Identification and Evaluation of the Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion

Added Work Related to Weather Events

SHRP 2 Project L07
MRI Project 110622

AMPLIFIED WORK PLAN FOR ADDED SCOPE OF WORK

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Prepared for

Strategic Highway Research Program (SHRP 2)
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by

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Preface

This amplified work plan summarizes the approach of the research team to accomplish the expanded scope, which will address nonrecurrent congestion caused by snow and ice and other weather-related events, in SHRP 2 Project L07, “Identification and Evaluation of the Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion.” This plan describes the activities that will be added to MRI’s original work plan, submitted in February 2008, to implement MRI’s proposal to SHRP 2 for the added work, dated July 11, 2008.

The expanded scope will not affect the project period of performance, which is scheduled for completion by January 6, 2012.

The research team would appreciate any comments on this amplified work plan from SHRP 2.

Sincerely,

MIDWEST RESEARCH INSTITUTE

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Section 1.
Research Plan

This section presents a plan to conduct research on roadway design features to improve travel time reliability and reduce delays due to nonrecurrent congestion caused by snow and ice and other weather-related events. This amplified work plan addresses the new activities to be performed in SHRP 2 Project L07 to implement the expansion of the project scope to include nonrecurrent congestion caused by weather events.

1.1 Introduction

Congress created the second Strategic Highway Research Program (SHRP 2) to perform targeted, short-term research to address the challenges of moving people and goods efficiently and safely in four areas: Safety, Renewal, Reliability, and Capacity. SHRP 2 is managed by the Transportation Research Board (TRB) in a manner similar to TRB’s Cooperative Research Programs, and following the example of the original SHRP program that was conducted between 1987 and 1992. SHRP 2 will operate for a 7-year period and, during that period, conduct a planned and coordinated program of research.

The Reliability area of the SHRP 2 program focuses on the need to increase travel time reliability. Congestion and consequent delay to motorists result from both recurrent and nonrecurrent congestion. Recurrent congestion occurs on a daily basis and typically results from inadequate base capacity of the highway system. If motorists encountered only recurrent congestion that varied in predictable daily patterns, they might consider that the highway system provided poor quality of service at some times of day, but at least the level of congestion would be consistent and anticipated travel times would be reliable. The presence of nonrecurrent congestion, which varies from day to day and one incident to the next, creates unreliable travel times which can frustrate motorists. It is difficult for individuals and businesses to use their time efficiently if they are uncertain whether a given trip will take one hour or three hours.

Unreliable travel times are inconvenient and costly to individuals in both commuting and recreational trips due to wasted time, productivity, and fuel, and are a critical issue for efficient goods movement. Many industries have developed business models based on “just-in-time” deliveries, but where travel times vary substantially the deliveries may not always arrive “just in time.” Deliveries delayed due to congestion slow the production or sale of goods, with significant economic effects.

The key sources of nonrecurrent congestion (not related to inadequate base capacity and leading to unreliable travel times) are:

- Traffic incidents
- Work zones
- Demand fluctuations
- Special events
- Traffic control devices
- Weather

The initial focus of Project L07 was on the first five sources of nonrecurrent congestion, and weather was to be addressed in other research programs.

In the Fall 2007, the Reliability TCC reviewed the Reliability program and reconsidered the original scope of Project L07, in particular the exclusion of issues related to snow and ice and other weather-related events. Since these impacts are significant and have a direct operational effect on a major portion of the freeway and arterial network across the country, the Reliability TCC determined that they should be considered as part of Project L07.

Freeways and major arterials located in regions that are subjected to winter weather conditions require special design attention due to the potential negative effects of snow and ice on travel time reliability, as well as safety. Design elements can influence the impacts of weather on the surface transportation network. Design considerations can lessen or mitigate primary and secondary impacts from weather events. In addition, some design elements, including ITS and other technologies, can greatly aid in the provision of both proactive and reactive winter services.

Weather in the form of snow, rain, runoff, wind, and fog are major contributors to nonrecurrent congestion. A single weather event may impact reliability over many days through the transition of the event from one type to another. For example, a primary event could be the snowstorm with its nonrecurrent congestion impacts. Before the snow has a chance to melt, wind can create subsequent low visibility and/or drifting snow events with associated nonrecurrent congestion. Without adequate snow storage, or where physical barriers prevent adequate clean-up after a snow event, daytime melting and runoff can cause water-on-road or icing conditions during night-time hours once again contributing to nonrecurrent congestion.

The scope of SHRP2 Project L07 will be expanded to address the role of highway design treatments to reduce nonrecurrent congestion caused by snow and ice and other weather-related events. Highway agencies need better guidance on the design of such treatments, their advantages and disadvantages, and, to the extent such information is available or can be developed, quantitative estimates of their effectiveness. This amplified work plan presents a carefully considered approach to assembling this information and presenting it in a well organized and easily accessible design guidebook for application by highway agencies.
1.2 Research Objectives and Scope

The overall objectives of SHRP 2 Project L07 are to (1) identify the full range of possible roadway design features used by transportation agencies on freeways and major arterials to improve travel time reliability and reduce delays due to key causes of nonrecurrent congestion, (2) assess their costs and operational and safety effectiveness, and (3) provide recommendations for their use and eventual incorporation into appropriate design guides. The objective of the added work is to develop guidance for highway design features to reduce nonrecurrent congestion related to snow and ice and other weather-related events within the framework of the existing SHRP 2 Project L07. Each phase and task of the existing project will be expanded to include consideration of highway design features that can help highway agencies minimize the extent of nonrecurring congestion caused by snow-and-ice events. The research will also address any highway design features that are found to assist highway agencies in responding to other weather-related events such as blowing or drifting sand, flooding, high winds, low visibility, and weather-related evacuations. Snow-and-ice events will be the primary focus of the added work; other weather-related events will also be considered, but with a lower priority. Application of new technologies, including Road Weather Information Systems (RWIS) and Intelligent Transportation Systems (ITS) technologies, will be considered where these technologies would enhance the effectiveness of the highway design features during snow and ice and other weather-related events.

The primary product of the existing Project L07 will be a design guidebook for application by highway agencies in reducing the effects of nonrecurring congestion. The added work will extend the scope of this design guidebook to include design treatments to mitigate the effects on nonrecurring congestion of snow and ice and other weather-related events. Design treatments, by themselves, cannot eliminate or reduce the duration of winter storms. However, most of the design treatments to be considered will support highway agencies in responding quickly and effectively to winter storms, which will assist in limiting the time period following storms when roadways are covered with snow and ice. Since snow-and-ice-covered pavements contribute to slower speeds and weather-related incidents, quickly cleared pavements can minimize the impact of weather events on nonrecurrent congestion. Design treatments, such as fences, living barriers, or other physical obstacles, can help minimize the occurrence of low visibility conditions and snow-and-ice-covered pavements associated with blowing and drifting snow during or after a storm. The design guidebook will not only include design guidance on application of these treatments but will also be as quantitative as possible in estimating their traffic operational and safety effects. The design guidebook will also provide design guidance for treatments to reduce nonrecurrent congestion due to weather-related events not involving snow and ice, but will not necessarily provide quantitative traffic operational and safety effectiveness estimates for such treatments.

In weather-related emergencies, such as hurricanes, when evacuations must be conducted, the objective should be to complete the evacuation as quickly and efficiently as possible. This is a different goal than reducing nonrecurrent congestion, but the overall need to maintain efficient traffic operations remains the same, and many of the same
design treatments are applicable both to reducing nonrecurrent congestion and facilitating emergency evacuations. Conversion of two-way roadways to one-way operation is often an element of evacuation planning. Much of the guidance developed in Project L07 for dealing with nonrecurrent congestion is directly applicable to traffic operations in the normal direction of travel and indirectly applicable to traffic operations in the reverse of the normal direction of travel on roadways during emergency evacuations. Design guidance to make such conversions to reverse operations easier for highway agencies to implement and to move traffic in the reverse direction as efficiently as possible should be included in the design guidebook to be developed in Project L07.

The following sections describe the activities to be conducted in each phase and task of the added work.

1.3 Phase I—Data and Information Gathering on Existing and Candidate Design Features

The overall objective of Phase I is to document existing knowledge and design practice; identify, classify, and make a preliminary assessment of the design treatments to be considered in the research; and develop work plans for the evaluations to be conducted in Phase II. The scope of Phase I will be expanded to include treatments that address nonrecurrent congestion caused by snow and ice and other weather-related events. The expanded scope will be considered in each of the four existing tasks in Phase I: Task I-1 (Identify State of Design Practice); Task I-2 (Document Agency Experience with Treatments); Task I-3 (Develop Preliminary Assessment of Treatments); and Task I-4 (Reporting). Each of these tasks is discussed below.

1.3.1 Task I-1—Identify State of Reliability-Related Design Practice

The objective of Task I-1 is to identify the state of reliability-related design practice by gathering and synthesizing information on existing and promising design features capable of reducing delays due to key causes of nonrecurrent congestion. While weather was not initially included as one of the causes of nonrecurrent congestion to be considered in Project L07, the scope of the research will be expanded to include attention to weather-related treatments, with emphasis on treatments specifically related to snow-and-ice conditions that have the potential to reduce nonrecurrent congestion. The key activities in this task related to design treatments will be to identify and catalog:

- Objectives of design treatments in use or contemplated
- Types of design treatments in use or contemplated
- U.S. highway agency experience with treatments
- International highway agency experience with treatments
As noted in the earlier discussion of the scope of the added work, the term treatments in this context will specifically include new technology, such as RWIS and ITS, that may enhance the effectiveness of design treatments.

**Objectives of Treatments in Use or Contemplated**

Task I-1 will involve the development of a classification system for treatments based on their objectives. The objectives of treatments to address nonrecurrent congestion caused by snow and ice and other weather-related events are expected to be similar to the objectives of other treatments considered in the research, but it is likely that new objectives will be identified in the expanded scope. Objectives identified in Task I-1 may include:

- Reduce duration of congestion associated with snow-and-ice-covered roadways or limited visibility following winter storms
- Reduce duration of congestion associated with other weather-related events
- Provide faster arrival of maintenance vehicles and materials for roadway treatment
- Minimize extent of blowing and drifting snow on the roadway
- Maintain roadway capacity despite adverse weather
- Reduce potential for secondary incidents
- Provide better information to motorists concerning pavement surface conditions
- Provide better information to motorists regarding weather-related incidents and alternate routes
- Increase efficiency of emergency evacuations associated with weather-related events

**Types of Treatments in Use or Contemplated**

A key step in developing a treatment classification system will be to identify specific treatments for consideration. The classification system currently under development in Phase I will be expanded to include treatments that address nonrecurrent congestion caused by snow and ice events. At a lower priority, treatments that address nonrecurrent congestion caused by other weather-related events will also be considered. Potential design-related treatments for addressing nonrecurrent congestion that will be considered include:

- Provide fences or living barriers to control blowing and drifting snow (or sand)
- Utilize barriers, topography, and other physical features to control blowing and drifting snow (or sand)
- Provide snow storage areas within the highway right of way
• Improve access for maintenance vehicles to potential snow storage areas (e.g., remove or provide access around physical obstacles such as guardrail or concrete barriers)

• Divert meltwater from snow storage areas away from the traveled way or provide overflow areas to avoid water flow across the traveled way or refreezing of water on the traveled way

• Provide storm water discharge mitigation to avoid flooding or water flow across the traveled way

• Design drainage ditches to function effectively even when covered with snow and ice

• Provide accommodation for maintenance vehicle and materials staging for snow removal (or flood response) near the roadway without reducing highway capacity

• Provide weather-oriented traffic control devices (signs and other warnings) that can be operated effectively without contributing to nonrecurrent congestion

• Utilize RWIS to provide information to traffic managers (as well as highway maintenance managers) so that warnings can be provided to motorists about high winds, low visibility, and other weather-related events

• Utilize dynamic signal timing to mitigate reduction in highway capacity during weather events

• Utilize dynamic message signs to provide warnings and other information to motorists for routing options during weather events

• Provide reversible lanes for emergency evacuation related to weather events

• Provide roadway design features to facilitate operation of normal lanes in the reverse direction for emergency evacuation related to weather events

This list will be refined and expanded in Tasks I-1 and I-2 based on the literature review, highway agency practice and experience, and research team assessments. A prioritized list of candidate treatments will be presented in the Phase I interim report for consideration by SHRP 2.

**Literature Review**

To refine the list of objectives and treatments, and to begin the assembly of treatment effectiveness data, the research team will conduct a review of completed and ongoing research and technical articles to identify practices, policies, and other key information on the use of design features to address nonrecurrent congestion caused by snow and ice.

Topics to be addressed in the literature review will include:
Weather-related causes of nonrecurrent congestion, including snow-and-ice events (blowing and drifting snow, snow melt and refreezing, and snow storage) and other weather-related events (blowing and drifting sand, flooding, high winds, low visibility, and weather-related evacuations) that contribute to or increase the likelihood of nonrecurrent congestion

Existing treatments used to reduce nonrecurrent congestion caused by snow and ice or other weather-related events, including both geometric design treatments and operational treatments that may be aided by geometric design considerations

Capacity impacts and delay from winter storms and from snow storage and removal activities

Pre-congestion planning for expected winter weather conditions, including designation of alternate routes and geometric design considerations

Use of drift control measures to control blowing and drifting snow (or sand)

Impact of fences, barriers, and topography on blowing and drifting snow (or sand)

Strategies for removing snow from a facility or storing it along the right of way

Storm water discharge mitigations

Treatments to improve access to potential snow storage areas within the right of way

Accommodations for maintenance vehicle and materials staging for snow removal or response to other weather-related events

RWIS operations, with emphasis on traffic management applications, as opposed to maintenance management applications

Dynamic signal timing during weather-related events

Dynamic message signs to provide warnings and other information to motorists for routing options during weather-related events

Highway design treatments for emergency evacuation including provision of reversible lanes or facilitating the operation of normal lanes in the reverse direction

The literature review will specifically include relevant research from the first SHRP program, research conducted in the Snow and Ice Pooled-Fund Cooperative Program (SICOP), and research performed for NCHRP and individual state highway agencies. For example, work by MRI in SHRP Project H-208, “Evaluation of Anti-Icing Technology” (1) provides a good model for safety and benefit-cost analysis of winter maintenance treatments. Research in NCHRP Project 20-7(147) and its predecessor SHRP project provides useful results on design treatments for blowing and drifting snow (2,3).
Highway Agency Experience with Design Treatments

In Task I-1, the research team will begin the process of obtaining information from highway agencies regarding treatments to address nonrecurrent congestion caused by snow and ice and other weather-related events. The types of information we will be seeking include:

- Design policies and guidelines
- Traffic operational effectiveness
- Safety effectiveness
- Costs—all components of life-cycle costs including construction, maintenance, and/or operating costs
- Application criteria (when and where treatments should be used)
- Perceived advantages and disadvantages
- Ongoing traffic incident management and other programs that may relate to geometric design

At this stage of the project, we will stress the acquisition of existing information and current practices from highway agencies. Organized acquisition of expert opinion and guidance will come through the workshop planned in Phase II.

A tentative list of states that will be contacted in Task I-1 for information concerning snow-and-ice-related treatments includes Alaska, Colorado, Idaho, Iowa, Maine, Massachusetts, Michigan, Minnesota, Montana, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Utah, Washington, Wisconsin, and Wyoming. This list includes states with experience in dealing with extreme winter weather as well as large states with major metropolitan areas that regularly experience winter storms. In addition, we will contact states that are experienced in dealing with blowing and drifting sand or weather-related evacuations including desert, south Atlantic coast, and Gulf coast states.

Initial contacts with individual highway agencies will be by e-mail. The primary purpose of the e-mails will be to arrange telephone interviews with knowledgeable engineers in each agency.

International Experience with Design Treatments

The research team will also document international experience with design treatments to reduce nonrecurrent congestion caused by snow and ice or other weather-related events.
Assemble Results

The results of Task I-1 will be assembled for inclusion in the Phase I interim report to be prepared in Task I-4.

1.3.2 Task I-2—Document Highway Agency Experience with Design Alternatives

The objective of Task I-2 is to gather details and insights about design treatments identified in Task I-1 and about highway agency experience with and insights into those treatments. The types of treatments will include those that address nonrecurring congestion caused by snow and ice.

We anticipate that most of the information obtained from highway agencies will be gathered through extensive telephone interviews and e-mail contacts. However, during the four focus groups that are already being planned as part of the original scope for Project L07, we will include in the agenda a discussion of issues related to nonrecurring congestion caused by snow and ice and other weather-related events. A workshop with highway agencies to address design treatments related to snow and ice in more detail is planned for the Summer of 2009 in Task II-1 (see below).

1.3.3 Task I-3—Develop Preliminary Assessment of Design Alternatives

The objective of Task I-3 is to develop a preliminary assessment for a set of design treatments that appear to be most promising for inclusion in the Phase III design guidebook. The list of treatments to be assessed in this task will include treatments that address nonrecurring congestion caused by snow and ice and other weather-related events.

The research team will identify factors to be considered in the assessment and to help with the development of the final list of design treatments. We expect that the candidate factors to be used in the assessment will include the same factors identified in the original Project L07 work plan, but we will consider additional factors that may be unique to weather-related treatments.

Each design treatment on the list will be assessed in accordance with a formal assessment methodology that will be developed in preliminary form in Task I-3 and refined throughout the project.

1.3.4 Task I-4—Prepare Phase I Interim Report

The objective of Task I-4 is to prepare a Phase I interim report that describes the information gathered, the analysis methodology, the results of the preliminary
assessment, and detailed work plans for Phase II. The scope of the interim report already planned for preparation in Task I-4, including the Phase II work plan, will be expanded to include treatments that address nonrecurring congestion caused by snow and ice and other weather-related events. In particular, the Phase II work plan will address in detail the data collection and analysis of data activities needed to assess weather-related treatments.

1.4 Phase II—Assessment of Design Measures

The overall objective of Phase II is to assess design treatments for reduction of nonrecurrent congestion. The scope of this objective will be expanded to include treatments that address nonrecurrent congestion caused by snow and ice and other weather-related events. The expanded scope will be considered in each of the three tasks in Phase II: Task II-1 (Data Collection), Task II-2 (Data Analysis), and Task II-3 (Reporting). Each of these tasks is discussed below.

1.4.1 Task II-1—Execute Approved Data Collection Plan

The objective of Task II-1 is to execute the data collection plan developed and approved in Phase I. The list of treatments to be evaluated will include treatments that address nonrecurrent congestion caused by snow and ice and other weather-related events.

Review List of Treatments to be Evaluated

The first step in Task II-1 will be to review the list of design treatments to be evaluated in Phase II. For each design treatment identified in the Phase I interim report as in need of evaluation, the list of treatments will identify the type of evaluation that is needed. Based on the preliminary assessment of treatments in the Phase I interim report, treatments may need a traffic operational evaluation, a safety evaluation, or both.

Conduct Workshop with Highway Agencies

Design treatments to mitigate nonrecurrent congestion related to snow-and-ice events constitute a special area of interest within the overall framework of Project L07. The development of design guidance in this specialized area will need to tap a unique set of expertise within state highway agencies that differs from the expertise needed for the rest of Project L07. In Task I-2, we will be holding a series of focus groups with individual highway agencies that will look across the full range of issues in the existing scope of Project L07. In Task II-1, we plan to invite design and winter maintenance professionals from five or six highway agencies to come together to help the research team assemble existing knowledge, develop design guidance, and identify what still needs to be learned about design treatments to reduce nonrecurrent congestion caused by snow and ice. Meetings involving winter maintenance personnel are easiest to schedule during the
summer months. We suggest that this workshop be held during the Summer of 2009. We have budgeted to hold the workshop in Kansas City, which is centrally located, but, if a specific benefit for the workshop were identified, it could be held in one of the participating states.

Issues discussed in the workshop may include:

- What design treatments have been used in your region to reduce nonrecurrent congestion caused by snow and ice events?
- What information is available about the traffic operational effectiveness, safety effectiveness, and cost of these treatments?
- What difficulties and challenges have you encountered in implementing these treatments?
- What treatments that have not been tried in your region do you consider promising?
- What treatments for which traffic operational or safety effectiveness evaluations have not been conducted do you consider to be the highest priority for evaluation? A rating form may be developed to be completed by individuals and then tabulated and discussed with the group.
- What factors other than traffic operational effectiveness, traffic safety effectiveness, and life-cycle cost do you believe should drive the treatment selection decisionmaking process?
- What tools are needed to enable a rational treatment selection decision making process?

A memorandum will be prepared documenting the results of the workshop.

**Collect Data for Traffic Operational Effectiveness Evaluation**

Most of the design treatments under consideration for snow and ice conditions are anticipated to be effective in reducing nonrecurring congestion by reducing the duration of time when snow-and-ice conditions are present on the roadway, particularly following the end of a storm. If the reduction in the duration of snow-and-ice conditions for a particular treatment can be estimated, this information can be used with the relationships developed in Project L03 and other traffic operational data obtained in Project L07 to estimate the traffic operational effectiveness of the treatment. Therefore, the data collected in Task II-1 will be oriented toward determining the effectiveness of specific treatments in reducing the duration of snow-and-ice conditions. Research approaches that will be considered as candidates for assessment of specific design treatments include:

- Determine highway agency experience with treatments, including specific experience documented by the research team in Phase I and experience documented in case studies (see below).
• Collect data to conduct formal comparisons of traffic operational conditions in highway corridors with and without the treatment during and immediately after winter storms. The ideal situation for such comparisons would be to locate corridors with and without the treatment in the same metropolitan area (and, thus, subject to the same winter weather). Highway agency data would be needed to document that the corridors receive the same winter maintenance priority level, maintenance strategy, and maintenance cycle time, or to document any differences in maintenance priority, strategy, and cycle time. It would also be desirable if RWIS data and automated traffic data were available for the corridors.

• Perform traffic operational simulation modeling to estimate the traffic operational benefit of reducing the duration of periods during which pavements are snow-and-ice covered or visibility is limited due to blowing snow. Given estimates of the duration of snow-and-ice or blowing snow conditions and estimates of the effects of these conditions on traffic speeds, traffic simulation models can be used to quantify the effect of the conditions on nonrecurring congestion and the traffic operational benefits of reducing the duration of such conditions.

A key issue that will need to be addressed in the traffic operational effectiveness evaluation is that traffic volumes are often reduced during and in the immediate aftermath of winter storms. The impact of nonrecurrent congestion associated with winter storms may be reduced because planned trips by some motorists are not taken. While design treatments (with the possible exception of treatments for blowing snow) may not have much direct impact on deferred trips during the active storm period, restoration of the roadway to normal operations as quickly as possible after the storm will help to minimize nonrecurrent congestion for trips that are made and reduce the likelihood of trips being deferred. Investigation of traffic volume (i.e., travel demand) variations from normal levels during and after winter storm periods is clearly needed as part of the traffic operational evaluation.

Traffic operational effectiveness measures for treatments involving other weather-related events, such as blowing or drifting sand, may not be readily obtained. For such treatments, it may be sufficient to supply design guidance to assist highway agencies in applying treatments found to be effective for addressing blowing and drifting snow.

In weather-related emergencies, such as hurricanes, when evacuations must be conducted, the objective should be to complete the evacuation as quickly and efficiently as possible. Conversion of two-way roadways to one-way operation is often an element of evacuation planning. Much of the guidance developed in Project L07 for dealing with nonrecurrent congestion is directly applicable to traffic operations in the normal direction of travel and indirectly applicable to traffic operations in the reverse of the normal direction of travel on roadways during emergency evacuations. Design guidance to make such conversions to reverse operations easier for highway agencies to implement and to move traffic in the reverse direction as efficiently as possible should be included in the design guidebook to be developed in Project L07.
Collect Data for Safety Effectiveness Evaluation

The safety effectiveness of design treatments to reduce the duration of snow-and-ice conditions following a storm is a function of differences in crash rates by pavement surface condition. In SHRP Project H-208, “Development of Anti-Icing Technology,” MRI found that anti-icing strategies were effective in reducing the duration of snow-and-ice-covered pavements (1). It was also estimated in Project H-208 that crash rates for snow-and-ice-covered pavements were eight times higher than for dry pavements and two times higher than for wet pavements. Together, the reduction in duration of snow-and-ice-covered pavements and the difference in crash rates were used as a basis for a benefit-cost assessment of anti-icing strategies. The same approach is potentially applicable to design treatments whose effect on the duration of snow-and-ice-covered pavements can be estimated. The reduced crash rates associated with reduced duration of snow-and-ice-covered pavements is analogous to the reduction in secondary incidents that can be expected from other treatments to reduce nonrecurring congestion.

Safety estimates for design treatments for blowing or drifting snow will be based on research and on the experience of highway agencies that have dealt with that issue. For example, research by Tabler has found that, on Interstate Route 80 in Wyoming, up to 25 percent of all crashes occurred during blowing snow in areas without snow fences, compared to 11 percent in areas with snow fences (2). Similar experiences for highway agencies that have dealt with blowing and drifting sand will be sought. We do not expect to develop quantitative safety performance estimates for emergency evacuation scenarios; rather, for emergency evacuations, the emphasis in Project L07 will be on providing appropriate design guidance.

Obtain Detailed Cost Data for Implemented Projects

In Task II-1, we will obtain detailed cost data from highway agencies for implemented projects for all of the design treatments that have actually been implemented; this will include treatments that address delay caused by snow and ice and other weather-related events.

Assemble Project Data Base

All of the information gathered in Task II-1 will be assembled into a project database for analysis in Task II-2. The database will include information related to treatments that address delay caused by snow and ice.

1.4.2 Task II-2—Execute Approved Data Analysis Plan

The objective of Task II-2 is to execute the approved data analysis plan developed and approved in Phase I. The data analysis plan will identify the types of analyses to be performed and a suggested list of design treatments for which case studies will be performed in Task II-2. The scope of this task will be expanded to include treatments that
address delay caused by snow and ice. The activities in this task will include traffic operational evaluations, traffic safety evaluations, cost estimation, and case studies. The preliminary assessment methodology for design treatments developed in Phase I will be refined in Task II-2 and the updated methodology will be applied to each of the design treatments of interest.

**Perform Traffic Operational Evaluations**

A variety of traffic operational analysis methods will be considered for each design treatment depending on the type of treatment, the data available, and the performance measures selected for that treatment. As noted in the discussion of Task II-1, the traffic operational evaluations performed in Task II-2 may include review of highway agency experience with specific treatments, comparison of traffic operational conditions in corridors with and without specific treatments, or analysis of traffic operational simulation results with and without specific treatments.

**Perform Traffic Safety Evaluations**

As noted in the discussion of Task II-1, the traffic safety analyses in Task II-2 will most likely be based on estimates of the relative traffic safety performance of roadways under varying pavement surface conditions, as was done for SHRP Project H-208.

**Other Evaluation Types**

The Phase I interim report will indicate whether evaluation types other than traffic operational, safety, and cost evaluations need to be conducted in Phase II.

**Perform Cost Analyses and Conduct Life-Cycle Cost Evaluation**

A life-cycle cost analysis will be performed for every design treatment for which reliable effectiveness and cost data are available using a refinement of the approach applied in Phase I.

**Develop Case Studies**

As in the existing scope of Project L07, the research team proposes to use case studies to illustrate actual highway agency experiences and the potential applicability of specific design treatments. Case studies will be particularly appropriate for treatments that have been used only in limited situations and for which the case study site(s) may represent the most complete information available about the treatment. Two types of case studies will be considered:

- Review of implemented projects with a description of the project site, conditions existing before the project, the design treatment selected, comparison of traffic operational and safety performance measures before and after the project,
application of the assessment methodology as refined in this task (see below),
and lessons learned for future design guidance.

- Development of preliminary designs for typical projects, which will be
  considered particularly where implemented projects are not available to serve as
  case studies. Preliminary design activities would be undertaken by HDR
  Engineering and would help to develop guidelines where previous highway
design experience is not available or not generalizable. We will look for
opportunities to use actual projects that HDR Engineering has under design for
highway agencies as case studies of this type. This approach will also be very
appropriate for developing cost estimates where none are available.

The specific mix of these two approaches to case studies will be determined as part of the
research. For each case study for an implemented project, the research team will collect
additional available data from the participating agency, including as-built plans,
topographic data, and other site conditions. For projects in which preliminary design
activities are undertaken, it is not our intent to develop detailed design plans, but rather to
develop concepts for each specific site that generally account for site conditions and
address the nonrecurrent congestion issues present at the site. The plans will depict
improvements at a plan-view level, with design details (e.g., barrier dimensions,
pavement section, or roadside design) developed only to the extent appropriate. The
preliminary designs will be used to illustrate the design guidebook to be developed in
Task III-1, and will also be provided to the participating agencies for their consideration
as candidate projects. Whether ultimately implemented or not, the designs (and the effort
underlying them) will be used as “lessons learned” tools.

**Apply Assessment Methodology**

The research team will refine the assessment methodology developed in Phase I and
apply it to the full set of design treatments, including snow and ice treatments, and the
full range of site conditions of interest.

**Assemble Results**

The results of Task II-2 will be assembled for inclusion in the Phase II interim report
to be prepared in Task II-3.

**1.4.3 Task II-3—Prepare Phase II Interim Report**

The objective of this task is to prepare a Phase II interim report that describes the
data collection and analysis activities, presents the data analysis results, presents an
outline of the final report, presents an annotated outline of the design guidebook,
identifies in summary form the key geometric design guidelines that will be presented in
the guidebook, and presents detailed work plans for Phase III.
The Phase II interim report will document the results of Tasks II-1 and II-2. The scope of the Phase II interim report already planned for preparation in Task II-3, including the Phase III work plan, will be expanded to include treatment to address nonrecurring congestion caused by snow and ice and other weather-related events.

### 1.5 Phase III—Develop Recommended Design Guidelines

The objective of Phase III is to put the research results in final form for implementation. This objective does not change, but the scope will be expanded to include treatments to address nonrecurrent congestion due to snow and ice and other weather-related events. Delay caused by snow and ice will be considered in all four tasks of Phase III: Task III-1 (Prepare Design Guidebook); Task III-2 (Prepare Draft Final Report); Task III-3 (Prepare Information Dissemination Plan); and Task III-4 (Prepare and Conduct Presentations). Each of these tasks is discussed below.

#### 1.5.1 Task III-1—Prepare Design Guide

The objective of Task III-1 is to prepare a design guidebook according to the approved plan and annotated outline presented in the Phase II interim report. The scope of the design guidebook will be expanded to include design treatments, and guidelines for implementing those treatments, that address nonrecurring congestion caused by snow and ice and other weather-related events. Task III-1 involves developing a draft of the guidebook, review of the draft guidebook by outside experts, and revision of the guidebook in response to review comments.

The workshop we are planning to conduct in Task III-1 with participants from across the country—including FHWA representatives, state and local highway agency representatives, and design or traffic engineering consultants—for the purpose of reviewing and critiquing a draft of the design guidebook will include experts who are knowledgeable about design treatments that address delay caused by snow and ice. Specifically, at least two of the key participants in the Task II-1 workshop on highway design treatments for snow-and-ice conditions—one design engineer and one winter maintenance engineer—will be invited to the Task III-1 workshop.

#### 1.5.2 Task III-2—Prepare Draft Final Report

The objective of Task III-2 is to prepare a draft final report that documents all of the work performed in the project and provides support for the design guidebook. We anticipate that the draft final report will document the treatments for reducing nonrecurrent congestion, including nonrecurrent congestion caused by snow and ice and other weather-related events; the evaluation of the traffic operational performance, traffic safety performance, and cost of the treatments; and the results of the life-cycle cost
analysis. The draft final report will also document supporting rationale for the guidance provided in the design guidebook and the life-cycle cost analysis methodology.

### 1.5.3 Task III-3—Prepare Information Dissemination Plan

The objective of Task III-3 is to prepare an information dissemination plan to guide implementation of the research results and, especially, the design guidebook. The information dissemination plan will present recommended strategies for integrating the research results into the design guides and policies of highway agencies and, thus, into design practice. The scope of the information dissemination plan already planned for preparation in Task III-3 will be expanded to include treatments that address delay caused by snow and ice and other weather-related events.

The organization types that need to receive information about the research results are primarily the same for the expanded scope as they were in the original scope. They include state highway agencies; MPOs; other regional and local agencies; FHWA headquarters and field offices; bridge and tunnel owner-operators; design and traffic engineering consultants; and other appropriate groups. Logically, those organizations located in regions that are subjected to winter weather conditions will be most interested in the research results related to snow and ice, but some snow-and-ice-related results may be applicable to other weather-related issues such as blowing and drifting sand. For research results related to snow and ice and other weather-related issues, the target audience within those organizations should include decision makers, design and traffic engineering practitioners, maintenance staff, and other stakeholders.

### 1.5.4 Task III-4—Prepare and Conduct Five Presentations

The objective of Task III-4 is to make presentations to five selected stakeholder groups with key roles in implementing the research results. The scope of the presentations already planned for Task III-4 will be expanded to include research results related to treatments that address nonrecurrent congestion caused by snow and ice and other weather-related events.
Section 2.
Project Schedule

The research in SHRP 2 Project L07 began on January 7, 2008, and will be completed by January 6, 2012. The added work described in this plan will begin when authorized by SHRP 2. MRI proposes to accelerate the added work in Phase I so as to have no impact or minimal impact on the schedule for completion of Phase I. If the added work is authorized by September 1, 2008, MRI proposes to complete Phase I by January 6, 2009, as already planned. If the added work is authorized after September 1, 2008, MRI will at SHRP 2’s option (1) submit the Phase I interim report including the added work on a date later than planned or (2) submit the Phase I report initially without the results of the added work in Phase I on the current schedule and then submit a revised report including the added work at a later date. In either case, the added work in Phases II and III will be completed on the same schedule as the existing work in those phases. No change in the overall project period of performance will be needed.
Section 3.
References

