	accident analysis codes: load too high	NA	NA	NA
contributing circumstance: load was too wide	accident analysis codes: load too wide	NA	NA	NA
contributing circumstance: failed to have vehicle under control (speed not involved)	accident analysis codes: failed to have vehicle under control (speed not involved)	NA	NA	NA
contributing circumstance: passenger released from vehicle	accident analysis codes: passenger released from vehicle	NA	NA	NA
contributing circumstance: pavement markings worn or not visible	accident analysis codes: pavement markings worn or not visible	NA	NA	NA
contributing circumstance: pedestrian not plainly visible	accident analysis codes: pedestrian not plainly visible	NA	NA	NA
contributing circumstance: temporary physical impairment (neck brace, sling, cast, etc)	accident analysis codes: temporary physical impairment (neck brace, sling, cast, etc)	NA	NA	NA
contributing circumstance: police pursuit involved	accident analysis codes: police pursuit involved	NA	activity prior: evading police	NA

Generic Code Description (used for this project)	Montana Code Description	Idaho Code Description	Wyoming Code Description	Yellowstone National Park Code Description
contributing circumstance: road was icy or slippery	accident analysis codes: road slippery or icy	NA	NA	NA
contributing circumstance: glare from sun	accident analysis codes: sun glare	NA	NA	NA
contributing circumstance: water on roadway	accident analysis codes: water on roadway	NA	NA	NA
contributing circumstance: whiteout	accident analysis codes: whiteout	NA	NA	NA
contributing circumstance: whiteout - meeting or following vehicle	accident analysis codes: whiteout -meeting or following vehicle	NA	NA	NA
contributing circumstance: careless driving	contributing factors (driver related): careless driving	NA	NA	NA
contributing circumstance: no apparent violation	contributing factors (driver related): no apparent violation	NA	human factor: no violations	no violation
contributing circumstance: reckless driving	contributing factors (driver related): reckless driving	NA	NA	NA
contributing circumstance: vehicle fire	contributing factors (driver related): vehicle fire	event 1: fire	1st harmful event: explosion/fire	NA

APPENDIX B - DATA REQUEST SURVEY

The three state departments of transportation and Yellowstone National Park provided a majority of the data collected and analyzed. Data was initially requested by mailing the following questionnaire.

Agency Name: ____

Contact Person: ____

Phone Number: ____

TRAFFIC DATA AND INFORMATION
Do you have an inventory of roadway characteristics in your area? (volumes, vehicle classification, travel times, Origin-Destination (O/D) surveys etc.) Please supply or attach.

____
____
____
____

Inventory of Inter Regional Travel Corridors
Please list the primary route(s) which serve as "through routes" in your area.

____
____
____
____

Please provide the number and location of rest areas your organization is responsible for. (provide map if it is more convenient)

____
____
____
____

Please provide the number and location of maintenance locations your organization operates. (provide map if it is more convenient)

____
____
____
____

VISITOR CHARACTERISTICS
Do you have information on visitors or tourists who visit your area (group size, age, time spent, origin, number of visits, method traveler learned of your establishment, transportation information utilized, median income, average $ spent on trip, etc.)? If yes please supply or attach.

____
____
____
____

How much money has your agency spent collecting and analyzing this information in the last year? (Estimate only, may be applicable to local match.)

____
____
____
____

If the information requested above is the responsibility of another agency, please supply agency name and contact person.

____
____
____
____

EXISTING AND PLANNED SYSTEMS
Before each question, please indicate if the system is existing or planned by circling the correct word in the parenthesis.

Safety and Hazardous Warning (Please circle - Existing or Planned)
How does your agency learn of unsafe travel conditions?________________________
____
____

How do you inform the traveling public of unsafe or potentially hazardous driving conditions (weather, traveling at excessive speed for conditions, etc.)?____________________________
____
____

Where are these information devices located? (please provide mile post, geographic location, or a map)

____
____
____
____

Traffic Management
Where do you have permanent count stations? (Please provide mile post, geographic location or a map)

A. How do you communicate with the count location(s)? (fiber optics, download from portable collector, modem, radio, custom software, etc.)
____
____
______

B. Is there a central control system for the count stations? Please describe.
____
____
______

C. Are there any other surveillance/data collections systems (not mentioned above) that are in your area (detectors, weather sensors, cellular call-in, etc.)?
____
____
______

D. What other ITS activities/programs exist or are underway in your jurisdiction/area? Please describe.
____
____
______

Traveler Information
Variable Message Signs (VMS). If you operate VMS please answer questions A-H, if not move on to the next section (HAR). (Please circle - Existing or Planned)

Where do you have (or plan to have) VMS? (Please provide milepost, geographic location or a map.)

____

A. How many of the VMS are: portable ___________ or fixed installations _____________?

B. How do you communicate with the sign(s)? (fiber optics, modem, radio, etc.)
____
____
______

C. How is the sign controlled and from what location? (P.C., mini computer etc.)
____

____
______

D. What software or management system is used to control the device? ____________________
____
______

E. How many messages can be generated or stored? ___________________________________
____
______

F. What is the standard message library? (Please provide a copy.) ________________________
____
______

G. What is the primary purpose and message associated with each VMS? _________________
____
______

H. What is the secondary use? ____
____
______

Highway Advisory Radio (HAR). If you operate HAR please answer A-J, if not ignore A-J. (Please circle - Existing or Planned)

Where do you have HAR systems? (Please provide milepost, geographic location or a map.)
____

A. How many HAR do you operate? ____
____
______

B. How do you communicate to the HAR(s)? (fiber optics, modem, radio, etc.) _____________
____
______

C. How are the HAR(s) controlled? (telephone, control unit, computer, etc.) _______________
____
______

D. How many messages can be generated or stored? ____________________________________
____
______

E. What is the primary purpose and message associated with each HAR? __________________
____
______

F. How do you inform the public about the existence of the HAR system or presence of a current message being broadcast? ____
____
______

G. What are the prerecorded messages? (Please provide a list.) ___________________________
____
______

I. What is the output power and range of the system? ____________________________________
____
______

J. How is the system powered? (AC, solar, etc.) ____________________________________
____
______

Other Methods of Informing Travelers (Please circle - Existing or Planned)________________
____

What other methods are used to provide the traveler with important traffic information? (Please provide milepost, geographic location or a map if applicable.)?____
____

A. How is the information updated? ____
____
______

B. How is the system controlled and managed? ________________________________
____
______

C. What type of information is sent by this system (standard messages)? ______________
____
______

How do you find out about road conditions at each of the above locations (VMS, HAR, etc.)?
____
______
____
______

Emergency Response
What is the typical emergency response time? ____
Accident to Emergency Services Notification:____
Notification to Emergency Services arrival on the scene: ______________________________
Arrival at scene to Arrival at medical or other facility: _______________________________

Commercial Vehicles (CVO)
On your main through routes, how many CVO's are there and what are the routes? ___________
____
______

How are the weight and safety requirements monitored?__________________________________
____
______

Public Transportation
Is there an operating public transit system in your area? If yes please provide the following information:

A. Name: ____
B. Who operates and controls this system? ________________________________
C. What type of system is it? (fixed route, demand responsive, etc.) _________________
D. What is its area of coverage? ____
E. What are its characteristics? (headways, routes, etc.) __________________________
____
______
F. What are, if any, the plans for improvements or upgrades to this system? ___________
____
______

Fleet Management

A. How many vehicles are in your fleet? ______________________________________
B. Describe the system used for communication with the vehicles __________________
____
______

C. Is any system used to automate vehicle dispatch (i.e., computer aided dispatch)? ____
____
______

Communications Infrastructure
What communications infrastructure, not mentioned above, does your organization manage or utilize?
____
____

TRANSPORTATION IMPROVEMENT NEEDS
Inventory of the Transportation Operational Deficiencies
Please list the transportation system or corridor deficiencies in your jurisdictions. These would consist of items such as congested corridors, access constraints, lack of transit service, high accident areas and signal coordination. ______________________________
____
____
____

Inventory of the Institutional Opportunities and Barriers
Please list (if any) institutional barriers or opportunities that you are aware of that might impede or improve coordination and cooperation between the coalition members. ____________
____
____
____

How do you coordinate transportation information sharing and incident management with other jurisdictions?____
____
____
____

What regional transportation management groups do you belong to? ______________
____
____
____

Are there traffic-reporting services that you interact with regularly regarding traffic information?
____
____
____

Inventory of Stakeholders:
Stakeholders are individuals, groups or institutions who have a direct "stake" or primary interest in the improvement of the transportation system in the study area. Please give the name and

address of any major stakeholders in your jurisdiction that should be considered for inclusion in the planning process. (Use additional sheets if necessary.)

Large Employers
____
____
_____

Transit Providers
____
____
_____

Tourist Attractions
____
____
_____

Freight Operators
____
____
_____

Military Institutions
____
____
_____

Major Activity Centers
____
____
_____

Special Event Centers
____
____
_____

Other
____
____
_____

Modal Transfer Locations within Your Jurisdiction
Please list (if any) modal transfer points located in your jurisdiction. This would include items such as airports, bus stations, rail stations, and park-n-ride lots. ____________________________
____
____
____

What (if anything) is prohibiting modal transfers (or use of other modes)? __________________
____
____
____

Are there currently any plans to improve the modal transfer system?
____
____
______
____
______

Have there been any ITS (or similar) studies in your area (if yes please provide title and author)?
____
______
____
______