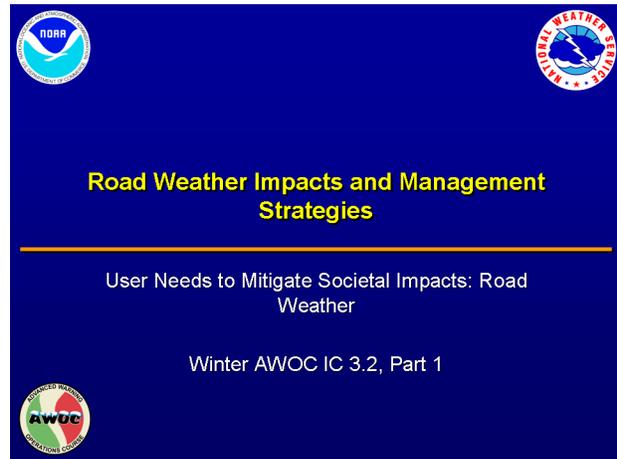

1. Road Wx Impacts & Management Strategies

Instructor Notes: This module presents an overview of Road Weather Impacts and Management Strategies. This presentation is the first of five parts of a lesson that discusses how the transportation community views weather and mitigates its negative impacts. This presentation should take approximately 15 minutes.

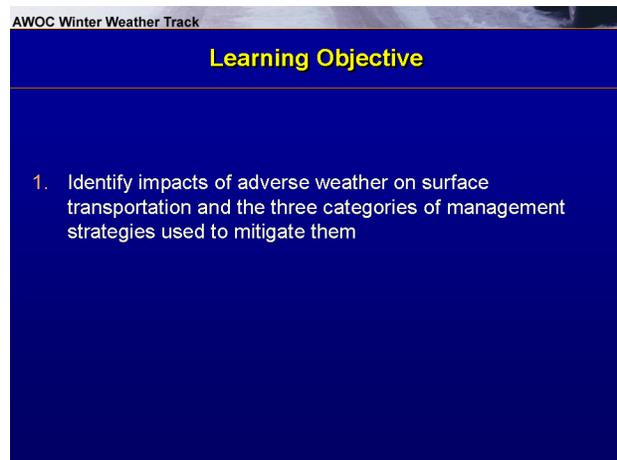
Student Notes:



2. Learning Objective

Instructor Notes: There is one learning objective for this part of lesson 2: 1. Identify impacts of adverse weather on surface transportation and the three categories of management strategies used to mitigate them.

Student Notes:



3. Weather Impacts on Surface Transportation: Nature's "Environmental Impact" on Roads

Instructor Notes: To say that weather impacts surface transportation is to state the obvious. Anyone who has lived in a large metropolitan area has likely experienced traffic delays due to some form of weather. While the discussion often focuses on significant winter weather events, adverse weather can impact ground transportation at any time of the year. It's probably best to think of weather as nature's "environmental impact" on roadways because weather is an ever-present reality to transportation operators and the driving public. Surface transportation agencies see weather differently than meteorologists do. What matters to DOTs and similar agencies is what's happening at or near the ground. Weather information disseminated to them should focus on how weather impacts surface conditions. Here are some other important points to remember about surface transportation and weather (from Nelson and Persuad, 2002): [CLICK] 1. Actions to mitigate weather impacts are taken with regard to the road system, not the weather; [CLICK] 2. Just like the NWS, mitigation efforts are decided by people who control the appropriate tools and techniques; and [CLICK] 3. Better weather forecasts are needed for transportation personnel to make better decisions.

Student Notes:

AWOC Winter Weather Track

**Weather Impacts on Surface Transportation:
Nature's "Environmental Impact" on Roads**



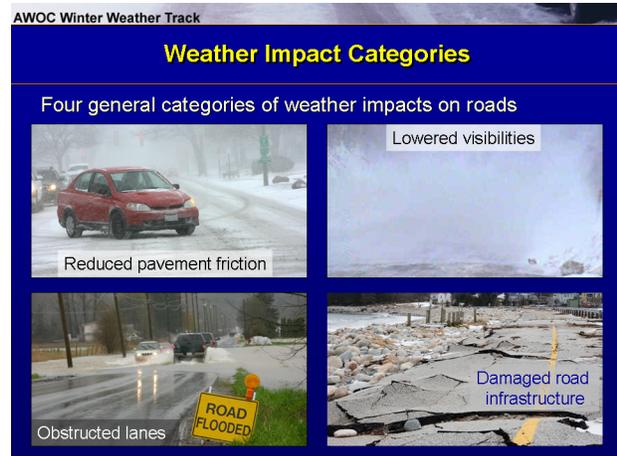
- Mitigation steps taken with regard to the road system, not the weather
- Those actions are decided upon by people
- Better weather forecasts needed to make better decisions

4. Weather Impact Categories

Instructor Notes: There are many ways that adverse weather can impact surface transportation. From a transportation operators point of view, all adverse weather impacts can be categorized into four groups by how the road surface, near-surface, and sub-surface conditions change as a result of the weather (Pisano and Goodwin, 2004). These impacts are: [CLICK] 1. Reduced pavement friction (due to wet, snowy/slushy, or icy pavement), [CLICK] 2. Lowered visibilities (due to fog, smoke, or heavy precipitation), [CLICK] 3. Obstructed lanes (due to significant snow accumulations, water infiltration of the road surface, or even debris on the road due to strong winds/tornadoes), and [CLICK] 4. Damaged road infrastructure (potholes, washed out roads, or road restrictions

due to freeze/refreeze conditions). The first three categories can generally be mitigated during the event using various techniques. The last category generally requires some form of maintenance that can take significant time after the event (days, months or year) to complete.

Student Notes:



5. Reduced Capacity or Volume

Instructor Notes: The surface transportation network in the U.S. operates most efficiently during benign weather conditions. [CLICK] As adverse weather conditions begin, the efficiency, or quality, of roadway operations drops. The first way that adverse weather impacts roadway operation quality is by reducing road capacity, or volume. The capacity reduction can be a direct (such as icing conditions causing traffic to slow down) or indirect (such as closing a highway during a blizzard) result of weather. During significant weather events, the demand for traffic volumes will often drop as a result of: [CLICK] - people changing travel plans (i.e., leaving earlier or later for a vacation), [CLICK] – travelers eliminating discretionary trips all together, [CLICK] - schools and businesses closing for the day, [CLICK] - commuters leaving early (or late) for work to avoid “rush hour” congestion, and [CLICK] - more commuters utilizing public transportation. Even with the decrease in demand, the reduction in roadway capacity due to adverse weather will generally result in some congestion. The impacts of this congestion are most significant during the morning and evening peak periods. In fact, adverse weather is the 2nd largest cause of non-recurring congestion on U.S. roadways (Pisano and Goodwin, 2004).

Student Notes:

AWOC Winter Weather Track

Impacts on the Quality of Roadway Operations: Reduced Capacity or Volume



During significant adverse weather, demand for traffic volume drops due to:

- People changing travel plans
- Eliminating discretionary travel
- Schools and businesses closing
- Commuters avoiding "rush hour"
- More utilization of public transportation

6. Lower Average & Free Flow Traffic Speeds

Instructor Notes: In addition to reducing road capacity, adverse weather can lead to possible reductions in traffic speed. Speed reductions can be apparent in both free flow speed (i.e., vehicle speed when traffic volume is well below capacity) and average speed. These speed reductions can be significant both on freeways and arterial routes when: [CLICK] - heavy precipitation, especially snow and ice, makes roads slick and hazardous and [CLICK] - when visibilities drop below 1/4 mile. As a result of the lower speeds, traffic is delayed. The increase in travel time (excluding additional delays from accidents) can be up to 50% in extreme cases (Stern et al., 2003).

Student Notes:

AWOC Winter Weather Track

Impacts on the Quality of Roadway Operations: Lower Average & Free Flow Traffic Speeds

Adverse weather can cause reductions in traffic speed on freeways and arterial routes when:



Heavy precipitation (especially snow and ice) makes roads slick and hazardous

When fog, smoke, or other particulates reduces visibilities below 1/4 mile

7. Changes in Driver Behavior

Instructor Notes: During adverse weather, there will be a variety of general changes in driver behavior. Most drivers, but certainly not all, become more cautious as conditions deteriorate. In general, these more cautious drivers will exhibit the following behaviors (Sterzin, 2004): [CLICK] - An increase in headway (or forward spacing) between vehicles, [CLICK] - A decrease in desired speed, [CLICK] - An increase in gap between

nearby vehicles when changing lanes, and [CLICK] - A decrease in the amount of vehicle acceleration/deceleration (i.e., drivers try to avoid sudden speed changes). [CLICK] Because some, but not all, drivers will exhibit these behaviors there is often an increase in driver speed variance during adverse weather. Increases in driver speed variance generally lead to increases in the accident rate (Pisano and Goodwin, 2004). This is true in adverse or benign conditions. A different study by the Federal Highway Administration (FHWA, 2006) identified a different change in driver behavior during inclement weather. Comparing traffic data from Minneapolis-St. Paul and Baltimore, the authors found that the Minneapolis-St. Paul area roads experienced larger speed reductions under snowy conditions (19% vs. 5%). A possible explanation is that drivers in the snowier climates are more aware of the dangers of snow, slush, and ice on roadways and slow down voluntarily.

Student Notes:

AWOC Winter Weather Track

**Impacts on the Quality of Roadway Operations:
Changes in Driver Behavior**



During adverse weather, some general changes in driver behavior are:

- An increase in spacing between vehicles
- A decrease in desired speed
- An increase in gap distance between vehicles when changing lanes
- An avoidance of sudden speed changes

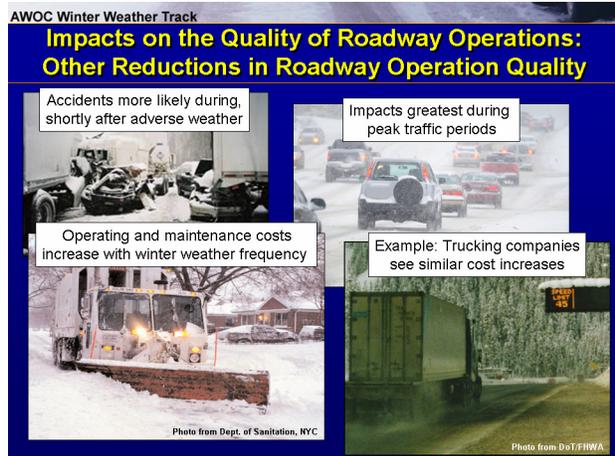
Because behavioral changes are not universal:

- Increase in driver speed variance = General increase in the accident rate

8. Other Reductions in Roadway Operation Quality

Instructor Notes: As a result of reduced capacity, reduced traffic speeds, and changes in driver behavior, other reductions in traffic operations quality are likely. [CLICK] For instance, property-damage, injury, and fatality accidents may possibly increase during and shortly after adverse weather events. [CLICK] When adverse weather does impact traffic operations, the impacts are greater during the peak periods. These times include the morning and afternoon “rush hour” periods, as well as “special event” traffic (FHWA, 2006). [CLICK] All of these reductions in roadway operation quality ultimately lead to an increase in costs. Transportation managers see an increase in operating and maintenance costs as the frequency of adverse weather increases. Businesses, especially those in weather sensitive industries, will see an increase in costs as well due to traffic delays. [CLICK] For example, trucking companies will experience significant increases in operating costs when they have to re-route trucks due to (or worse, have vehicles stuck in) adverse weather.

Student Notes:



9. Interactive Question

Instructor Notes:

Student Notes:

10. I'm Sorry, That's Incorrect

Instructor Notes:

Student Notes:

AWOC Winter Weather Track

I'm Sorry, That's Incorrect

Damaged road infrastructure was the correct answer. It can take days, weeks, or even months in extreme cases to repair infrastructure damage caused by adverse weather. The other three weather impacts can generally be mitigated by surface transportation agencies during the event.

1. Lowered visibilities
2. Reduced pavement friction
3. **Damaged road infrastructure**
4. Obstructed lanes

[Proceed to the next slide in the module](#)

11. That's Correct!

Instructor Notes:

Student Notes:

AWOC Winter Weather Track

That's Correct!

Good job. It can take days, weeks, or even months in extreme cases to repair infrastructure damage caused by adverse weather. Each of the other weather impacts can generally be mitigated by surface transportation agencies during the event.

1. Lowered visibilities
2. Reduced pavement friction
3. **Damaged road infrastructure**
4. Obstructed lanes

[Proceed to the next slide in the module](#)

12. Weather Needs During Adverse Weather

Instructor Notes: It's the job of transportation management to put into place practices to mitigate weather impacts. There are a variety of local and state transportation agencies that implement these strategies. The following list identifies those agencies and provides a short explanation on how they may view, or utilize, weather information: [CLICK] Transportation Management Centers (TMCs): TMC personnel look at weather from a broad point of view. Of primary concern to TMC's is precipitation in its various forms and the "big picture" traffic impacts from weather in the area. [CLICK] Traffic Operations (including Traffic Operations Centers, or TOCs): Precipitation and wind are still of primary interest, but possibly in more detail than for TMCs. Weather can affect electricity to traffic signals, damage or shift large materials or equipment, and adversely impact the drying time of adhesives and paints. [CLICK] Maintenance Operations: Maintenance personnel are very focused on their area of responsibility and they are impacted by any

Warning Decision Training Branch

adverse weather affecting the road surface (rain, thunderstorms, tornadoes, high winds, snow, freezing rain, sleet, black ice, and frost). [CLICK] Construction Operations: This work is often handled by contractors. The contractors are responsible for accessing how weather impacts them from day-to-day. [CLICK] Customer Service: Operators must be able to answer travelers questions about weather and road conditions, as well as questions from field personnel who don't have access to weather information. They need a broad perspective (like TMCs), but also require more detailed info as events unfold.

Student Notes:

AWOC Winter Weather Track

Transportation Management Staff: Weather Needs During Adverse Weather

Photo from DOT/FHWA
Transportation management center (TMC)

Traffic operations center (TOC)
Photo from Oregon DOT

Maintenance operations
Photo from WSDOT

Construction operations

Customer service

13. Mitigation Techniques & Their Goals

Instructor Notes: The ultimate goals of these agencies' mitigation techniques are to: [CLICK] - Improve traffic mobility by increasing capacity and making traffic flow more uniform, [CLICK] - Increase public safety by reducing the number of accidents that occur, and [CLICK] - Make road maintenance operations safer and more productive. To achieve these goals, the transportation community has organized these mitigation techniques into specific management strategies based on similarities in applications and goals of the individual techniques (FHWA, 2008).

Student Notes:

AWOC Winter Weather Track

Transportation Management Staff: Mitigation Techniques and Their Goals

The ultimate goals of mitigation techniques are to:

Improve traffic mobility & capacity

Reduce accident rates

Year	Adverse Weather (Millions)	Flank Operations (Millions)
1995	282,218	2,400,000
1996	308,418	2,450,000
1997	302,987	2,500,000
1998	324,794	2,550,000
1999	404,780	2,600,000
2000	437,432	2,650,000
2001	387,897	2,700,000

Make maintenance safer & more productive

Photo from Sandy, UT PWD

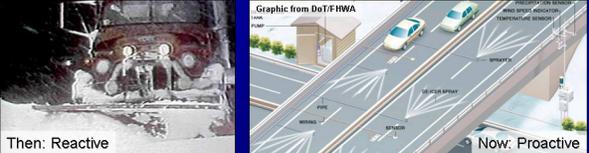
14. Trending from Reactive to Proactive

Instructor Notes: Traditionally, transportation management has responded reactively to weather events. Transportation departments, maintenance garages, and construction contractors would order supplies based on budgetary constraints and a rudimentary “climatology”. When they learned about an impending event, they would make some preparations in advance. [CLICK] However, routine forecast updates were not necessarily part of the process. Often, mitigation strategies would not be implemented until after adverse weather began (FHWA, 2006). [CLICK] This pattern of behavior was not limited to just mitigating impacts on road conditions. Many times, climatology & weather information were not regularly consulted prior to scheduling or performing maintenance activities. If the weather was not suitable to perform maintenance (e.g., light precipitation falling when road painting scheduled), it would not be unheard of for maintenance personnel to just wait around until the weather cleared up (or the end of the day came). This process caused significant losses in productivity. [CLICK] To improve efficiency and reduce costs, transportation managers have started to become more proactive in dealing with adverse weather. This process has involved integrating weather information more into daily operations and developing more proactive transportation management strategies. The goal is to view weather events as non-recurring incidents that can be predicted, observed, and mitigated.

Student Notes:

AWOC Winter Weather Track

Surface Transportation Management Strategies: Trending from Reactive to Proactive



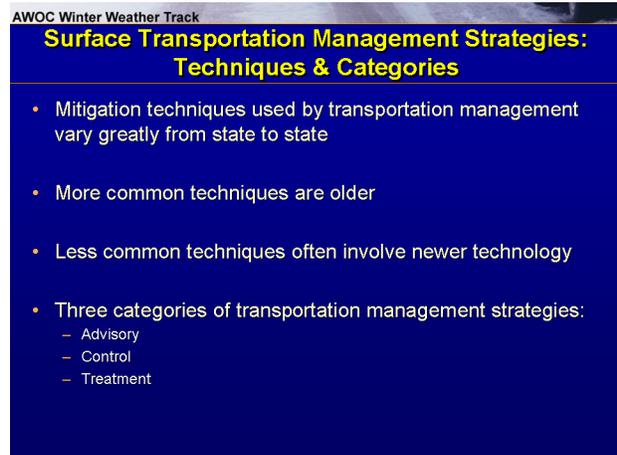
- Traditionally, transportation operators responded reactively to adverse weather events
- Weather information was not well integrated into the process
- Examples: winter weather mitigation, maintenance, and construction projects
- To improve efficiency, transportation agencies are integrating weather information to be more proactive

15. Techniques & Categories

Instructor Notes: The individual management strategies that are implemented nationally vary greatly from state to state (and variations may be significant within a state depending on the geography and climatology). [CLICK] The more common techniques have been around longer. For instance, plowing first started approximately 150 years ago and basic road treatment is, for all practical purposes, universal. For these more common strategies, what will vary is the who, what, where, when, and how of implementing the strategy. [CLICK] The newer, less common mitigation techniques involve newer technologies. In some cases, the technologies have only been commonly used in the last

decade or so. Some examples of these tools are Dynamic Message Signs (DMS), 511 phone service, and weather-related traffic signal timing plans. While not available everywhere, these mitigation techniques are becoming more common. [CLICK] The various mitigation techniques fall in three general categories (FHWA, 2008): - Advisory Management Strategies, - Control Management Strategies, and - Treatment Management Strategies. The next three modules in IC3.2 discuss each of these management strategies in detail.

Student Notes:



AWOC Winter Weather Track

Surface Transportation Management Strategies: Techniques & Categories

- Mitigation techniques used by transportation management vary greatly from state to state
- More common techniques are older
- Less common techniques often involve newer technology
- Three categories of transportation management strategies:
 - Advisory
 - Control
 - Treatment

16. Summary

Instructor Notes: To summarize, this presentation provided an overview of how adverse weather can impact surface transportation. In general, these impacts fall into four categories: - Reduced pavement friction, - Lowered visibilities, - Obstructed lanes, and - Damaged road infrastructure. [CLICK] These impacts act to reduce roadway operations efficiency by: - Reducing capacity, - Reducing speeds, and - Changing driver behavior. [CLICK] Transportation management implements a variety of management strategies to effectively mitigate these impacts. These strategies fall into three categories, which are covered in the next three parts of this lesson. To proceed to the next section of this lesson, click on the link at the bottom of the slide or use the navigation in the NWS Learning Center.

Student Notes:

AWOC Winter Weather Track

Summary of "Road Weather Impacts" Module

- Four general surface transportation impact categories:
 - Reduced pavement friction
 - Lowered visibilities
 - Obstructed lanes
 - Damaged road infrastructure
- These impacts reduce roadway operations efficiency by:
 - Reducing capacity
 - Reducing speeds
 - Changing driver behavior
- Mitigation techniques fall into three general categories:
 - Advisory
 - Control
 - Treatment

[Proceed to next part of this lesson](#)