Public Roads

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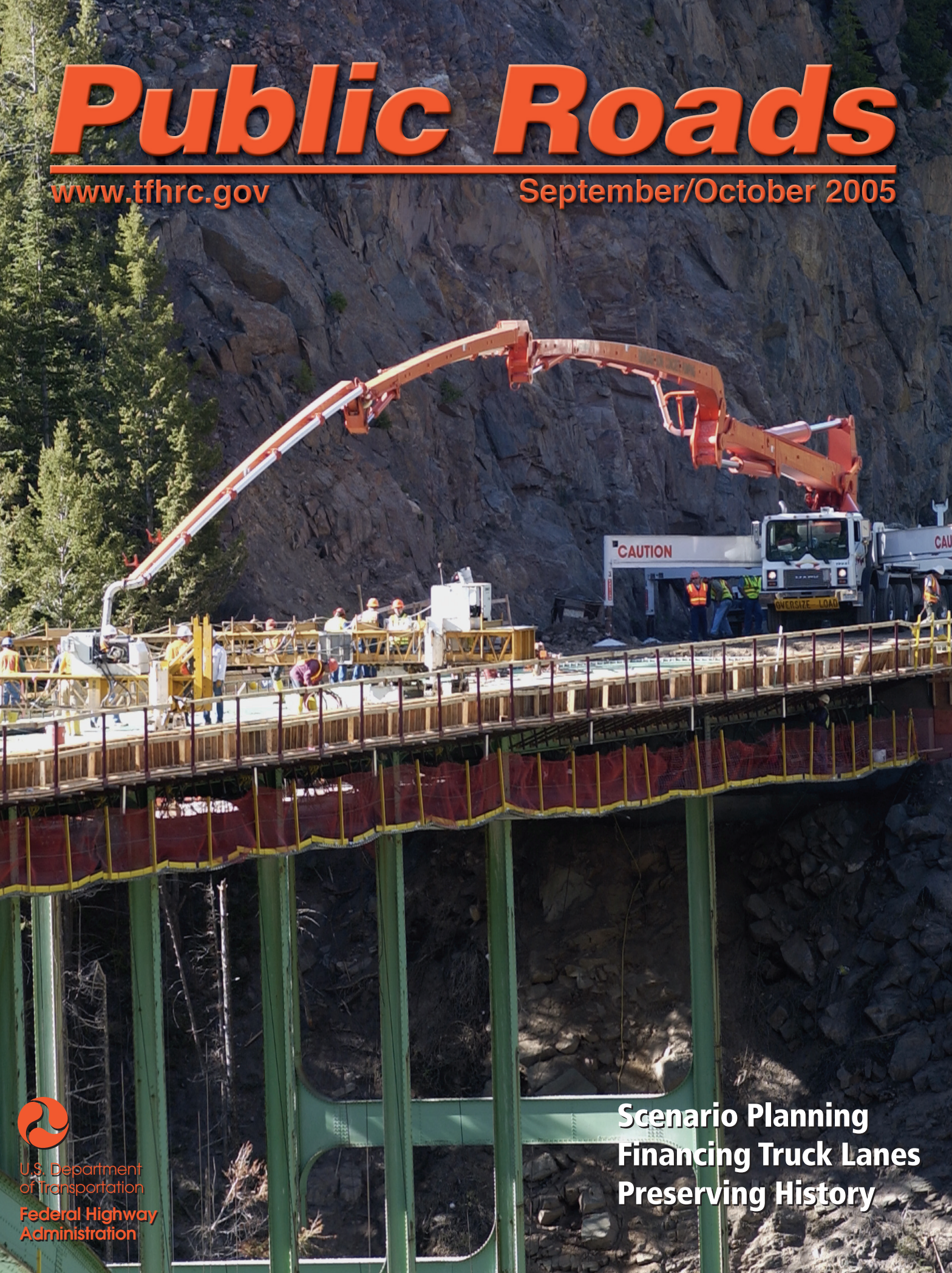
September/October 2005



U.S. Department of Transportation
Federal Highway Administration

Scenario Planning
Financing Truck Lanes
Preserving History

Public Roads

—featuring developments in Federal highway policies, programs, and research and technology—

September/October 2005 www.tfhrc.gov Vol. 69, No.2

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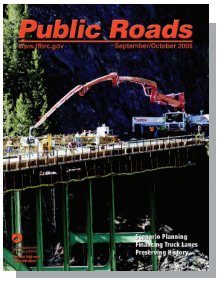

Front cover—In March 2004, the Colorado Department of Transportation (CDOT) began rehabilitating the 64-year-old Red Cliff Arch Bridge, which carries U.S. Highway 24 over Eagle River in Colorado's Rocky Mountains. The goals were to update the structure to meet current Federal safety standards and to preserve the bridge's historic and aesthetic features. Here, workers are pouring the deck on the south side of the bridge. *Photo: Gregg Gargan, CDOT.*

Back cover—In May 2000, the Delaware Department of Transportation (DelDOT) completed construction of this toll plaza at Biddles Corner in New Castle County. The plaza, shown in this aerial photo, features two express lanes in each direction that enable drivers with an E-ZPass℠ to pay their tolls electronically while maintaining the posted highway speed. DelDOT estimates that the E-ZPass booths process close to 700 vehicles per lane per hour, as compared to about 400 for traditional manned booths. *Photo: DelDOT.*

U.S. Department of Transportation
Federal Highway Administration

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Guest Editorial

Financing Tomorrow's Roads

Two events—one recent and one upcoming—draw attention to America's continuing need for a strong transportation system that fosters economic growth. The recent signing of the Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU) by President George W. Bush recognizes the need for a multiyear, comprehensive plan to fund and implement improvements for the Nation's highway system. And the upcoming milestone of the 50th anniversary of the interstate system serves as a reminder of how far the Nation has come since 1956 when President Dwight D. Eisenhower signed the bill creating the new transportation network.

But it's time to move on from the system that was designed to fund interstate construction. Traditional ways of financing transportation improvements have certainly served the country well, but is that funding architecture correct or calibrated properly for funding surface transportation requirements in the future? The Highway Trust Fund that was set up to finance the Dwight D. Eisenhower National System of Interstate and Defense Highways is inadequate to support all of the Nation's transportation needs in a robust economy. The next reauthorizing legislation is only 4 years away, and the urgency to address this issue is rapidly emerging. The transportation community needs to earnestly explore additional, more efficient ways of paying for highway transportation.

And the community is doing just that. The Federal Highway Administration (FHWA) and State departments of transportation are conducting studies of public-private partnerships (PPPs) and reviewing methods to embrace them and a host of new innovative financing tools. FHWA is helping several States implement innovative PPPs that enable projects to be completed faster—and in one case retire debt in record time—and is encouraging the public sector to create an environment that will attract, not discourage, private-sector investment. Enthusiasm is growing for PPPs as innovative ways to finance projects and as avenues to get roads and bridges built quicker and at less cost to taxpayers.

FHWA recently created a PPP program and management position to strengthen the agency's promotion and oversight of these partnerships. The PPP program will provide a central point of contact for State and local transportation officials and private-sector representatives who want to explore new and creative ways to design, develop, and deliver highways and bridges. This issue of PUBLIC ROADS examines some of the issues involved in tolling and innovative financing, and touches on the importance of PPPs in the article "Issues in the Financing of Truck-Only Lanes."

Upcoming issues of PUBLIC ROADS will cover PPPs in depth and will continue to highlight innovative financing methods and initiatives. In the future, not only will Federal and State agencies work together; private industry will join the partnership and be able to offer its efficiency, creativity, economies of scale, and innovations. Together, we will help the Nation's transportation system keep the economy moving.

J. Richard Capka
Acting Administrator
Federal Highway Administration

This new paradigm for decisionmaking is helping communities and States prepare for the future.

by Sherry B. Ways and Cynthia J. Burbank

Scenario Planning

Nobel Prize Laureate Niels Bohr once said, "Prediction is very difficult, especially if it is about the future." With land development occurring rapidly, pressures on the environment increasing, congestion levels growing, housing costs rising, and the population aging, what is to be done?

(Above) In a scenario planning process, participants at Envision Utah workshops work in small groups such as this one to visualize a desired future for their community. *Photo: Envision Utah.*

These quality-of-life concerns and others appeared to be foremost on the minds of citizens in the Greater Wasatch region of the Salt Lake City, UT, metropolitan area when they took control of their future through a scenario planning process called Envision Utah. As with many regions, Utah faces serious challenges of rapid growth and deficits in needed infrastructure. "The Greater Wasatch region could not continue to grow in the future as it had in the past," says Ted Knowlton, planning director at the Coalition for Utah's Future, which sponsors Envision Utah.

Formed in 1997 as a public-private partnership, Envision Utah guides the development of a broad and publicly supported growth strategy to protect the State's environment, economic strength, and quality of life. Instead of using a typical approach to planning that involves one forecast and one solution, participants in a series of workshops convened by Envision Utah set out to develop and evaluate a range of alternative futures. Participants developed four possible alternatives for future growth and identified criteria—including total land

consumption, average daily vehicle miles traveled, and air quality—to evaluate each alternative.

In a subsequent public survey, residents voted for their preferred scenario. Based on the scenario chosen, Envision Utah generated a vision document with 42 specific strategies. Envision Utah now is working with the various governments in the region to implement those strategies.

What Is Scenario Planning?

The scenario planning process employed by Envision Utah is an analytical tool that can help prepare for the future by providing a framework for developing a shared vision. In other words, scenario planning is a part of strategic planning that incorporates assumptions, risks, and environmental factors by using scenarios to present various situations that may affect the future. Transportation scenario planners analyze various forces that affect growth, such as the economy, transportation, health, the environment, and land use.

Scenario planning is applicable at the statewide level or for individual metropolitan areas. Scenario planners test various future alternatives that could meet State and community needs. A defining characteristic of successful scenario planning for the public sector is that it actively engages the public, the business community, and elected officials in identifying the growth trends and tradeoffs, gaining a mutual understanding, and incorporating their values into future plans.

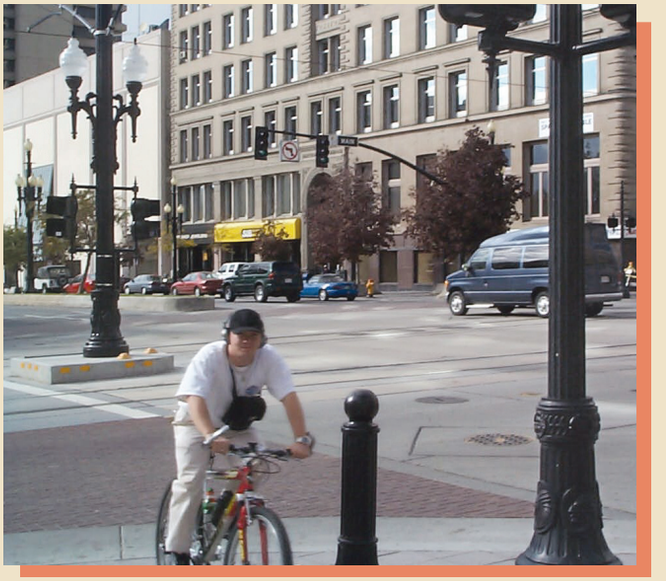
Envision Utah is one of many examples. Other communities and regions that have used scenario planning include Sacramento, CA, which called its process the Sacramento Blueprint; Chicago, IL (Chicago Metropolis 2020); the Delaware Valley Regional Planning Commission; Charlottesville, VA (Jefferson Area Eastern Planning Initiative); the Idaho Transportation Department (Idaho's Transportation Future); and Binghamton, NY (Binghamton Metropolitan Transportation Study).

Scenario planning offers the following benefits:

- Provides an analytical framework and process for understanding complex issues and responding to change
- Facilitates consensus building by giving communities the capacity to participate actively in planning
- Includes tools and techniques to assess the impact of transportation and other public policy choices on a community
- Allows the opportunity to recognize the impact of tradeoffs among competing goals
- Yields an enhanced decisionmaking framework
- Helps ensure improved management of increasingly limited resources

The Federal Highway Administration (FHWA) actively encourages and supports scenario planning to help citizens, businesspeople, and government officials understand the impacts of growth, especially the relationship between transportation, social and environmental issues, and economic development. This relationship is a two-way street: Growth and development affect transportation performance, while transportation affects social, environmental, and economic development.

Envision Utah promotes multiple transportation options, accommodating bicyclists on busy urban streets as well as pedestrians, motorists, and users of public transportation.



Envision Utah

Scenario Planning and Transportation Planning

Scenario planning enhances regional transportation planning, which is a comprehensive, holistic look at the needs and the future of a region and its inhabitants. (See "Transportation Planning" for more details.) Scenario planning takes the transportation planning process a step further by increasing participants' awareness of external forces of change (such as population growth and aging, immigration, and economic factors) and by enabling participants to consider alternative approaches to shaping their future, including policies related to land use, the environment, and transportation.

A Brief History

According to Keith Bartholomew in "Land Use-Transportation Scenario Planning: State of the Practice?" presented at the Association of Collegiate Schools of Planning 2004 Annual Conference, one of the first uses of scenario planning was in the Roman Empire. To prepare for battle, commanding officers used the technique to anticipate their opponent's next move by providing a range of possible actions and reactions. Many centuries later, the RAND Corporation in the 1950s used a modern version of the Roman military's application to assess potential nuclear threats, actions, and responses, according to Bartholomew.

Christopher Zegras, Joseph Sussman, and Christopher Conklin in the 2004 article "Scenario Planning for Strategic Regional Transportation Planning," in the *Journal of Urban Planning and Development,* attributed the phrase "scenario planning" to Royal Dutch/Shell, which first began applying the process in the early 1970s as a strategic tool to prepare for the economic downturn of the mid-1970s that resulted from the 1973 oil crisis. Large corporations use scenario planning to anticipate future market conditions and reduce business risk, particularly from external conditions.

Transportation Planning

"Transportation has a comprehensive, well-supported planning process to shape decisions," says Gloria M. Shepherd, director of the FHWA Office of Planning. Transportation planning first appeared in Federal transportation legislation 43 years ago, with the Federal-Aid Highway Act of 1962. The law requires States and metropolitan regions, as a condition for receiving Federal funding, to adopt long-range transportation plans for multiple modes of transportation. The required planning must be "continuing, comprehensive, and cooperative."

Over the years, the emphasis on effective transportation planning has been strengthened through legislation, Federal funding, and guidance and technical assistance provided by FHWA and the Federal Transit Administration. State and metropolitan regions have developed regional long-range transportation plans based on projecting demographic, housing, employment, and other conditions 20 years into the future. Public involvement, financial feasibility, conformity with air quality standards, consideration of the environment, and intermodal coordination are all key requirements for transportation planning.

In fiscal year 2004, FHWA made more than $500 million available for State and metropolitan transportation planning.

Regional transportation planning is a collaborative process, led by a metropolitan planning organization (MPO) and other key stakeholders in a region. The process is designed to foster involvement by all interested parties—businesses, community groups, environmental organizations, and the public—through proactive participation facilitated by the MPO in coordination with the State department of transportation (DOT) and transit operators.

Transportation planning in a regional context provides the information, tools, and public input needed for improving the system's performance. Transportation planning should reflect the city's vision for its future, whether the community be Charleston, WV, or Charleston, SC. The planning should include a comprehensive consideration of possible strategies; an evaluation process that encompasses diverse viewpoints; the collaborative participation of relevant agencies; and open, timely, and meaningful involvement of the public.

For more on the transportation planning process, see www.fhwa.dot.gov/hep.

Inevitably, the process involves difficult tradeoffs, especially regarding land use policies; therefore, public participation is essential to raise awareness and foster collaborative thinking. Scenario planning enables participants to realistically evaluate a wider variety of potential futures and determine a community's future.

"FHWA sees scenario planning as an enhancement of, not a replacement for, the traditional transportation planning process," says Gloria M. Shepherd, director of the FHWA Office of Planning. "It enables communities and transportation agencies to better prepare for the future."

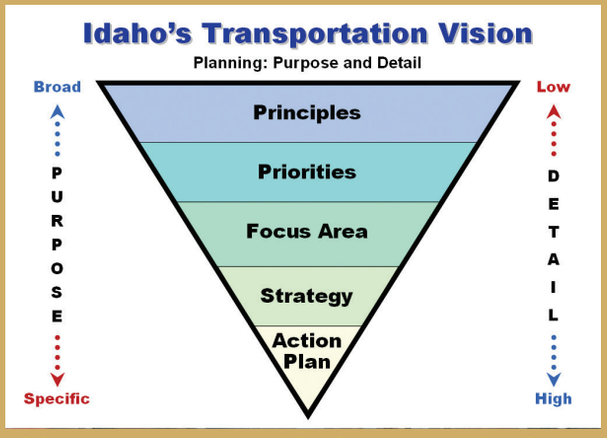
Scenario planning highlights the major forces that may shape the future, such as an aging population moving into an area perhaps calling for more transit opportunities or dense land use calling for additional road capacity. Scenario planning identifies how those forces might interact, rather than attempting to predict one specific outcome. As a result, regional decisionmakers are better prepared to recognize the various forces shaping the future, to make more informed decisions today, and to strategize for meeting tomorrow's needs.

Idaho's Transportation Future: Getting There Together

As the final step prior to development of a draft vision for the State's transportation future, Idaho's Transportation Partners convened a summit on transportation scenario planning and policy. "The goal was to create an initial policy framework and to better understand the effect of not only making policy decisions for the future of Idaho's transportation system, but perhaps more importantly, the unintended consequences of different paths," says Matthew E. Moore, research program manager at the Idaho Transportation Department (ITD).

To better understand the impact that today's decisions can have on tomorrow's world, participants in the summit used a scenario planning tool called the Quest model, which was developed in Vancouver, Canada. Quest is a visual interface tool that enables many models to work together to provide a projected future based on a number of policy decisions. The Quest model has more than 60 questions related to an area's economic base, transportation, housing, and health care. For Idaho's Transportation Future project, the transportation partners asked 12 policy questions that were primarily related to transportation and land use.

The participants used electronic townhall polling, which enables voters to make their choices anonymously, in combination with the Quest model to give their answers. "The questions generated productive discussions about the integrated nature of decisions," says Moore. "Many participants received a better understanding of the effect of being proactive on maintaining quality of life and meeting the mobility needs of the future. These discussions served to inform top-level priorities and policy decisions for the draft vision document and now for the final document."



Idaho's transportation vision has a set of fixed principles and priorities for the next 30 years (2004–2034). From these, focus area plans are developed to generate operational strategies and detailed action plans, as illustrated in this figure. *Source: ITD.*

The final vision document, *Idaho's Transportation Future: Getting There Together*, is available at www.idahofuturetravel.info/vision.asp. Information on the Quest model is available at www.envisiontools.com/questsite/index.html.

For more information, contact Matthew E. Moore, M.A., at matthew.moore@itd.idaho.gov or 208–334–8296.

Trends

The Greek philosopher Aristotle once said, "The whole is more than the sum of its parts." Aristotle's assertion can be applied to scenario planning, which depends upon understanding many different forces and trends that feed into mobility and transportation, and can affect that system. Each scenario may have a tremendous impact on the future, such as the shutdown of mines in the past that created ghost towns across areas in the West. Today, alternative fuel sources for automobiles may change the funding of road infrastructure. Economic, demographic, health, technological, and environmental factors are all important in determining future demands on the country's transportation system and its role in people's lives. Changes in demographics, safety, congestion, the environment, technology, and health and activity all produce trends.

Demographics. According to Alan E. Pisarski, a noted transportation researcher, the United States adds the equivalent of Canada's population to its own population every 10 years. But have we been adding the equivalent of Canada's transportation infrastructure? Not even close.

Complicating the situation, current growth patterns are different than those in the past. Today, population growth is spread across the country such that in the last decade, every State in the Nation experienced an increase. By the year 2000, more than half the country's population lived in suburbs. Half also worked outside the county in which they lived. These new growth trends must be understood on an individual basis because they may vary from one region to another.

Safety. According to a research note by the National Highway Traffic Safety Administration (NHTSA), "Motor Vehicle Traffic Crashes as a Leading Cause of Death in the United States, 2001," motor vehicle crashes are the leading cause of death among Americans from age 4 to 33. Major contributors to the death toll are alcohol, speed, and various other driver behaviors. The kinds of vehicles people drive and the roads on which they travel also contribute to crashes. In the year 2000, NHTSA estimated that motor vehicle crashes cost $230 billion, or 2.3 percent of the gross domestic product.

Congestion. The *2004 Urban Mobility Report*, published by the Texas Transportation Institute, shows traffic congestion growing across the Nation in cities of all sizes, consuming more hours of the day and affecting more travelers and shipments of goods than ever before. In 2002, congestion (based on wasted time and fuel) cost about $63.2 billion in 85 urban areas, compared to $61 billion in 2001. Up to 60 percent of unexpected traffic delays stem from what traffic engineers call "nonrecurring congestion." FHWA research shows that the causes of this type of congestion are crashes and disabled vehicles (25 percent), bad weather (15 percent), work zones (10 percent), special events (5 percent), and poor signal timing (5 percent). When roadways are congested, air quality worsens, security degrades, leisure and family activities are curtailed, service calls are less reliable and more costly, intermodal shipments are disrupted, and economic vitality is wasted due to lost productivity and wasted fuel.

To combat the growth of congestion and make travel times more reliable, FHWA is promoting and funding a number of strategies, including high-occupancy vehicle (HOV) lanes, transit improvements,

Scenario Planning In a New York Community

The Binghamton Metropolitan Transportation Study (BMTS) is the metropolitan planning organization (MPO) in Binghamton, NY. Like many other metropolitan areas in the Northeast, Binghamton is experiencing a decline in its manufacturing-based economy, accompanied by a slow population loss. When BMTS began to update its long-range transportation plan, Executive Director Steven Gayle opted for a scenario planning approach. After hosting a Federal Highway Administration (FHWA) scenario planning workshop, Binghamton's policy committee accepted this approach.

One of the BMTS guiding planning principles is that transportation investments must not only improve the regional transportation system but also contribute to achieving community development goals. Alternative scenarios typically address the question, "Where is the best place to put the growth that we know is coming?" Reflecting on its guiding principle, BMTS instead asked, "What are alternative scenarios for the region's future, and how can we use transportation investment to move in the right direction?"

The MPO began the process by involving the public and local officials in a community visioning exercise, followed by a series of interactive exercises called "Placemaking for Prosperity." Participants were asked to map where growth in certain economic sectors might occur, what they considered desirable land use patterns, and where population groups such as young professionals or active seniors would want to live. The MPO then considered an optimistic but moderate level of growth over the next 25 years versus a continuation of the current trend. The focus, which could be broadly applicable to similar regions, was how Binghamton can be a vibrant and successful community without substantial growth. Binghamton officials expect the final plan to be adopted in September 2005.

For more information, contact Steven Gayle at sgayle@co.broome.ny.us or 607–778–2443.

BMTS

The plan that resulted from a scenario planning exercise conducted by officials in Binghamton, NY, addresses the revitalization of the community's downtown, shown here.

Bruce W. Parker, Planning and Development Services

Scenario planning depends upon increased understanding of social and transportation trends, including safety. This photograph of children walking to school along a busy street clearly illustrates the need to address conflicts between pedestrians and automobiles.

traffic signal synchronization, congestion pricing on toll facilities, traveler information systems, incident management systems, dynamic message signs, improved freight connectors, public-private partnerships to finance new capacity, and much more. But travel demand continues to outpace improvements in transportation capacity.

Environment. After the publication of Rachel Carson's *Silent Spring* in 1962, Americans became increasingly concerned about protecting the natural environment. Federal, State, and local governments passed dozens of laws that improved air and water quality while protecting wildlife habitat and wetlands. Population and economic growth, however, continue to put pressure on natural resources. Americans want to continue improving air and water quality while accommodating housing, economic development, and recreational needs, and allowing mobility that is unparalleled in the world. This trend has resulted in an increased recognition by transportation agencies that protection of human, natural, and cultural resources must be a goal early in the transportation planning process.

Health and Activity. According to the Centers for Disease Control and Prevention, obesity is on the rise. The number of States with an obese adult population of more than 15 percent has increased from 4 out of 45 participating States in 1991 to 49 out of 50 States in 2002. U.S. Department of Health and Human Services testimony before Congress in 2003 indicated that nationally about 65 percent of adults and 15 percent of children and adolescents were overweight. Obesity is a major risk factor for many serious health problems, such as diabetes, hypertension, and psychosocial conditions. It also contributes to soaring health care costs in the United States, undermining the financial stability of all levels of Government as well as families and individuals. Obesity trends are important to transportation planning because investments in infrastructure may have an impact on people's lifestyles. Changes in the built environment, such as provision of sidewalks, bicycle trails, parks, and recreational facilities, can help support the trend toward more active lifestyles and exercise.

Other Trends. Other relevant trends include public finance, global trade competition, energy consumption, and land development. All of these trends are considered drivers of social change, and they are related to a region's values, quality of life, and land use. Integrating them will lead to improved transportation planning.

Planners can communicate the importance of these trends to the broader community through scenario planning. In some cases, trying to address or mitigate one trend could affect another. By creating and evaluating various scenarios, communities can understand how the trends might interact and therefore choose options that best address the myriad issues they are facing.

The Steps in Scenario Planning

Using a variety of tools and techniques, participants in scenario planning assess trends in the key factors and bring them together in alternative future scenarios, each reflecting different trend assumptions and tradeoff preferences. As a result of the process, all stakeholders in a region—the public, business leaders, and elected officials—strive to gain consensus on a preferred scenario. This scenario becomes the long-term policy framework for the community's evolution, is used to guide decisionmaking, and can be embodied in the long-range transportation plan.

An underlying premise of scenario planning is that it is better to get the future imprecisely right than to get the future precisely wrong. Predictions of the future are never exactly correct. Rather than picking one definitive picture of the future and planning for that future, scenario planning enables stakeholders in a region to consider various possibilities and identify policies that can adapt to changing circumstances. Scenarios do not describe a forecasted end state but rather are stories about future conditions that convey a range of possible outcomes.

People are notoriously reluctant to accept change. They resist increased development, increased traffic, limits on land use, limits on their mobility, and loss of open space. But the United States continues to grow, and growth brings positive as well as negative impacts on the lives of Americans. There are tradeoffs. Scenario planning can help people understand the forces of change and the collective choices they have.

Highway congestion like this is one trend evaluated in scenario planning processes.

For many, the first step is to identify the quality of life values that are important to the region. This information provides the foundation for scenario development. These issues can be expressed as questions about the future that the scenarios might answer. Planners, working in close coordination with community leaders, businesses, local officials, the public, and other stakeholders, could undertake the following additional six steps.

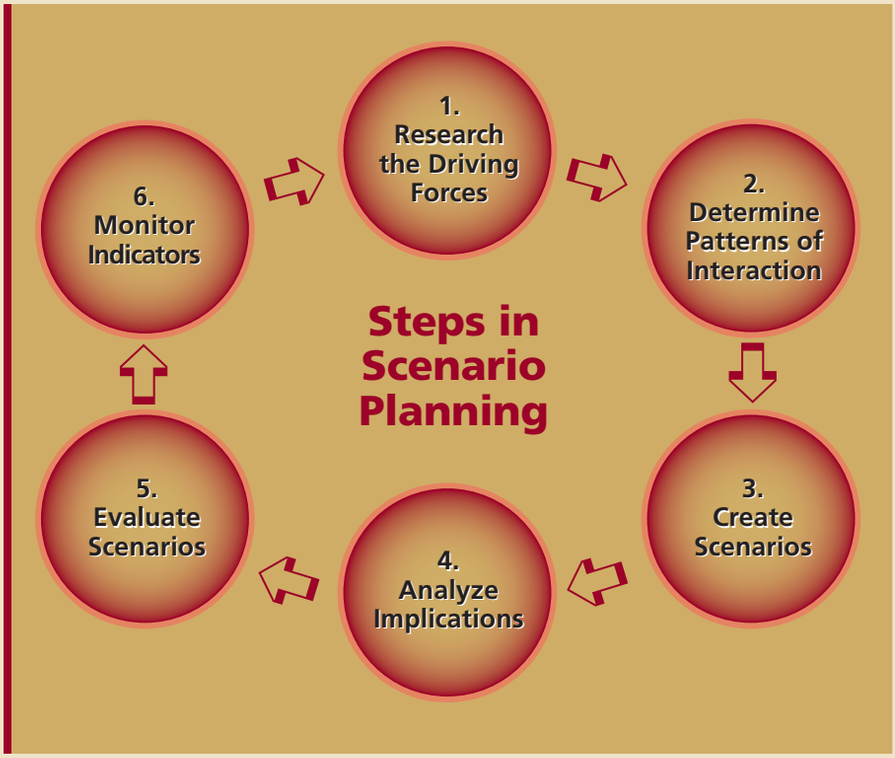
Step 1: Research the driving forces. Define the major sources of change that affect the future, whether those forces are predictable or not. Some of the relatively predictable elements are local demographics, trends in local land use, levels of congestion, and mode split. Less predictable are macro elements such as the global economy, future availability of funding for infrastructure, global environmental conditions, and technological innovation. Many other driving forces are uncertain, but narrowing them down will help advance a scenario planning process.

Step 2: Determine patterns of interaction. Consider how the driving forces could combine to determine future conditions. To determine these patterns of interaction between driving forces, planners can develop a matrix that identifies the driving forces as a pair of opposites with a potential positive or negative outcome. For example, if the economy is a driving force, it can be labeled as having either no growth or fast growth. By determining the interaction of each driving force, scenarios can be created.

As part of a scenario planning process, the Delaware Valley Regional Planning Commission, the MPO for the Greater Philadelphia-Camden-Trenton region of Pennsylvania and New Jersey, developed a matrix that categorized various transportation impact assessments and relevant policy concerns that affect long-range planning. To determine patterns of interaction, the MPO assessed scenarios against future spatial characteristics of the region, future mobility and accessibility needs, and potential congestion locations, and then quantified delay costs. The matrix enabled the MPO to understand the interactions and devise five scenarios to present for public review, along with policy support measures for each scenario. The results of this process served as a foundation for the region's 2030 transportation planning process.

Step 3: Create scenarios. When generating scenarios, planners should think through the implications of different strategies in different future environments. The goal is to bring life to the scenarios so that community stakeholders can easily recognize and connect the various components. Planners creating stories based on the interaction of driving forces and how those drivers affect local factors might develop scenarios that challenge existing thought patterns.

Step 4: Analyze the implications. Ultimately, scenario planning is a technique for improving decision-making, not only about transportation but also about land use, public



investment, and environmental policies. The scenarios enable planners to explore the shape and nature of transportation in a variety of circumstances, using a range of tools. They can present scenarios visually by employing various software tools, such as geographic information systems. The use of visual information to show the interactions in each scenario can help the public and decisionmakers understand the consequences of potential actions and the potential impacts of various scenarios.

Step 5: Evaluate scenarios. Planners can measure the scenarios against one another by comparing indicators relating to land use, transportation, demographics, environment, economics, technology, and other driving forces. During large regional public meetings, graphic simulations of alternative scenarios can stimulate understanding and decisionmaking among stakeholders. Through this process, the community can formulate reasoned responses and enhance its ability to respond to change.

Step 6: Monitor indicators. Scenario planning is an ongoing process. As the future unfolds, planners need to assess and compare real growth patterns to the selected scenarios and devise new scenarios, make new decisions, or create policies to address changing conditions.

Federal Initiatives

FHWA offers technical support, fund planning, information, and research to State, regional, and local partners as they undertake scenario planning. Recent FHWA efforts include the following:

- Scenario planning in California, Illinois, Michigan, Missouri, Utah, Virginia, and Wisconsin funded by FHWA
- A national peer roundtable for policymakers, community leaders, and technical experts to discuss the keys to effective support for scenario planning—concluding with a report on the roundtable, *Scenario Planning: A Framework for Developing a Shared Vision for the Future* (FHWA-HEP-04-027)
- Peer workshops hosted and funded by FHWA division offices to discuss benefits, strategies, and examples of scenario planning for transportation decisionmaking
- Coordination or participation in national conferences and meetings discussing the benefits and uses of scenario planning
- In fiscal year 2004, more than $500 million in transportation planning funds for States and MPOs, funds that can be used to support scenario planning
- A 2005 launch of a Web site dedicated to scenario planning best practices and research

Scenario planning enhances traditional transportation planning by recognizing uncertainty, focusing on major forces or drivers that have the potential to affect the future, and by educating and involving the public. By developing scenarios that tell alternative stories of the future, planners and the public are better able to recognize the interaction between these forces and determine those planning activities that can be implemented today and those that will be available for future adoption. The intent of scenario planning is not to replace traditional planning practices. Instead, it is a process that can be applied to recognize the range of outcomes in the future, which then can be fed into the traditional transportation planning process. The process also enables planners and decisionmakers to consider system performance in the context of other relationships in the community and to use the latest software tools to analyze and visualize alternative futures.

"Planning is bringing the future into the present so that you can do something about it now," said time management guru Alan Lakein.

Sherry B. Ways is a transportation planner for the FHWA Office of Planning in Washington, DC. She has more than 10 years of experience in transportation planning and is a staff member of the Transportation Planning Capacity Building Team. She can be contacted at sherry.ways @fhwa.dot.gov.

Cynthia J. Burbank is the associate administrator of the FHWA Office of Planning, Environment, and Realty. She has worked for the U.S. Department of Transportation for 30 years for a variety of agencies. She can be contacted at cindy.burbank @fhwa.dot.gov.

For more information about FHWA's scenario planning initiative, go to http://www.fhwa.dot.gov/planning/scenplan/index.htm.

Issues in the Financing of Truck-Only Lanes

by David J. Forkenbrock and Jim March

A number of questions, such as "who benefits" and "who pays," need to be addressed when considering mechanisms for funding special-purpose lanes.

For almost 40 years, transportation planners have debated the efficacy of separating traffic into lanes reserved for passenger vehicles and others kept solely for trucks. Today, two principal objectives underlie the argument for designating special-purpose or managed lanes on interstates. One purpose is to separate heavy trucks from lighter vehicles on major truck corridors. The second is to create lanes on urban freeways that are reserved for high-occupancy vehicles and exclude trucks.

With the growing U.S. economy and rapid increase in freight traffic, the question of how best to transport freight becomes more and more critical. Whatever modal

Truck-only lanes are one strategy for relieving congestion like this, which can occur on some rural interstates as well as urban freeways.

AAA Foundation for Traffic Safety

Many trucking firms are opting for larger vehicles like this triple-trailer combination truck as an economic strategy. Truck-only lanes are a way to separate large trucks like this one from light passenger vehicles, increasing safety while reducing congestion.

options are chosen, they likely will involve major facility investments. If past trends continue, trucks will be used to haul an increasing volume of freight. But traffic on many interstates has already become congested, and in some cases large trucks constitute a significant portion of this traffic. Under these conditions, would it make sense to separate this growing truck traffic from lighter vehicles with truck-only lanes? Several States, in fact, are considering truck-only lanes, but the costs could run into the billions. Where might the funding come from, and who ultimately should pay the cost? More precisely, how should the costs of constructing and operating those lanes be distributed among the users of special-purpose and general-purpose lanes?

The Argument for Truck-Only Lanes

The debate over whether to construct additional lanes along certain interstate highways has been receiving attention recently. In part, this interest is due to the steady increase in heavy truck traffic as the U.S. economy grows and trucking commands an increasing share of freight shipments. In *The Freight Story: A National Perspective on Enhancing Freight Transportation* (FHWA-OP-03-004), the Federal Highway Administration (FHWA) estimated that freight truck vehicle miles traveled will increase by more than 70 percent by 2020. The Transportation Research Board (TRB) in its 2003 report, *Freight Capacity for the 21st Century,* called on the U.S. Congress to study the cost and market potential of exclusive truck lanes.

Trucking advocates contend that truck-only lanes would increase the opportunities for significant improvements in the effectiveness of this freight mode, especially if longer, multitrailer trucks were allowed, as was recommended in a recent study by the Reason Foundation, *Corridors for Toll Truckways: Suggested Locations for Pilot Projects*. In addition, R.W. Stokes and S. Albert in *Preliminary Assessment of the Feasibility of an Exclusive Truck Facility for Beaumont-Houston Corridor* and F.L. Mannering in *Truck Restriction Evaluation: The Puget Sound Experience* argued that the benefits of truck-only lanes go beyond operational gains for trucking firms and include traffic safety improvements, reduced conflicts, and lower maintenance costs on general-traffic lanes. Moving heavy trucks to separate lanes could also improve the comfort and convenience of those traveling in passenger vehicles.

The Southern California Association of Governments recently conducted a study of the conditions under which truck-only lanes would be most feasible (see www.dot.ca.gov/hq/traffops/trucks/trucksize/fs-trucklanes.htm). Specific conditions that would signal a possible need for truck-only lanes include:

- Truck volumes exceeding 30 percent of the vehicle mix
- One-way traffic volumes greater than 1,800 vehicles per lane-hour during peak hours
- Offpeak volumes in each direction exceeding 1,200 vehicles per lane-hour

In *Corridors for Toll Truckways: Suggested Locations for Pilot Projects*, Robert W. Poole, Jr., and Peter Samuel used similar parameters: average daily traffic of 40,000 in each direction, with 20 percent accounted for by heavy trucks. Most rural interstates are unlikely to meet those conditions, suggesting that truck-only lanes are likely to be a cost-effective solution only when traffic volumes are comparatively high, with a sizable presence of heavy trucks.

Types of Truck-Only Lanes

Proposals for the construction of truck-only lanes vary in design and capital cost, but three general designs have been discussed most often.

1. Two additional lanes in each direction for heavy trucks only. These lanes would be separated from existing lanes, which would be limited to passenger vehicles, by barriers.
2. One additional lane in each direction that would be limited to heavy trucks, a breakdown lane, and an additional passing lane for trucks every few miles. Where feasible, the added lane would be located in the median, with a concrete barrier separating traffic flowing in opposite directions. Another barrier would separate the truck lane from existing passenger vehicle lanes.
3. One additional lane, for a total of three lanes in each direction. The right lane in each direction would be limited to trucks, the left lane to other types of vehicles, and the middle lane could be used by both groups.

Proposals also vary in terms of the configuration of entrance and exit ramps. The most extensive designs minimize interactions between heavy trucks and other vehicles, implying the need for constructing special entrance and exit ramps. They probably would be spaced farther apart than current general-purpose ramps are spaced.

Cost and Financing Of Truck-Only Lanes

In principle, the concept of truck-only lanes has fairly broad appeal, but such lanes would be expensive to construct. Poole and Samuel estimate that, in general, constructing a truck-only facility alongside an existing rural interstate would cost approximately $2.5 million per lane-mile (about $10 million per route-mile for two lanes in each direction), plus land acquisition costs, if applicable. The cost would

vary considerably, depending on right-of-way availability, topography, the need for overpass reconstruction for heavier gross vehicle weights, number of entrance and exit ramps needed, and a host of other factors. Costs in densely developed urban areas could be much higher.

Highway cost allocation studies, such as FHWA's *1997 Federal Highway Cost Allocation Study*, provide some basis for analyzing the issue of how much of the cost might be paid by various vehicle classes. Those studies estimate the cost responsibility of different vehicle classes, including the relative infrastructure wear-and-tear that each vehicle type occasions per mile traveled on various classes of roads and each vehicle's relative contribution to the need for new capacity. Cost allocation studies have not addressed the issue of truck-only lanes and do not capture all the issues that should be reflected in decisions on how to share improvement costs among the different users.

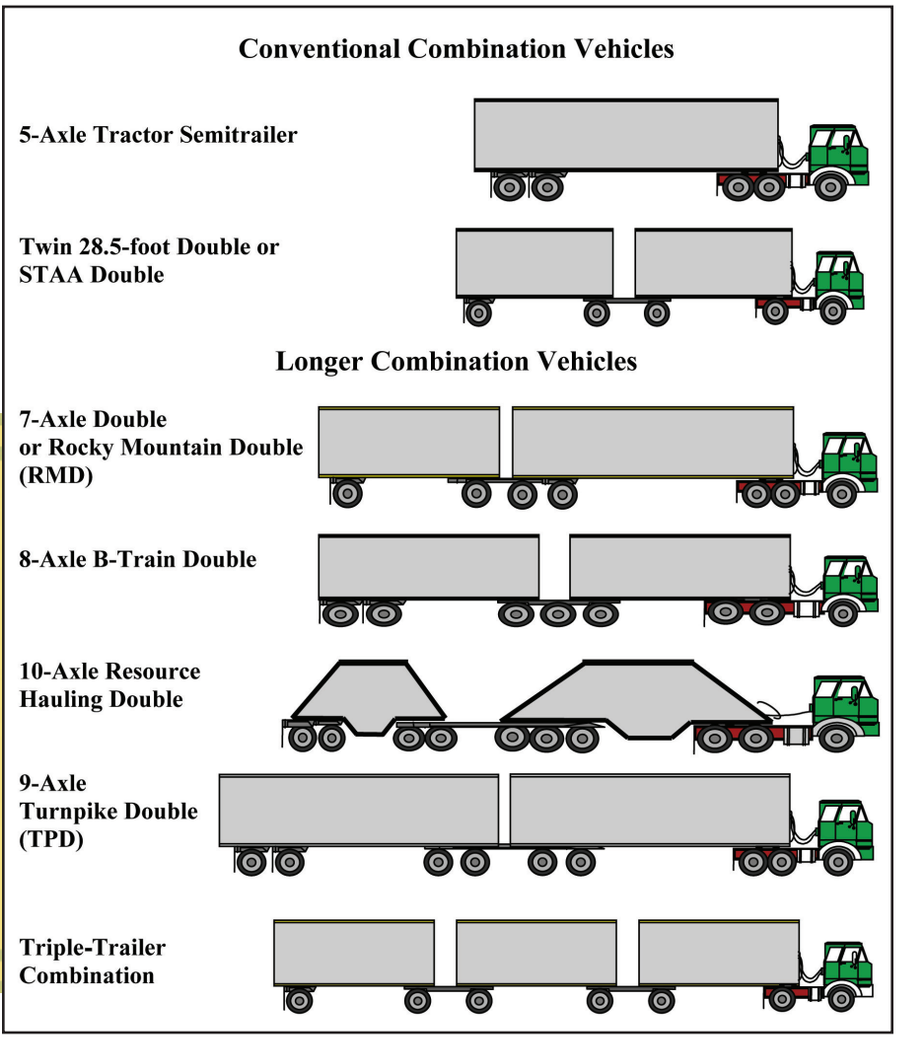
Regarding financing, truck lane proposals generally have assumed that the new lanes would be paid for through tolls. This is true for truck lane proposals in California, Virginia, and the Trans-Texas Corridor in Texas.

Many questions arise about the appropriate level of tolls, which users should pay those tolls, and the extent to which tolls can cover the full costs of the facilities. A central issue in considering financing options for truck lanes is the relative portion of costs that should be paid by trucks that use the special-purpose lanes and by other vehicles that continue to use existing lanes. Some studies have assumed that only trucks using the new truck lanes would pay a toll, others have assumed that all vehicles would pay a toll, and yet others have left that question open, recognizing the controversial nature of the issue. A recent study of the feasibility of adding truck lanes to S.R. 60 in the Los Angeles area concluded that "even if tolls were optimally applied to the truck lanes, less than 30 percent of the project costs could be recovered from project revenues."

Countering arguments that only trucks using the new truck lanes should pay for those lanes, Darren Roth, director of highway operations for the American Trucking Associations (ATA), argues, "Truck operators helped pay the capital costs of current lanes and so have an equity position in them." To the extent that this is true, a credit for this equity could be applied to their cost responsibility for the additional lanes to be constructed.

However, if during the time since the existing lanes were constructed trucks have not paid their share of the costs of wear-and-tear, it could be argued that this underpayment should be deducted from any equity credit. A rather complex accounting of costs and credits would be required to determine how much, if any, credit for trucking firms should be applied.

Another argument against charging only trucks for the costs of constructing new truck lanes is that those lanes provide additional capacity to move both people and goods in the corridor. Even though only trucks would be using the new lanes, vehicles using the existing lanes would face less congestion.



As shown in this illustration, conventional tractor semitrailers include 5-axle tractor and twin double tractor semitrailers. Common forms of longer combination vehicles (LCVs) shown here include: (1) a 7-axle Rocky Mountain double, consisting of a tractor, a 15-meter (48-foot) trailer, and an 8.5-meter (28-foot) trailer, with a total length of about 34 meters (100 feet); (2) an 8-axle B-train double; (3) a 10-axle resource hauling double; (4) a 9-axle turnpike double, consisting of two 15-meter (48-foot) trailers, with a total length of about 37 meters (120 feet); and (5) a triple-trailer combination. *Source: FHWA.*

One method for estimating the share of the new capacity costs that should be assigned to trucks and to other vehicle classes is based on their passenger car equivalencies. The concept of passenger car equivalents is used by traffic engineers to estimate the relative use of highway capacity by different classes of vehicles. Because trucks are longer and have poorer acceleration than automobiles, their contribution to congestion is greater than that of automobiles and other passenger vehicles. The *1997 Federal Highway Cost Allocation Study* used passenger car equivalents as a factor in assigning new capacity costs to different vehicle classes.

Rather than attempting to apply a cost-based approach to the issue of the share of truck lane costs that should be paid by various vehicle classes, a more workable basis for estimating the relative cost burdens of truck-only lanes might be to consider the nature and magnitude of benefits that the two groups of users would be likely to derive if truck-only lanes were constructed. These benefits influence the willingness to pay on the part of each group.

Benefits to Trucking Firms

The key potential benefits of truck-only lanes to trucking firms would be fourfold. First, the firms would be far less exposed to the risk of car-truck crashes, many of which result from errors on the part of passenger-vehicle drivers. In 2001, according to the National Highway Traffic Safety Administration's Fatality Analysis Reporting System, 631 fatalities resulted from collisions involving combination trucks on noninterchange sections of rural interstate highways. According to FHWA, in 71 percent of two-vehicle fatal crashes involving a large truck and another vehicle, police reported "one or more errors or other factors" related to the behavior of the passenger vehicle driver and none for the truck driver. Reduced involvement in serious crashes would be an economic benefit to the trucking industry.

Second, with lower traffic volumes in the lanes they would occupy, trucks could operate more efficiently Reduced need for braking, accelerating, and overtaking would decrease per-mile operating costs. If longer combination vehicles (LCVs)—longer twin-trailer or three-trailer combination trucks with gross weights of up to 68,100 kilograms (150,000 pounds)—were allowed in truck-only lanes, as has been proposed by Poole and Samuel in their Reason Foundation report, the total number of trucks required to carry a given quantity of freight could be reduced. The reduction in potential truck travel would depend on a number of factors, including how extensive a truck lane network was in place, what regulations were imposed on LCV use off the truck lanes, and the toll rates charged for LCVs and other trucks operating on those facilities. The U.S. Department of Transportation's (USDOT) *Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association* estimated that allowing uniform LCV use throughout a group of Western States could result in a 25-percent reduction in truck travel, but travel

Truck-only lanes might help improve traffic flow for lighter vehicles, as shown in this photo.

reductions on a smaller network of truck-only lanes would not be expected to result in as great a travel reduction.

Third, the added capacity would help alleviate congestion, thereby reducing travel time and the uncertainty of arrival time. In *The Freight Story: A National Perspective on Enhancing Freight Transportation* (FHWA-OP-03-004), FHWA estimated in 2001 that of the Nation's 53,117 kilometers (32,992 miles) of rural interstate highways, 842 kilometers (523 miles) or 1.6 percent were "severely congested," and another 2,091 kilometers (1,299 miles) or 3.9 percent also were congested, albeit not as severely. With projected growth in vehicle miles traveled on rural interstates, congestion will grow, absent capacity increases, and trucking firms' costs will increase. It should be stressed, however, that it is unlikely congestion will be widespread on rural interstates in the foreseeable future, according to an article by W.G. Waters II, Cary Wong, and Kevin Megale, "The Value of Commercial Vehicle Time Savings for the Evaluation of Highway Investments: A Resource Saving Approach," which appeared in the *Journal of the Transportation Research Forum* in 1995.

Timely and reliable trucking is essential to an economy in which businesses keep inventories low and use just-in-time delivery to keep costs down and maintain responsiveness to customers. This explains in part why the value of time for trucks is much higher than for passenger travel. The value of time used by FHWA is $25.24 per vehicle-hour for large trucks, compared to $15.71 for small cars. In other studies in the United States and Europe, estimated values of time for trucking range as high as $193.80, with a median value among the studies of $40 and a mean of $51.80. The value of reliability (that is, the cost of unexpected delay) is another 50 to 250 percent higher than these values of time. The effects of recurring and nonrecurring delay discussed in Chapter 21 of the FHWA report to Congress, *Status of the Nation's Highways, Bridges, and Transit: 2002 Conditions and Performance Report,* are thus greatly magnified for trucking and therefore for the role that trucking plays in the economy.

Fourth, the argument for greater use of LCVs would be strengthened because they would not need to operate in the same lanes as passenger vehicles. Most States and USDOT currently oppose more widespread use of LCVs on existing highways, but if such vehicles were restricted to exclusive truck lanes, some of the basis for this opposition might be eliminated. For trucking firms, the benefits are related to productivity improvements, although the gains are net of the cost of acquiring LCVs. "Various authors contend that longer combination vehicles have considerable potential for improving the productivity of the trucking industry," says ATA's Roth.

Benefits to Passenger Vehicles

In general, passenger vehicles could benefit from truck-only lanes in three ways. First, safety would improve. According to the Federal Motor Carrier Safety Administration's *Large Truck Crash Facts 2003* (FMCSA-RI-04-033), published February 2005, of all crashes involving large trucks and passenger vehicles, 84 percent of the fatalities in 2003 were passengers in vehicles other than the large truck. The great differential in size and mass generally places the occupants of the passenger vehicle at a major disadvantage in such collisions. Thus, separating trucks from passenger vehicles could substantially improve the safety of passenger vehicle travel because approximately 12 percent of all passenger vehicle occupant fatalities occur in crashes with heavy trucks.

In addition, the quality of the traveling experience would improve. Large trucks can intimidate motorists traveling in passenger vehicles. It is not unusual for relatively small passenger vehicles to be boxed in by trucks in front, behind, and alongside them. If all vehicles in the general-traffic lanes were roughly the same size, there would be less stress on those motorists who are nervous about sharing the road with large trucks.

Truck-only lanes also would help improve speeds. Because the acceleration and braking performance of trucks is much lower than that of most passenger vehicles, removing trucks could substantially improve the flow of segments with heavy traffic. According to TRB's *Highway Capacity Manual 2000*, one combination truck takes up approximately the same road capacity as 1.8 to 8.0 autos, depending on the terrain and traffic conditions. A caveat is that in some instances improved traffic flow may induce additional traffic.

Estimating Willingness to Pay

Somewhat different approaches are needed to estimate the benefits to occupants of passenger vehicles versus operators of heavy trucks. For passenger vehicles, the issue is willingness to pay to enjoy the aforementioned benefits of driving on highways without trucks.

In "Measuring the Non-Pecuniary Costs of Triple Trailer Operation in Oregon: A Contingent Valuation Approach," published in 1996 in the *Journal of the Transportation Research Forum*, Anita Bambe and B. Starr McMullen explored the amount that operators of passenger vehicles would be willing to pay to have trucks moved to separate lanes. Using contingent valuation analysis, a method for estimating nonmarket prices, they found that motorists would be willing to pay about $35 (1995 dollars, equating to approximately $41 in 2004 dollars) annually to remove triple-trailer combination trucks from Oregon's highways. Contingent valuation is an especially appropriate approach for gauging benefits because it involves asking participants about their willingness to pay for changes in goods or policies.

The Bambe and McMullen analysis has the advantage of not being hypothetical because triple-trailer trucks are allowed in that State, so respondents were familiar with the circumstances addressed in the study. The nonhypothetical nature of the study is important. As a practical matter, it usually is difficult to accurately estimate willingness to pay for goods or services that are not currently available because there is no functioning market. In hypothetical situations, there can be a tendency for people to misstate their willingness to pay either because the situation is not one with which they are sufficiently familiar or because it may not be in their best interest to express their full willingness to pay. Also, there is no consequence of

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Truck-only lanes could accommodate triple-trailer combination trucks like these two in Oregon, where LCVs are allowed.

making a statement about one's preference because of the hypothetical nature of the situation.

The New Jersey Turnpike is a potential case study of revealed preference regarding travel choices by operators of passenger vehicles in auto-only and auto-truck lanes. This facility has barrier-separated lanes that are available only to autos and other lanes that are open to autos and other types of vehicles, including heavy trucks.

Improvements in Trucking Productivity

An analysis by Herbert Weinblatt for FHWA in a 1991 working paper titled "The Effect of Size and Weight Limits on Truck Costs" concluded that on a cost-per-ton basis in comparison to a standard 16-meter (53-foot), five-axle combination truck with a gross vehicle weight of 35,412 kilograms (78,000 pounds):

- A seven-axle, triple 8.5-meter (28-foot) trailer truck with a gross vehicle weight of 52,664 kilograms (116,000 pounds) would be 20.1 percent more productive.
- A nine-axle, twin 15-meter (48-foot) trailer truck (turnpike double) with a gross vehicle weight of 57,840 kilograms (127,400 pounds) would be 23.8 percent more productive.

In *The Feasibility of a Nationwide Network for Longer Combination Vehicles*, published by USDOT in 1986, D.J. Maio estimated that for volume-limited cargo, a national LCV network would allow 23 to 42 percent productivity gains, while for weight-limited cargo the increase in productivity would be about 17 to 32 percent.

"Although a national network of highways on which LCVs would be permitted would produce maximum productivity gains given financial, political, and engineering constraints, this is neither possible nor desirable," says ATA's Roth. "Constructing truck-only lanes in a limited number of locations is far more realistic, and although productivity increases would be more modest, substantial benefits are possible on a regional basis."

Financing Mechanisms

Estimating the potential benefits to users of general-traffic lanes and to

operators of heavy trucks provides one basis for assessing the relative amount that users of those lanes should contribute toward the cost of new truck lanes. A related issue is how these costs should be paid. As noted above, most States that are considering truck-only lanes are assuming those lanes would be paid for at least in part by tolls. Once a decision is made to pay for the new lanes through tolls, a further question is whether existing lanes carrying passenger vehicles also should be tolled or should only the truck lanes be tolled? Answers to this question will in part determine the extent to which tolls can cover the full cost of the added lanes or whether other revenue sources will have to be tapped as well.

Another question related to the use of tolls is whether a credit should be given for fuel taxes paid on travel that is also tolled. Whether such a credit is applied or not, the amount paid via a toll and/or through the fuel tax should total the amount determined that various users should pay based on the benefits they receive. "If both methods of collection are used simultaneously, some may regard it as double taxation," says ATA's Roth.

To raise the necessary capital for constructing the truck-only lanes, a State probably would choose to issue revenue bonds, which would be secured mainly by future toll revenues. Or, as Virginia is considering, the State could allow a private-sector firm to finance part of the improvement cost and collect toll revenues to repay private debt and equity contributions. Regardless of whether public or private financing was used, if tolls were levied, they would still apply to some or all users of the facility. Two alternative scenarios can be examined. The first would involve toll payment only by large trucks, and the second would entail payment of tolls by passenger vehicles as well.

Scenario 1: Tolls Paid Only by Large Trucks

In this scenario, it is assumed that bonds would be issued to cover the share of the capital cost to be defrayed by tolls paid by large trucks. The share of capital costs to be covered by passenger traffic would be paid from the State's road-use tax fund. The road-use tax fund in most States depends on general-user charges (primarily motor fuel taxes and registration fees). General-user charges paid into the road-use tax fund by large trucks would be used for operation and maintenance (O&M) of the truck-only lanes. An alternative not examined in detail in this article would be to have truck tolls cover not only trucks' share of capital costs, but also their share of O&M costs. Depending on the nature of the project, it might also be possible to cover part of the cost from other private-sector beneficiaries that own and develop land adjacent to the new truck lanes, but current truck lane proposals are not looking at such options.

Scenario 2: Tolls Paid By All Vehicles

Another scenario would require passenger vehicles traveling in the general-traffic lanes to pay tolls, just as large trucks operating in the truck-only lanes would. Tolls paid by passenger vehicles would be justified on the basis of motorists being able to travel with faster and more consistent speeds, without the safety risks due to heavy trucks operating in the same traffic stream, and with the more relaxed environment made possible by the elimination of large trucks from passenger vehicle lanes.

In short, the occupants of the passenger vehicles would be offered a higher quality service with the addition of truck-only lanes, and they would be asked to pay a premium for this higher quality service. Motorists have been very reluctant to pay tolls on lanes that previously were not tolled, and it may be difficult to obtain support for this scenario unless motorists are willing to pay for having trucks shift to the new truck lanes.

Setting Toll Levels

As discussed, the cost of truck-only lanes could reasonably be assigned to passenger vehicles and to large trucks based on the relative benefits each group of road users would derive. Estimates of toll rates are possible through analyses of the benefits and by application of approaches such as contingent valuation analysis, which are aimed at gauging how much various road users would be willing to pay for the separation of heavy trucks into different lanes.

A practical issue arises, however, in setting the level of tolls on road users to finance the construction

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The capital for constructing truck-only lanes like this one in Oregon is most likely to come from issuing bonds that are repaid by revenues from tolls paid by passenger vehicles and trucks.

and O&M costs of truck-only lanes: the issue of diversion. If a trucking firm believes that the economic benefits of traveling on a highway with truck-only lanes are not commensurate with the magnitude of the toll for using the facility, the company will search for an alternate route that entails lower overall costs.

The likelihood of diversion depends on the following factors:

- Availability of alternative routes that are not excessively circuitous and that allow an acceptable speed and level of safety
- Length of the haul, as longer trips are more likely to offer more choices of routes
- Level of the toll for traveling on the truck-only lanes
- Whether LCVs are allowed on the truck-only lanes and whether use of an LCV is appropriate for the trip in question
- How timely the delivery is required to be and whether truck-only lanes are likely to produce a comparatively low time variability en route

Potential Traffic Diversion

In a 2004 study for the Virginia Department of Rail and Public Transportation, *The Impact of Tolls on Freight Movement for I–81 in Virginia*, Reebie Associates estimated the likely diversion if truck-only lanes were established on I–81. Their modeling effort led them to conclude that to a point, the numbers of heavy trucks that would divert from a truck-only facility are approximately linear with the cost of tolls per mile. Reebie estimated that toll levels above $0.20 per mile would bring about sufficient diversion that such tolls would be counterproductive. Rather, the researchers concluded that toll levels in the range of $0.15 to $0.20 per mile probably would produce optimal results.

Their analysis, of course, applies to circumstances where diversion is possible. The exact toll rates that would be optimal would vary from case to case depending on the proximity and quality of alternative routes and the other factors noted above. Diversion of traffic from truck-only lanes on the interstate system to other routes could have undesired impacts on those other routes. The magnitude of these impacts would depend on the characteristics of the diversion route(s) and the surrounding land uses. In general, diverting truck traffic from interstate highways to lower order roads will increase potential safety problems, pavement wear, and traffic disruption.

The Reebie analysis did not consider the potential for LCV use of the truck lanes since LCVs were not part of the Commonwealth of Virginia's plan. If LCVs were being considered, another potential type of diversion that could be a concern is diversion of rail traffic to LCVs. The extent of potential rail diversion would depend on many factors, but railroads can be expected to raise concerns about rail diversion if LCVs were allowed on truck-only lanes.

Truck Tolls That Are Commensurate with Economic Gains

As noted above, operators of heavy trucks stand to gain economically from truck-only lanes. One way to estimate a reasonable toll rate would be to estimate total gains that typical trucks realize from use of the toll lanes, to allow operators of those trucks to keep a certain portion of that gain, and to require that they pay the remainder to the public- or private-sector organization that constructed the improvement.

Increased productivity for trucks traveling in truck-only lanes would stem from two separate but related sources: reduced costs due to traveling on the improved facility and the possible use of LCVs, which can enhance trucking productivity. In a 2002 report for the Reason Public Policy Institute, *Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation*, Peter Samuel, Robert W. Poole, Jr., and Jose Holguin-Veras estimated

Al Covey, VDOT

Researchers for the Virginia Department of Rail and Public Transportation studied the likelihood of truck companies diverting to other routes if truck-only lanes were established on congested I–81 in Virginia, shown here in Roanoke County north of Salem.

productivity gains to trucking firms that could be attributed to allowing LCVs to operate on a national system of highways. Using a specific set of conditions, Samuel and his colleagues estimated gains from operating on a truck-only facility that allows axle loads 50 percent higher than those currently allowed in the United States. Under those conditions, the authors concluded, a $3.04 per vehicle-mile increase in productivity could result for an LCV that is 37 meters (120 feet) in length with a maximum gross weight of 79,450 kilograms (175,000 pounds) and an average cargo weight of 29,964 kilograms (66,000 pounds).

Samuel and his colleagues further suggested that the toll assessed to LCVs operating in truck-only lanes should be half of the productivity gains experienced by the trucking firm by virtue of their being allowed to operate LCVs in the relatively unencumbered truck-only lanes. Their reasoning is that a 50-percent productivity gain is a reasonable return to trucking firms, given that in many instances new rolling stock would have to be procured, and because LCVs would have to be broken down into shorter rigs once off the special facility. Within a given firm, multiple varieties of trucks would be required to operate on these and other facilities.

The authors' analysis of potential productivity gains led them to conclude that a per-mile toll of up to $1.50 would be possible, which would amount to half of the productivity gain. Whether the toll for heavy trucks should be set at half of the productivity gains or at some other level is an open question. More information is needed on the productivity gains likely in various segments of the trucking market, both with and without LCVs being allowed; the trucking industry's response to the option of operating on truck-only lanes and the associated option of using LCVs on these routes; capital, operating, and maintenance costs of adding truck-only lanes; and passenger vehicle occupants' willingness to pay for a higher quality traveling environment and therefore the tolls that could be assessed to them.

Not all States would want to allow LCVs on truck-only lanes. Furthermore, the LCV freeze instituted in the Intermodal Surface Transportation Efficiency Act of 1991 currently prohibits expanded LCV operations. The same kind of productivity analysis could be carried out assuming that only standard-sized trucks would be allowed on the truck lanes. Productivity gains would be lower and thus the maximum toll that could be charged would be lower, but such a scenario still might be feasible in some locations.

Conclusions

Adding truck-only lanes to existing highways would be expensive enough that State and local DOTs are unlikely to find sufficient resources to fund them using traditional sources, such as a State's road-use tax fund. Therefore, tolls would likely be assessed on users of the improved facility. In terms of financing, the central policy questions are who should pay these tolls and how high the tolls should be.

For each potential truck lane project, a feasibility analysis could be carried out that takes into account the following:

- Current traffic volume by time of day, flow speed, safety record, and percentage of traffic due to heavy trucks
- Potential for trucking productivity gains if the truck-only lanes were added, including an assessment of whether the State would want to pursue the possibility of allowing LCVs to operate on the new lanes
- Potential offsets to productivity gains that could result from diversion of truck traffic to other lower order roads or diversion rail traffic to highways
- Potential environmental, community, and other social costs associated with the operation of truck-only lanes
- Cost of adding the lanes with a suitable number of entry and exit points and design features to minimize interactions between trucks and other traffic as trucks are moving on and off the truck-only lanes

The above analysis suggests that truck operators would receive the majority of benefits from truck-only lanes and ideally should pay the preponderance of costs. Unless the traffic stream contained a sufficient number of heavy trucks, the toll levels for these special-purpose lanes may be high enough to prompt significant diversion of truck traffic to nontolled facilities. Allowing LCVs to use the truck-only lanes, as has been proposed by Poole and Samuel, could enable public- or private-sector operators to charge higher tolls while limiting the diversion of truck travel to alternative roads. There are many obstacles, however, including legislative and environmental issues, to allowing LCV use, even if those vehicles were limited to dedicated truck lanes.

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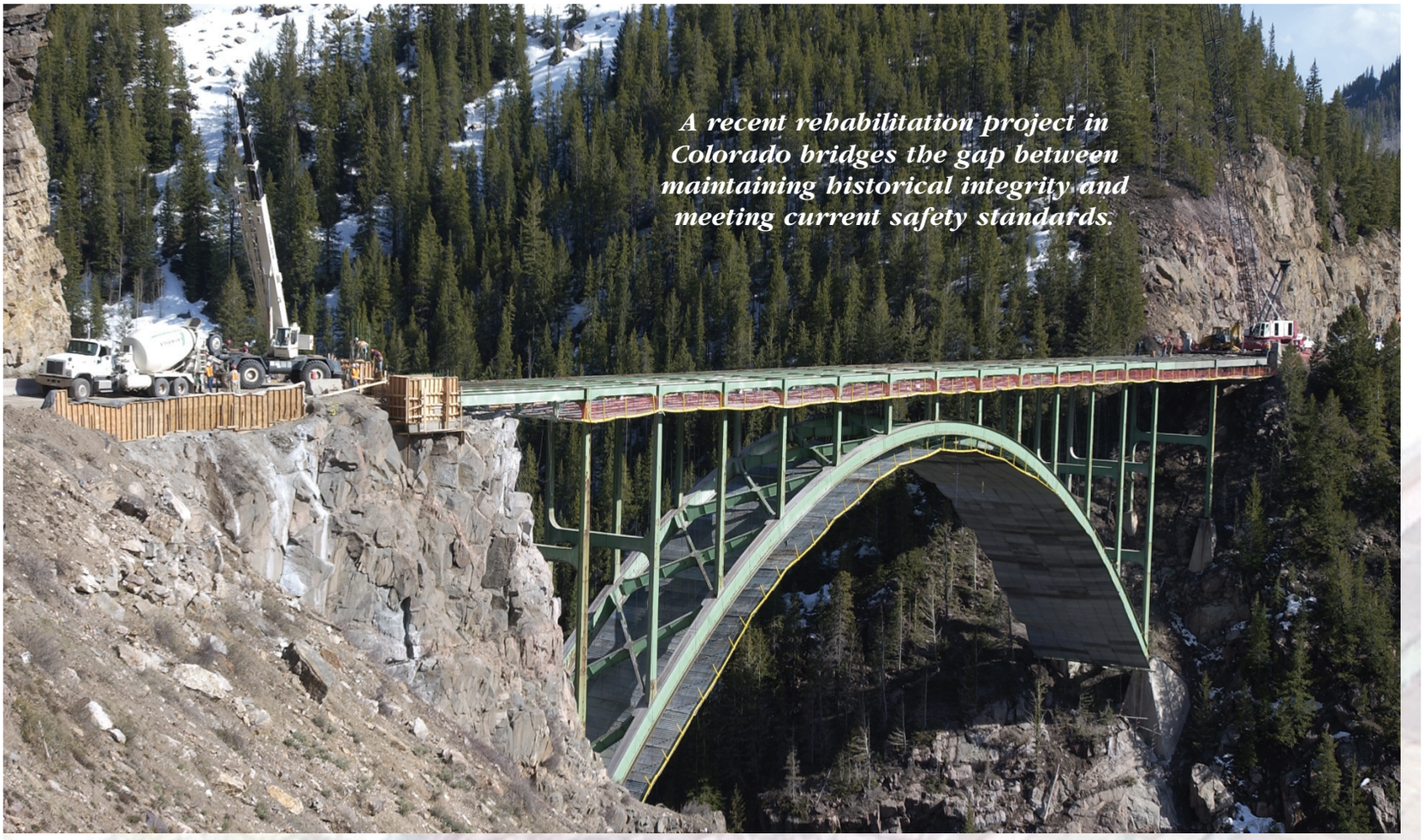
This article is the second in a series on innovative financing that will continue to run in the next few issues of PUBLIC ROADS. One of FHWA's priorities is encouraging the use of innovative financing.



A recent rehabilitation project in Colorado bridges the gap between maintaining historical integrity and meeting current safety standards.

Preserving Red Cliff Arch

by Nancy Shanks

According to his peers in the transportation industry, many considered Colorado bridge design engineer King Burghardt to be ahead of his time. Today, more than 60 years after Burghardt designed one of his State's most aesthetically notable structures, bridge design and construction engineers at the Colorado Department of Transportation (CDOT) challenged themselves to "think historic" when planning to rehabilitate the Red Cliff Arch Bridge.

Historic preservation was a major consideration, as the bridge is located on a section of highway that represents an important link along Colorado's Top of the Rockies National Scenic and Historic Byway. In addition, the bridge itself is a historic structure and was added to the National Register of Historic Places in 1985. CDOT's historian and the Colorado Historical Society provided consultation early in the design phase, offering feedback on construction drawings. In addition, prior to the start of the work, the Colorado Historical Society photographed and videotaped the bridge to document the historical aspects of the structure.

While preserving the bridge's historical features, CDOT officials needed to update the structure to meet current Federal safety standards. "After 60 years of service and enduring the effects of weather at 8,790 feet [2,680 meters] above sea level, the bridge required major rehabilitation," says Peter Lombardi, CDOT project engineer. "The concrete, reinforcing steel, and paint on the structural steel were decaying to the point where they were straining maintenance forces' ability to keep up with the repairs."

The 64-year-old Red Cliff Arch Bridge—which carries U.S. Highway 24

(Above) Workers are beginning substructure work on the north approach to the Red Cliff Arch Bridge in Colorado's Rocky Mountain region.

All photos by Gregg Gargan, CDOT.

over Eagle River in Colorado's Rocky Mountain region—is one of the State's two remaining steel arch bridges. CDOT officials expected the rehabilitation to be a daunting project, one that would require 21st-century design engineers to come to the table with historical sensitivities, and construction workers to come to the work site with the guts to deal with the inherent hazards of the project.

According to historical documents, the original work on the structure required long days of hanging from a cantilevered platform—61 meters (200 feet) above the canyon floor—in sometimes subzero temperatures. Burghardt had written in his journal, "In the morning, each gang was lifted to its scaffold on a platform hung from the high line. They took their lunches with them and spent the entire day in the air with the winter wind continually blowing up the canyon."

The rehabilitation project began in early March 2004, and the ribbon-cutting occurred the following November (176 working days later), just before the early winter snows began to fall. Even without having to contend with the subzero temperatures typical of winter in that region, crews still had their work cut out for them.

"We knew the rehabilitation project would present challenges yet be very rewarding," says CDOT Resident Engineer Keith Powers. "The structure hangs above a deep gorge, creating a tenuous situation for workers at times, environmental considerations to address, and impacts on the Red Cliff community."

Getting Prepared

The $3.6 million rehabilitation work focused primarily on replacing and widening the bridge deck as well as repainting the steel portions, while maintaining the historic structure's appearance. The project also involved extensive work on the abutments, girders, and bridge rail. By comparison, the contract for constructing the original concrete abutment, piers, and arch pedestals in 1939 totaled $218,817, and fabricating and erecting the massive steel arch cost $153,590.

A number of concerns made the rehabilitation necessary and timely. Potholes in the bridge deck were increasing in size and becoming more commonplace. Due to the deteriorated condition of the wearing surface, maintenance repairs were not always effective, increasing the urgency of replacing the deck. In addition, the structural steel was corroding due to the failure of the paint system. The bridge had been painted three times since its original construction and required additional attention. But this time the entire paint system would need to be removed, down to the bare metal, and replaced with a new coating.

CDOT also completed preventive maintenance on the bridge piers and foundations. A shoulder retention wall near the bridge was secured to solid rock below by rock anchors to accommodate the widened template

The contractor uses a backhoe to remove the architectural rail for refurbishment.

Using heavy equipment, workers remove the existing deck from the bridge.

Scaffolding installed under the bridge deck (above) provides a safe and efficient platform for the workers and inspectors. A view of the bridge from below (left) shows the scaffolding in place beneath the arch, where it helps protect the county road and river from falling objects.

of U.S. 24 and prevent further sloughing of the fractured surface rock. This work included placing concrete around the toes of the bridge piers to curb the erosion that had occurred over the last 60 years. Workers removed the deteriorated surface concrete on the piers and, after dowelling new reinforcing steel into the sound concrete below, added concrete to bring the pier back to its original shape.

Other maintenance safeguards included rehabilitating the old bridge rail, which was cleaned of paint and rust and then hot-dipped galvanized for corrosion resistance. Micropiles were used for the new retaining walls north of the bridge to protect the roadway from further erosion.

Safety First

"Accomplishing this project while keeping crews safe was a primary concern for us," says Matt Cirulli, project superintendent for Lawrence Construction, the primary contractor on the rehabilitation project. "One of the biggest challenges in the work was, of course, the height of the structure, which rendered conventional construction methods impractical."

The contractor used an innovative work platform to provide a safe and efficient area for the workers and inspectors, contain falling objects, and protect the county road, Eagle River, and Union Pacific Railroad tracks below. Instead of erecting traditional rigid scaffolding, cables were strung from brackets and hangers attached to the flanges of the girders and stringers. The crews then strung two spans of corrugated steel panels to form working platforms and tightened the cables for support. One scaffolding system provided access beneath the deck, and the other beneath the structural steel members of the arch.

Removing the existing paint and recoating the structure presented another safety concern. Given the age of the bridge, CDOT and the contractor assumed that the existing paint system included lead-based paints. Removing the lead-contaminated paint required crews to encase the work areas completely and provide proper venting and containment of all paint removed. The workers used negative vacuum pressure to ensure containment as they sandblasted the paint, ran it through a filter, and bagged it for safe disposal in a landfill. Because of these safety procedures, crews ultimately were successful in removing the existing paint without harming the environment or their own health.

"This work was no small task," Powers says. "Our crews had to labor in a tight canyon, dealing with the effects of high altitude, fast-moving storms, high winds, and tough access. All this meant that containment was constantly being attended to."

To protect the bridge from corrosion, the coating contractor removed the old lead-based paint down to the bright metal and repainted the structure with a new three-coat paint system that retained the same green color of the existing arch.

Rebuilding with Modern Equipment

Like the new paint, the bridge repairs and upgrades also needed to blend visually into the structure to maintain its historic integrity. "When designing the rehabilitation, we minimized the visual changes to the bridge and adjacent roadway," says CDOT Bridge Designer Andy Pott. "All architectural elements such as the wingposts and pylons were duplicated from the original drawings."

The new exterior curb approximates the original curb with similar rail supports. Workers refurbished the original rail and reused it on the widened 1.8-meter (6-foot) deck, placing it outside a new crash-tested Type 10 bridge rail (a two-tube steel rail with concrete curb), so views of the bridge from a distance remain the same.

In removing the concrete deck, crews used 92-centimeter (36-inch) diamond-blade concrete saws to cut away portions from the bridge. Each portion could weigh no more than 2,270 kilograms (5,000 pounds). The workers used track excavators with hydraulic thumbs to peel off pieces of the crumbling deck. The work proceeded from the middle span so the bridge was unloaded evenly from alternate sides, keeping the structural loads balanced. To protect the structure, placement of the cast-in-place deck also was sequenced in a similar manner.

After the concrete decking was removed, crews jacked up the girders and replaced the concrete abutments on both ends. Working within tight tolerances and maintaining a high degree of craftsmanship also were among the challenges. According to project manager Cirulli, deciding on a concrete form for the pylons took a lot of time and effort. The contractor could not find a ready-made form on the market to cast the four corner pylons, and building the form in the field individually for each corner would have required additional time. Instead, the contractor commissioned a single, strong hand-built form that could be reused for the four pylons. The form was in two pieces, clamped together to create a pylon, which allowed the concrete to be poured in place monolithically. Once the concrete had enough strength, the form was removed and used to pour the next pylon. Workers used a forklift to move the forms. This procedure expedited the project, as the form was reused instead of rebuilt.

To increase the safety of the girder supports and strengthen the bridge to handle heavier loads, the contractors welded and bolted steel brackets to the structure and straightened the steel components that had been struck over the years by falling rocks. Workers employed heat-based straightening techniques to remove the dents. To avoid future damage, a subcontractor draped a cable net on the rock face of the north abutment, cable-lashed the large outcroppings, and removed the loose rocks on the south abutment slope. Brackets added to the girder connections supplement the support provided by the existing clip-angle connections. To strengthen the bridge to carry heavier loads, shear connectors were added to the existing girders to make them composite with the deck. The girders and deck now act as a single unit to resist loads. This modification increased

With the concrete deck and abutment removed, the bridge awaits placement of the new deck.

During the paint removal process, shown here, workers enclose the work area in vacuum-sealed plastic to contain and collect lead-based paint debris for safe disposal offsite.

A worker wearing a safety harness and protective clothing is spraying a new coat of paint on a bridge girder.

the load rating of the bridge enough to remove load restrictions.

The new cast-in-place deck features a silica-fume concrete, which is a newer CDOT mix (Class H) selected for its durability and ability to be left as a bare deck without a waterproofing membrane and overlay. The dense silica-fume mix resists water intrusion more effectively than ordinary concrete and provides additional protection to the deck's reinforcing steel.

Communicating With the Public

Aside from the challenges involved in the construction process, CDOT needed to manage the important issue of media outreach and public relations. The rehabilitation work necessitated a full closure of the bridge from May to July 2004, affecting not only travelers but also residents and business owners from the town of Red Cliff, which is nestled into the landscape below the bridge. Though Red Cliff remained accessible via secondary roads near both ends of the bridge, messages regarding the bridge work and highway closures were sure to confuse some motorists.

"Traffic was a significant inconvenience for motorists, as well as the residents of Red Cliff, who ultimately endured increased through-traffic through their narrow town streets," CDOT's Lombardi says. "Although residents did not want detoured commuter traffic passing through town, they did not want to discourage the tourists from visiting. Trying to convey these two polar messages was a challenge."

CDOT met with community members prior to the project start date to work through the details of communicating the bridge closure without discouraging visitors to Red Cliff's restaurants and art studios—the lifelines of this small tourist community. Press releases, variable message signs, public announcements, and flyers all were relatively successful, according to CDOT officials, but a predominant message prevailed: ROAD CLOSED.

"We definitely took a hit when the bridge closure first began," says then-Town Manager of Red Cliff Guy Patterson, who contacted several area chambers of commerce anonymously to pose the question, "Can I get to Red Cliff from I–70?" "It took some additional, individual public relations to relay the message that Red Cliff was open for business—and we did okay after the bridge reopened. I have to say, the bridge looks great—we were glad it was done."

Another critical issue for the town was the wear-and-tear on its local roads due to the detoured traffic, including construction vehicles. When the bridge work was completed, construction crews patched and applied a chip seal to the road through Red Cliff.

Ready for Another 60 Years

Although the Red Cliff Arch Bridge received quite a facelift, its "surgeons" were careful to hide the evidence. The major changes were

Workers use a screed and finishing machine to smooth the concrete applied during the second deck pour on the north end of the bridge.

In October 2004, as the project neared completion, workers put the final touches on a new name plaque mounted on a concrete wingpost, an architectural feature that was removed and replaced during construction.

made primarily where safety was concerned: The structure was widened to accommodate modern traffic volumes, new bridge railing was added, and new materials were used where possible to enhance the bridge's service life and durability. But as far as its appearance is concerned, only the most discerning eye or astute historian will detect any modern updates. Most will simply see that the bridge looks brighter, perhaps cleaned up a bit. And that was the goal.

"The most important visual aspect of the bridge—the arch itself—was left the same," Pott says. "We merely cleaned and repainted the bridge to maintain it for future generations to enjoy."

Nancy Shanks has worked in the CDOT Public Relations Office for 8 years. In 2002, she relocated to the department's Durango office in the southwestern corner of the State. She is the public relations manager for CDOT's two western slope regions.

Note: The Red Cliff Arch Bridge was placed on the National Park Service's National Register of Historic Places in 1985, and the survey is archived at the Colorado Historical Society, Office of Archaeology and Historic Preservation, in Denver.

The author would like to thank Carol Carder, a contract writer for CDOT and FHWA, for contributing to this story.

This custom-built form enabled the contractor to pour the four pylons quickly without having to rebuild the form, saving valuable time on the project.

by James L. Sipes

Curb Appeal

Nevada is making aesthetics a central component of highway design.

The United States has become a society built around automobiles, and highways are the driving force shaping the landscape of many U.S. communities. The growth of the highway network definitely has had and will continue to have a visual impact on the environment.

Historically, many of the Nation's roads were designed using a utilitarian approach emphasizing safety and operations, interconnecting States, and accommodating growing traffic volumes. Aesthetic considerations often were limited to those directly related to a highway structure such as an overpass. Some of the results of this approach included freestanding walls that blocked views of surrounding mountains and bridges that lacked any visual appeal. Until recently, some States still followed that philosophy.

Nevada, the fastest growing State in the Nation according to the 2000 census, had traditionally followed the utilitarian philosophy. "In an effort to keep up with the changes, the philosophy of the Nevada Department of Transportation [NDOT] has been to build as much road as possible while doing it safely and cost effectively," says Ron Blakemore, supervising landscape architect with NDOT.

In recent years, NDOT has learned that aesthetic values are among the most important concerns to the communities with new highway projects. That is, to borrow a real estate term, the public wants highways and highway infrastructure to have "curb appeal," or exterior attractiveness, whether it means plantings, color treatments, facades, or other aesthetic elements.

A Master Plan

One NDOT project provided the impetus for Nevada to change its way of doing business. The Carson City Bypass was originally designed to follow a rather utilitarian approach, like other projects. According to Mark Hoversten, professor of landscape architecture at the University of Nevada, Las Vegas (UNLV), when the designs for the bypass were 60 percent complete, however, several organizations and citizens in Carson City banded together to oppose the project. Part of their concern was for improved landscaping, color schemes, and aesthetic treatments for the sound walls on the project. In addition, there were other community-related issues not directly related to aesthetics, such as inclusion of a bike path required in the transportation plan and traffic calming to alleviate impacts on local neighborhoods. Therefore, NDOT abandoned the original plans and went back to square one.

Nevada Governor Kenny C. Guinn directed NDOT to develop a strategy to help avoid similar problems in future transportation projects. NDOT conducted a study that helped with development of a final plan, *Pattern and Palette of Place: A Landscape and Aesthetics Master Plan for the Nevada State Highway System*. The master plan outlines a policy of integrating aesthetics into the design of all major highway projects in Nevada. NDOT adopted the master plan in 2002, and the State Transportation Board then adopted it as policy.

To help develop the master plan, former Nevada Attorney General Frankie Sue Del Papa, at the time a member of the State Transportation

(Above) The new *Landscape and Aesthetics Master Plan for the Nevada State Highway System* will guide NDOT in designing roadways that do justice to the scenery along roads such as S.R. 159, seen here entering Red Rock Canyon National Conservation Area. *Photo: UNLV.*

Board, contacted the landscape architecture program at UNLV because of its experience working on community-oriented design activities and projects. The master plan is designed to guide decisions and policies that will affect the aesthetic quality of all Nevada highways by setting a new standard for all transportation projects within the State, and it establishes a vision, policies, procedures, and guidelines. This master plan also defines a planning process for future projects.

"We have an incredible opportunity in this State, and everything we are doing today will have an effect on how highways are developed for the next 50 years," says Blakemore. "This plan is enabling [Nevada] to develop better projects and highways that not only look good but are safer and have a better fit with the environment."

Corridor Plans

Once the State Transportation Board had adopted the master plan, NDOT brought in a team of landscape architects and engineers to implement the concepts in the plan. The master plan will be followed by three other phases: corridor planning; project design; and construction, operations, and maintenance.

The landscape and aesthetic corridor plans build on the master plan to provide design guidance and priorities for making day-to-day decisions on specific projects. Out of 11 corridors, NDOT designated three as high priority and is currently developing plans for them: the Interstate 15 corridor, Interstate 80 urban corridor, and Interstate 80 rural corridor.

Each corridor plan includes final recommendations and a detailed vision for the landscape and aesthetic features. The vision synthesizes historic, current, and future conditions into a comprehensive guide to improve the corridor's visual appearance and contextual fit with the landscape.

To analyze the environmental features of the I–15 corridor, the design team gathered and analyzed data from a variety of sources. This map summarizes environmental features such as unique plant communities, scenic geological features, lakes, wetlands, riparian ecosystems, playas, elk habitat, bighorn sheep habitat, and national conservation areas.

Design Workshop, Inc.

The Nevada master plan encourages the use of native plant species, such as those shown here, as the revegetative palette, but also adds regionally adapted trees, shrubs, and other materials for diversity.

The corridor plans also identify the major design themes and materials to be used in the landscape and aesthetic treatments for transportation projects.

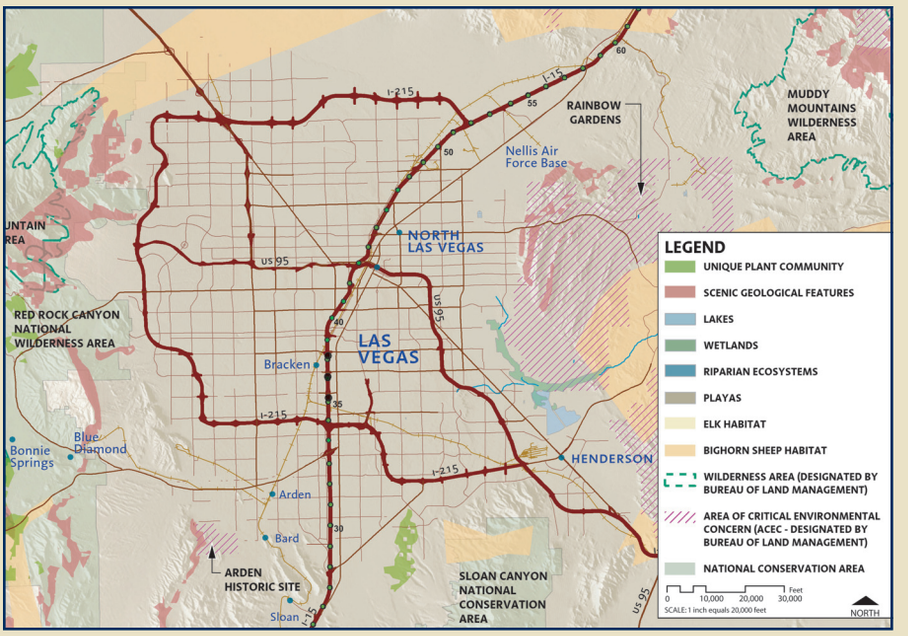
The initial planning phase for each corridor plan focused on producing an inventory of existing data, including history, settlement patterns, anticipated urban changes, travel and tourism, natural resources, wildlife habitats, "viewsheds" and landscape character, and existing NDOT standards and practices. In addition to collecting this information, the design team realized that recommendations regarding landscape and aesthetics needed to be based on valid engineering practices.

"You can't change something without understanding it first, and you can't ignore 150 years of highway knowledge," says Richard Shaw, a principal with Design Workshop, Inc., one of the firms involved in the corridor planning.

The corridor plans define landscape types and a hierarchy of treatment levels that NDOT can apply to landscape segments with common characteristics. The treatments range from standard to landmark approaches for the most striking and memorable landscape segments. Each level consists of various combinations of treatments for "softscape" features, such as trees, shrubs, perennials, grasses, and other ground treatments, and "hardscape" features, which include bridges, retaining walls, acoustic walls, pedestrian crossings, railings, barrier railings, lighting, and transportation art.

Project Design

During the project design phase of the master plan, NDOT selects individual projects for site-specific planning. These projects will change the



Design Workshop, Inc. and Jones & Jones

Nevada's Corridor Plan Inclusions

According to Nevada's "Landscape and Aesthetic Corridor Plans" Web site, the intent of the corridor plans is the following:

"Landscape and highway aesthetics" is the collective visual impression of a highway as interpreted by both motorists and citizens within communities along the State's highways. The individual plans will contain recommendations that include the following:

1. *Guidelines for the design of highway facilities, including themes, levels of treatment, cost goals, and priorities for further development, design, and construction*
2. *Right-of-way design and planning guidelines*
3. *Recommendations for cooperative planning in association with local governments along each corridor*
4. *Recommendations for continuing community involvement*
5. *Recommendations for long-range cost-effective solutions to solve operation and maintenance issues*

The Web site also indicates that Nevada's corridor planning process follows a sequence that includes the following milestones:

1. *Organize the plan development effort*
2. *Collect and inventory relevant data*
3. *Analyze data and draw conclusions about the land and people within the corridors*
4. *Describe the opportunities and constraints presented within the corridors*
5. *Describe options that might be considered*
6. *Summarize ideas and recommendations with illustrations of proposed design themes*
7. *Document the corridor plans to guide decisionmaking in the long term*
8. *Include an evaluation of the corridor planning process to assist future planning efforts*

For more information about Nevada's corridor plans, visit www.ndothighways.org/introduction.html#trc.

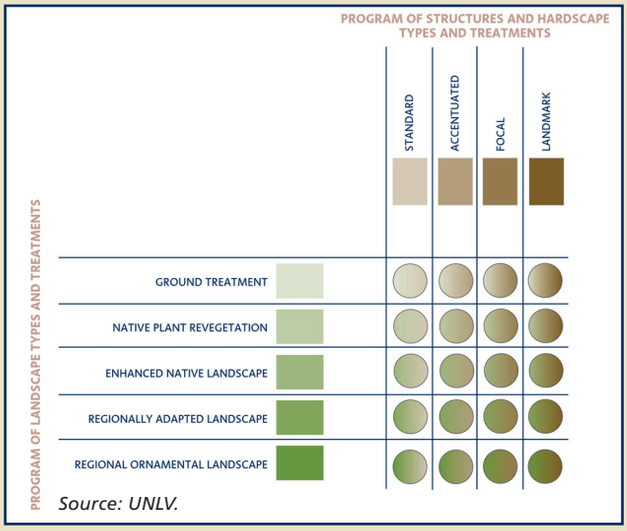
visual quality of neighborhoods and result in the addition of bicycle trails, parks, other green space, trees, public art, and enjoyable driving experiences. The projects also will help promote tourism by protecting natural resources and connecting visitors with local people, places, events, and stories associated with communities across the State.

The central Las Vegas "Spaghetti Bowl" interchange is one of the first site-specific aesthetics projects. NDOT completed the $92 million, 3-year reconstruction of the I–15, I–515, and U.S. 95 Spaghetti Bowl interchange 6 months ahead of schedule in 2000. The original construction did not include any aesthetics or landscape plantings, so the result was not visually appealing. The new aesthetic and landscape improvements at the Spaghetti Bowl were slated to be completed in August 2005.

Construction, Operations, And Maintenance

For their recommended projects to be successful, the members of the design team knew they would need to account for construction and maintenance concerns in the master plan. Project implementation involves understanding the life-cycle costs of each project. The team prepared detailed cost estimates for each combination of softscapes and

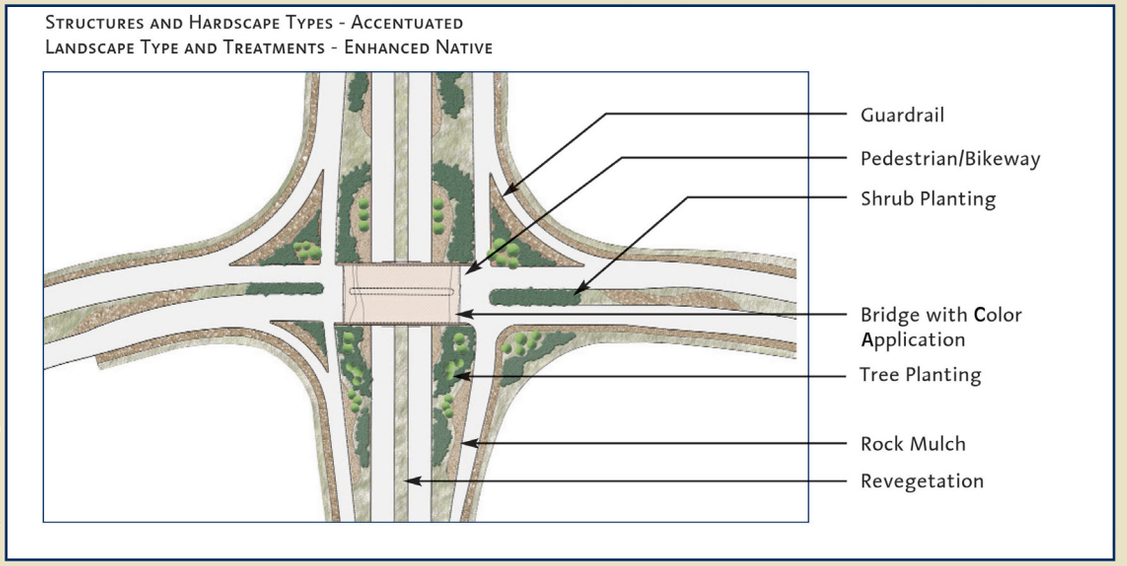
This matrix illustrates possible combinations of four landscape types and five treatments discussed in Nevada's master plan. Separately or in combination, these treatment levels will be used to establish a "design character" within each corridor.



Source: UNLV.

These illustrations (below, right, far right) of the sequence of travel over approximately 305 meters (1,000 feet) illustrates a possible sound wall design for a Nevada highway corridor. Characteristics include staggered wall planes, landscape planting in front of the wall face, and patterning on the wall face.

Design Workshop, Inc.

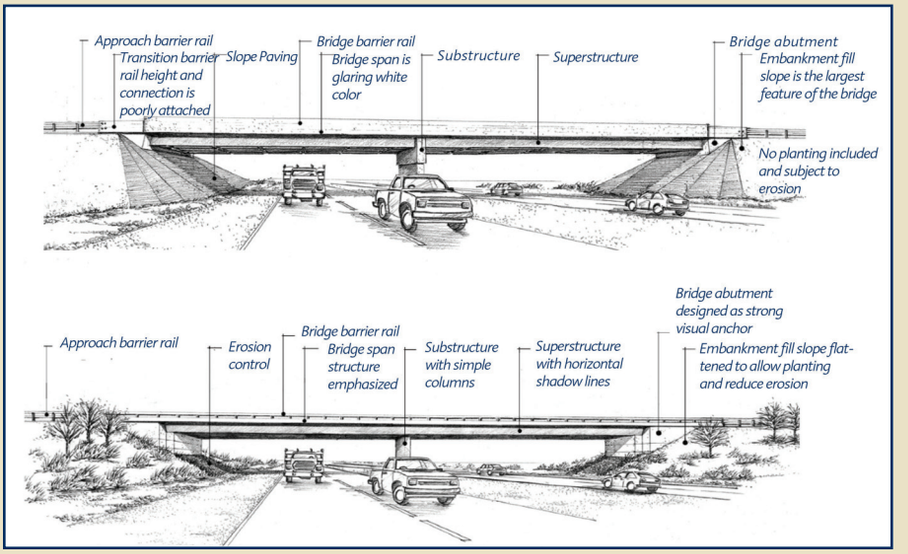


Design Worksbop, Inc.

In the master plan, NDOT developed typical designs such as this one for hardscape treatments for prototypical interchanges, with overall cost estimates for each level of treatment.

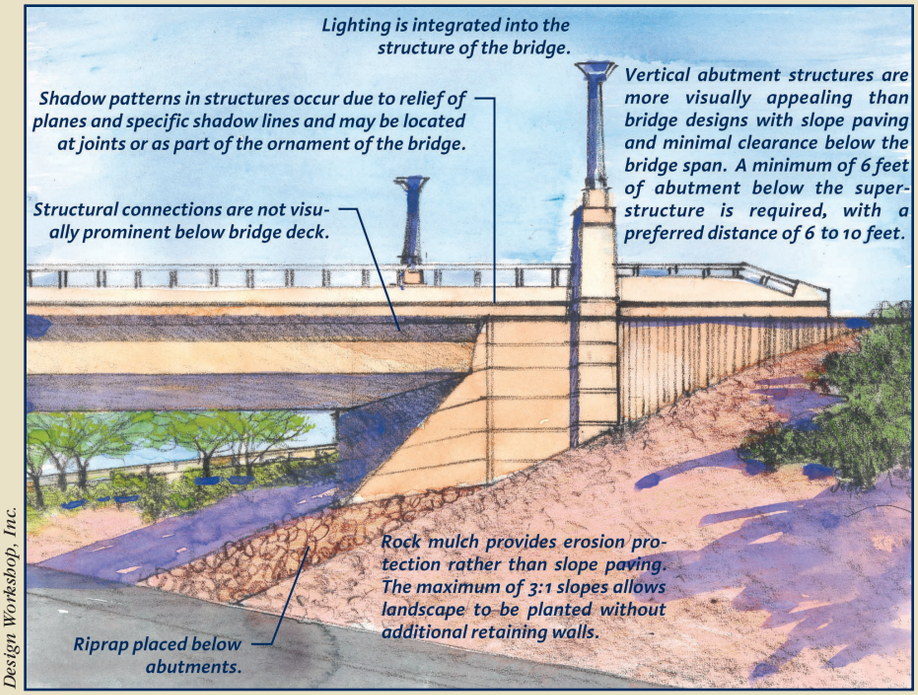
hardscapes that would be used for prototype designs in each landscape segment. The team members developed the estimates using data collected by UNLV, NDOT, local engineering and landscape architecture firms, contractors, and product manufacturers. A separate report examines long-term maintenance costs, such as graffiti removal, pruning, and irrigation. The team also is developing a technical support document that analyzes the day-to-day program work needed to manage the project.

With the landscape and aesthetics master plan, Nevada made an unprecedented financial commitment. The plan requires that up to 3 percent of the State's entire construction budget for new projects and capacity improvement projects be used to implement landscape and aesthetic recommendations. Funding



Design Worksbop, Inc.

The master plan's design guidelines for bridge structures require that landscape and aesthetics be integrated at the onset of project planning. The top illustration shows a typical bridge structure, and the bottom sketch indicates possibilities for aesthetic improvements.



Design Workshop, Inc.

As this illustration of an aesthetic treatment shows, bridge abutments and barrier rails can be designed so they visually "fit" with other parts of the bridge. The result is a more aesthetically pleasing design.

for the retrofit of landscape and aesthetic improvements to existing highways is based on matching funds contributed by local communities.

Public Involvement In Nevada

Implementation of Nevada's landscape and aesthetics master plan is still in its infancy, but the plan is expected to have a dramatic impact. During the corridor planning process, a public participation plan provided for outreach meetings, community workshops, newsletters, and establishment of a Web site.

Aesthetic Highways in Other States

Nevada is certainly not the only State creating highways that are more community friendly. The promotion of context sensitive design and context sensitive solutions by the Federal Highway Administration (FHWA) has raised awareness of designing safe transportation solutions that are in harmony with communities. States such as Arizona, California, Maryland, and New York all integrate aesthetics into their transportation projects and involve landscape architects in designing and planning projects.

As part of the Nevada project, UNLV analyzed 32 State programs, including those in Florida, Maryland, Massachusetts, New Jersey, Ohio, Texas, and the neighboring States of Arizona and California, and found a wide variety of approaches. Some States take an extremely broad-brush approach, some are developing detailed design standards, and others focus on design solutions at a local level. Examples of the broad-brush approach include the following:

The Florida Legislature directed the Florida Department of Transportation (FDOT) to include aesthetics in the development of all highway projects and suggested that local governments and municipalities require aesthetics in their comprehensive plans. FDOT's mission statement clearly states that it is the agency's intent to incorporate aesthetic design, art, and architecture in roadway and bridge design.

The Ohio Department of Transportation (ODOT) developed a design standards and guidelines policy to integrate aesthetics into major transportation projects. Through this program, ODOT incorporates patterns, colors, texture, and landscape planting to make highways, noise barriers, and bridges more visually pleasing to both motorists and residents. The agency estimates that the cost for improved aesthetics amounts to less than 1 percent of a project's total cost. ODOT's Gateway Landscaping Program was developed to help towns and cities improve the landscape along highways leading into their communities. The $500,000 set aside for the program is supported by Federal Transportation Enhancement Funds.

In Maryland, the State Highway Administration's Office of Environmental Design focuses on incorporating environmental design as part of highway planning. The Maryland approach addresses wetland mitigation, stream restoration, sound barriers, streetscapes, highway landscape planting, rest areas and welcome centers, greenways, scenic byways, trees and forest conservation, and highway aesthetics. The Office of Environmental Design includes three divisions that address the following areas: (1) wetland mitigation, stream restoration, and applicable environmental regulations; (2) reforestation and tree preservation, turf management, roadside maintenance, and wildflower programs; and (3) development of concepts and designs for landscape architectural projects. These divisions work closely with Project Planning, Design, and Construction units to achieve more context sensitive projects.

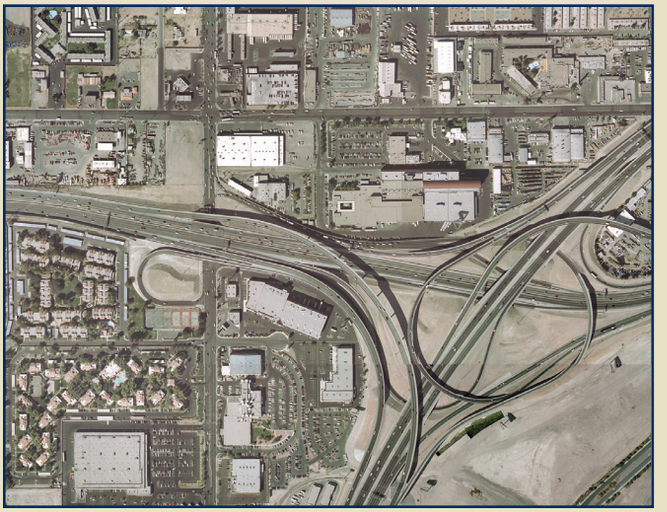
The California Department of Transportation (Caltrans) has been a leader for years in incorporating aesthetics and sensitive environmental planning into highway projects. Caltrans has implemented programs that seek to create more context sensitive highway designs, use native plant materials, incorporate transportation art and aesthetics into highway structures, and help ensure that community values are

Jones & Jones

U.S. 93 is an 89-kilometer (55-mile) road that traverses the Flathead Indian Reservation in western Montana. In another example of aesthetics as a component of highway design, Federal, State, and tribal governments worked together to create a road that respects the area's natural resources—on display in this aerial photo of the highway and its mountain setting.

National Environmental Policy Act

The National Environmental Policy Act of 1969 (NEPA) made sweeping changes to the way federally funded highway projects are developed. NEPA requires Federal agencies to consider the effects of their proposed actions on the human environment. The Federal-Aid Highway Act of 1970 requires that final decisions for any proposed project on the Federal-aid system consider "destruction or disruption of man-made and natural resources, aesthetic values, community cohesion, and the availability of public facilities and services (23 USC 109(h)(2))."



NDOT

This aerial shot shows the I–15 and U.S. 95 Spaghetti Bowl interchange, the first aesthetic project scheduled under the Nevada master plan.

NDOT held the meetings to solicit information, local knowledge, and ideas from the public. Technical review committees consisting of key stakeholders and representatives of public agencies and organizations also conducted meetings on a regular basis. The committees served as a conduit for local communities to become involved with the planning process.

"We are getting endorsements from communities so that there are no surprises when we are ready to

considered on an equal basis with safety, economics, and mobility. Caltrans' Landscape Architecture Program provides direction and coordination for context sensitive solutions; training development; erosion control and highway planting policies, standards, and guidelines; landscaped freeway designations; roadside management; and research and new technology.

The Michigan Department of Transportation's (MDOT) Aesthetic Project Opportunities Inventory lists approximately 2,000 opportunities for improving the visual quality of the environment along highways within the State. The inventory identifies eight types of aesthetic projects: landscape treatment opportunities, streetscaping opportunities, site or corridor management plans, scenic easement acquisitions, scenic turnout sites, structure removals or improvements, vegetation management opportunities, and landform improvements. In addition to MDOT staff, communities, agencies, and stakeholders interested in improving the visual quality of the environment use the inventory. One limitation of the program is that MDOT does not guarantee financial support for implementing aesthetic improvements.

The Texas Department of Transportation (TxDOT) addresses the visual characteristics of highways in its *Landscape and Aesthetics Design Manual*. The manual discusses the types of aesthetic approaches for highway design and provides general guidance as to how and when they should be applied. A supplemental document, *Develop Cost-Effective Plans to Add Aesthetically Pleasing Features to Transportation Projects*, provides TxDOT designers and consultants with guidance in the development and construction of aesthetic treatments.

A number of other DOTs consider aesthetics in roadway design at the local level. The Kentucky Transportation Cabinet (KYTC) spent $70 million to design and construct the 19-kilometer (12-mile)-long Paris Pike so it fits comfortably into the surrounding horse country. The project was initially proposed in 1966, but many stakeholders felt it would destroy the area's rural beauty and historical significance. Construction finally began in the mid-1990s after KYTC adopted a more sensitive design approach. Experts in highway design and landscape architecture alike hail Paris Pike as a model in highway design and historical preservation.

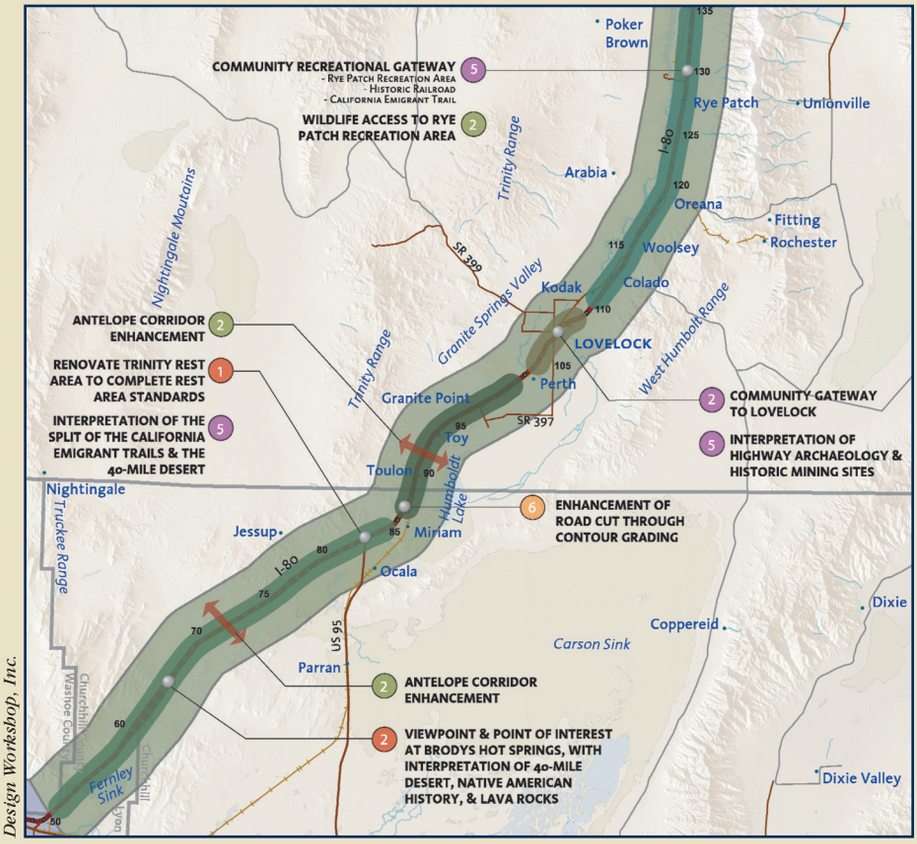
In Washington State, the city of Seattle is developing plans to replace the existing Alaskan Way Viaduct, which is a 3.5-kilometer (2.2-mile)-long highway along the western side of the city that parallels the Puget Sound shoreline. The preferred alternative in the environmental document proposed routing the new highway through a tunnel. The areas above the proposed highway would include public spaces and development that would help connect Seattle to its waterfront.

The proposed Seattle viaduct replacement is not the only recessed highway project. Much of the Central Expressway in Dallas, TX, was built below grade to reduce the impact of the highway on the surrounding communities. In Boston, MA, the Central Artery/Tunnel Project (the "Big Dig"), which is in the final stages of construction, is a 12.5-kilometer (7.8-mile) recessed highway that replaces the old elevated Central Artery that ran through downtown. The project is intended to meet transportation needs while helping unify the downtown area and urban neighborhoods that had been severed by the construction of the elevated expressway.

Jones & Jones

In addition to Nevada, Kentucky is one of a number of States that is integrating aesthetic considerations into highway design, as shown here in this photo of Paris Pike, a model of fitting the roadway to the surrounding horse country.

Design Workshop, Inc.



Design Workshop, Inc.

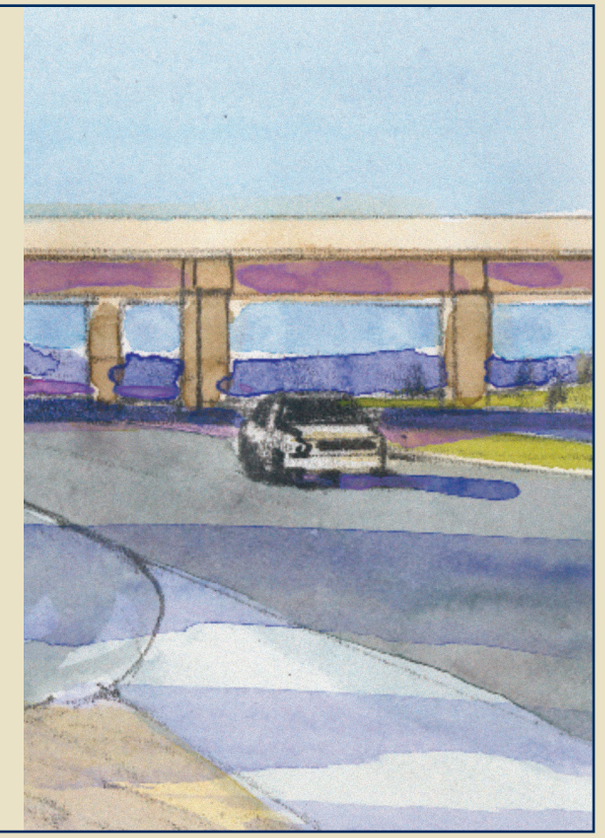
Landscape design segments define areas with similar characteristics, such as the Highway of the West segment pictured on this map. The highway goes through a rural area affected by geologic forces and characterized by both historical and cultural features.

design," notes UNLV's Hoversten. "State and local tourism departments are excited about the potential for increasing tourism within the State, and local communities see an opportunity to expand their economic base."

One of the advantages of the program for tourists is that it enables them to learn more about Nevada. NDOT's Blakemore says, "We want visitors to realize this is not just a desert. It is a place where immigrants took a wagon train across a 40-mile [64-kilometer] desert; it is where Indians lived and where pioneers started mines and built farms."

Improving Project Development

Through the master plan, the State will have gained not only a new, comprehensive approach to highway design, but also a greater awareness and understanding of how highways should be designed. "Our expectation is that we will have a management tool that we can use to develop projects as they come along," says Jim Souba, chief of maintenance for NDOT. "We want to get ahead of the game and know where we are going and what it is going to cost short term and long term."



This illustration conceptualizes a regionally adapted landscape planting at the embankment of a highway bridge along a segment of I–80 in northwestern Nevada, called the "Highway of the West" in the State's master plan. The State has made an unprecedented financial commitment to aesthetic improvements.

The master plan and corridor plans also will assist NDOT in meeting the requirements of the National Environmental Policy Act of 1969 (NEPA) and 23 USC 109. The plans identify important visual resources, help minimize adverse impacts on those resources, and identify ways to enhance the visual quality of an area. As noted in the FHWA *Guidance Material for Preparation of Visual Impact Assessments*, enhancement of the visual quality of an area as a result of a project could contribute to the general acceptance of the project by the public. (See http://environment.fhwa.dot.gov/guidebook/vol2/doc1a.pdf for the full document.)

Embracing landscape planting and aesthetics is a complete change in NDOT's culture, and the evolutionary process is going to take some time. "NDOT staff members seem supportive of the project," says Shaw, "in part because the design team made a concentrated effort to obtain buy-in from all staff." This is important because the idea of addressing landscape and aesthetics in highway design is not new in Nevada. NDOT actually introduced an *Aesthetics Manual* in 1968, but "unfortunately it had little impact," says NDOT's Blakemore.

Conclusion

Nevada's *Pattern and Palette of Place: A Landscape and Aesthetics Master Plan for the Nevada State Highway System* has been successful to date because of a dynamic partnership between NDOT and other State agencies, UNLV, and policymakers who are committed to building improved highways. The master plan will be the primary management tool that guides funding allocations, aesthetic design, and incorporation of highway elements that uniquely express Nevada's landscape, communities, and cities.

The master plan and corridor plans are in place. Now it is just a matter of making the master plan a reality.

James L. Sipes is an award-winning landscape architect with more than 25 years of experience, encompassing a wide range of design, planning, research, and communication projects. His design philosophy follows the spirit of Thoreau, Muir, and Leopold, and his design solutions evolve out of an understanding of the processes that sustain life across temporal and spatial scales.

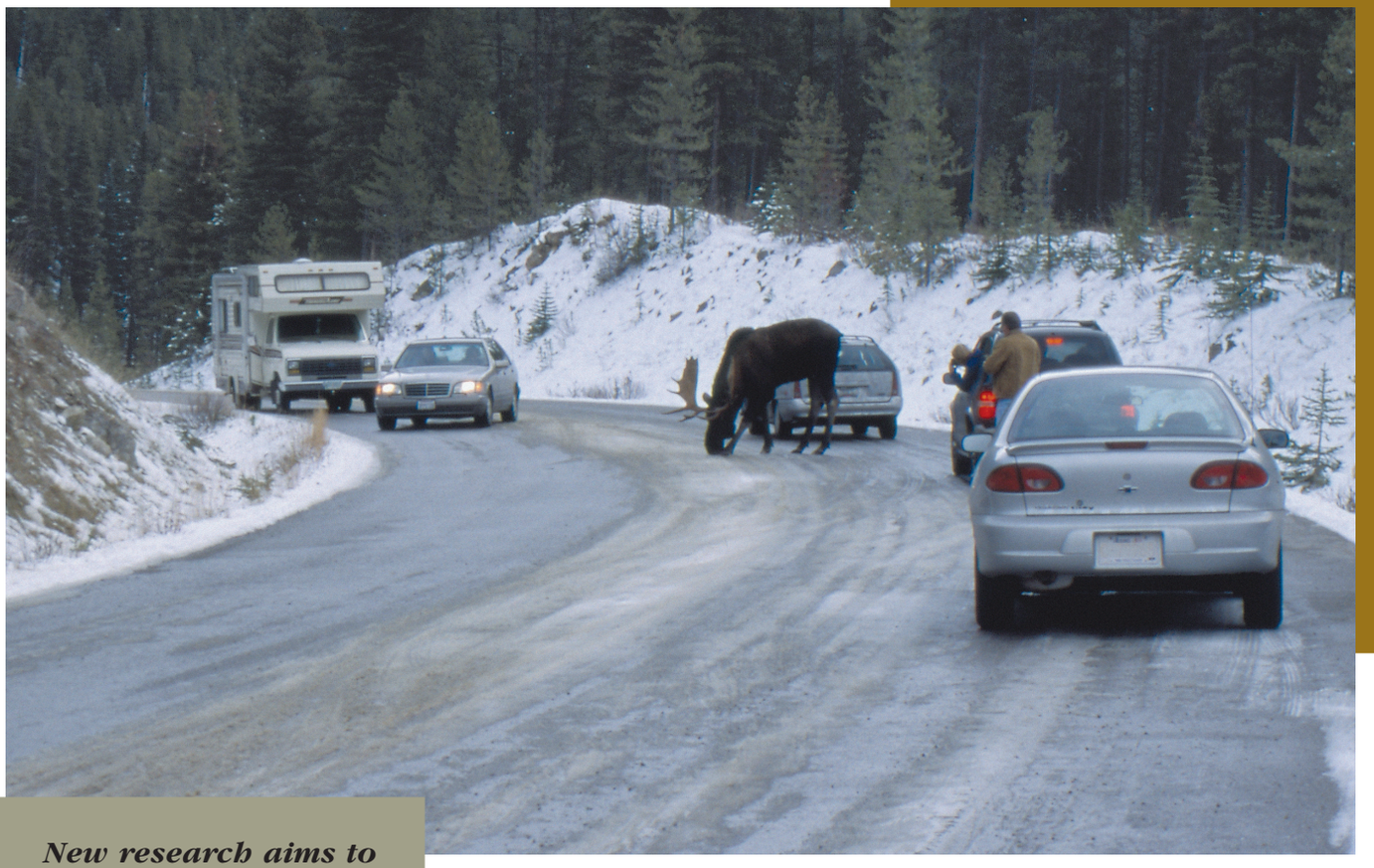
For more information about Nevada's Landscape and Aesthetics Master Plan*, visit www.ndothighways.org/MasterPlan-July3.pdf, and for the corridor plans, visit www.ndothighways.org or contact James L. Sipes at jsipes@sandcountystudios.com.*

The Truckee River corridor and adjacent vegetation patterns provide scenic interest for motorists traveling along I–80 in northwestern Nevada.

Design Workshop, Inc.

Of Moose and Mud

by Roy V. Rea and Roy V. Rea Sr.



New research aims to reduce animal-vehicle collisions by deactivating roadside mineral deposits.

(Above) This bull moose is licking deicing salts from the centerline of a highway in Jasper Park, Alberta, Canada. As one way to reduce the number of animal-vehicle collisions, researchers in Canada and California are studying the feasibility of deactivating roadside mineral deposits, which attract ungulates such as moose, deer, and mountain sheep dangerously close to roadways. *Photo: Hugues B. Massicotte, University of Northern British Columbia.*

Why did the moose cross the road? The answer, according to researchers, often is to visit a wet, muddy, mineral deposit on the other side.

Ungulates such as moose, mountain sheep, and deer may visit transportation corridors for a variety of reasons. Seasonal migrations to and from summer and winter ranges, roadside feeding, and ease of travel during the winter represent possible reasons why animals find their way into transportation corridors.

Recent research in British Columbia, Canada, now indicates that one important reason that these animals may use highways and byways appears to be to access materials found in roadside mineral deposits, or "mineral licks." Natural mineral licks are known to occur across the landscape and appear to be seasonally important in the nutritional ecology of moose and other ungulates. When these features exist near roadways, however, they entice animals to use habitat uncomfortably close to the motoring public.

According to research in Europe, Japan, and North America, automobile collisions with ungulates appear to be on the rise. Researchers link this trend to increases in animal populations, the number of vehicles on roads, the improving

quality of road surfaces, and faster vehicle speeds.

In a 1997 article, "Monetary and Intangible Valuation of Deer in the United States," published in *Wildlife Society Bulletin*, M.R. Conover reported that at least 200 people are killed and 29,000 injured in ungulate-vehicle collisions in the United States each year.

Determining how to reduce moose-car collisions is the focus of a new research project involving stakeholders from Canada and the United States. Researchers at the University of Northern British Columbia and in California are coordinating the early phases of the project, reviewing background literature, and canvassing transportation and resource management agencies for input. The project team is seeking new partners to participate in upcoming field tests and performance measurements.

The objectives of the study are threefold: to define strategies that will result in increased motorist safety, to reduce material damage claims, and to conserve the animal resource. Specifically, the project aims to diminish the attractiveness of roadside licks in an effort to reduce moose activity near roadways.

Reasons Ungulates Visit Transportation Corridors

- Roadside browsing
- Seasonal and daily movements
- Loafing
- Aquatic feeding
- Insect avoidance
- Pavement warming
- Roadside cover
- Travel (especially in winter)
- Access to highway deicing compounds
- Avoidance of hunters and predators
- Use of forest edges
- Access to roadside watering holes
- Access to sodium-rich pools or licks

Ecology and Mineral Licks

Scientific literature dating back to the early 1950s reveals that researchers have reported a strong inclination for moose and other ungulates to repeatedly visit mineral licks in wilderness areas. Because moose are plant eaters, they have limited access to high concentrations of mineral elements such as sodium and calcium that carnivores acquire through eating meat.

In "Sodium Dynamics and Adaptations of a Moose Population," published in 1981 in the *Journal of Mammalogy*, G.E. Belovsky and P.A. Jordan reported that plants provide considerable mineral nutrients for moose and other herbivores, but they appear to be an insufficient source during certain seasons, such as when moose are calving, providing milk to their young, or growing antlers. At these times, typically in June and July, moose seek supplemental sources of mineral elements and other material present in the mud and water of mineral deposits.

Research conducted by the British Columbia Ministry of Transportation shows a summer peak in moose-vehicle collisions in June and July, which corresponds closely with one time of the year when moose use

Hugues B. Massicotte, University of Northern British Columbia

A calf moose is learning a risky behavior from its mother. To obtain minerals lacking in their winter diets, these moose are licking chloride-based deicing materials from a rural highway, as motorists slow to drive around them.

Roy Rea

Biologically, moose show a drive for minerals to supplement their diets in winter and sometimes visit roadside mineral licks like this one when access is unimpeded by snow and ice.

mineral licks frequently. This finding, combined with other preliminary research results in British Columbia, suggests a possible relationship between increased use of roadside licks and vehicle collisions involving moose. Commonly reported winter peaks in moose-car collisions also may be tied to mineral supplementation as the animals brave icy roads to get access to minerals lacking in winter vegetation but available in deicing materials or roadside licks. Indeed, recent research in British Columbia suggests that moose will use wilderness mineral licks frequently in winter if accessible—and presumably roadside licks.

"We recently discovered a previously unreported peak in moose activity at mineral licks in midwinter," says Dexter Hodder, research coordinator of the John Prince Research Forest near Fort Saint James, British Columbia. "This demonstrates that moose seek minerals in winter, just as they do in summer, and points to the fact that mineral licks are important to moose more often than previously thought."

What distinguishes a mineral lick from other mudholes in a roadside ditch or areas where winter deicing materials from roads may collect during runoff? Mineral, or "muck," licks are wet, muddy seepage areas

Winter Maintenance And Deicing Compounds

Roadside areas where deicing materials, such as salt and sand, accumulate also are known to attract ungulates but represent a somewhat different phenomenon from naturally occurring mineral deposits. Although deicing materials theoretically could contribute to salt accumulations in muck licks, natural seepage areas act as an attractant even where deicing is not practiced.

One distinction between muck licks and roadside accumulations of deicing materials is important in this context. Simply moving away from chloride-based deicing compounds (like salt and sand) may help diminish animal-vehicle collisions in accumulation areas, whereas "fixing" the muck lick problem may be more complicated. It is still unclear whether it is mineral content, soil type, soil particle size, water, or other factors that draw animals like moose to licks.

Many States, including Montana, are studying alternative strategies for winter road maintenance, such as applying liquid chemical deicers instead of abrasive salt and sand. For more information, see the white paper "Past and Current Practices of Winter Maintenance at the Montana Department of Transportation (MDT)" at www.mdt.state.mt.us/departments/maintenance/docs/wintmaint_whitepaper.pdf.

Roy Rea

This mountain sheep is licking minerals from the soft shoulder along the side of a rural highway.

Dexter P Hodder

Moose often tend to move around at night, and their dark coloring makes them difficult for motorists to see. This bull moose died crossing the road at night when it was struck by an automobile.

where below-ground mineral springs upwell to deposit materials collected by waters percolating through surrounding soils. These mineral-laden seeps can range in size from a few to hundreds of square meters, and are easily identified seasonally by concentrations of animal tracks, on the order of those found in cattle feedlots. At least one trail, and more commonly a network of heavily used trails, often radiate away from the lick into the adjacent woodlands or fields. Biologists recognize that the sum of the components of a roadside muck lick—minerals, tracks, trails—distinguishes it from other muddy sections of ditch.

Although the jury is still out on what makes these sites so attractive to hoofed animals, the fact is that animals are drawn to roadside licks despite the dangers of entering the transportation corridor. If animals entered a mineral lick from the side of the road where the lick is located and left the same way they came, there would be no problem. When moose enter the lick from the opposite side of the highway, however, they put themselves in danger of collisions with motorists.

Roy Rea

Muck licks are easily distinguished from other muddy areas by dense concentrations of animal tracks and trail networks radiating away from them. A well-trod trail leads from this roadside mineral lick into the woods.

The time of day animals choose to visit licks also factors into the challenge. "Moose tend to use trails leading to a roadside mineral lick between dusk and dawn," says Peter Crawford, a former senior park ranger for the British Columbia Ministry of Water, Land, and Air Protection, Environmental Stewardship Division, Parks and Protected Areas–Omineca Region. Crawford studied roadside muck licks near West Lake, British Columbia, in 2002 and 2003.

Roy Rea

This motorist's car (barely visible in the vegetation) came to rest against a power pole after hitting a moose. The driver is one of the lucky few to walk away from a moose-car collision.

His findings corresponded closely with those from a 3-year study on the activity patterns of moose at a wilderness mineral lick in the John Prince Research Forest, where moose clearly visit the lick predominantly at night.

Research conducted by the Maine Department of Transportation shows that more than 70 percent of moose-vehicle collisions in Maine occur at night, according to *Collisions Between Large Wildlife Species and Motor Vehicles in Maine, Interim Report*.

The Cost of Hitting a Moose

Moose, unlike smaller animals, are particularly dangerous in a collision because their long legs elevate their large center of mass—500 kilograms (1,100 pounds) on average—above the hoods of most passenger vehicles. When struck, a moose tends to slide up the hood of the car and into the windshield, causing a rear and downward deformation of the front pillars of the windshield and roof, which often leads to injuries of the head, neck, face, and upper extremities of the motorists.

As noted earlier, more than 200 motorists die and another 29,000 are injured in the United States every year in collisions with ungulates. In addition to the impact on human lives, these crashes take their toll on the animals—and society's pocketbook as well. In 1997 M.R. Conover reported in *Wildlife Society Bulletin* that animal-vehicle collisions kill more than 1.5 million deer and cost insurance companies more than $1 billion each year in the United States alone. Now that mineral licks appear to be at least partly responsible for luring animals into roadways, removing or diminishing the attractiveness of these features becomes critical to reducing the probability of collisions.

Identifying Potential Countermeasures

Unlike moving a salt block, removing an entire muck lick can prove impractical and does not appear to be a viable option for field testing. In the past, researchers have successfully used chemical deterrents such as putrescent egg compound and other big game repellents to inhibit animals from consuming materials in roadside pools. But these solutions generally last only until rain, wind, or intense animal activity disturbs or removes the chemical compound. Furthermore, the use of some herbivore repellents (such as putrefied meat scraps) may actually serve to attract scavengers or other carnivores to motorways, according to Alex Levy, an ecologist with the Federal Highway Administration. Reducing the attractiveness of muck licks through various forms of deactivation, however, may represent a feasible, cost-effective, and long-term means of reducing animal activity near roadways.

One deactivation technique—excavating a lick site and backfilling the area with unattractive materials such as sand or gravel—could eliminate access to the mineral-rich soil that attracts moose. Another option—reinforcing fabric or similar materials placed over the site—could inhibit access to the mineral soils and water and serve as a base for placing sod and planting unpalatable plant species. Likewise, simply covering the site with boulders or asphalt debris could deter visits as long as the materials are of a size, shape, and quantity that will make it

Implications of Moose-Car Collisions

- Loss of human life
- Crash cleanup and carcass removal
- Injury, medical treatment, and hospitalization
- Traffic congestion
- Property damage
- Towing charges
- Escalating insurance premiums
- Emotional trauma to motorists
- Consumptive value of the animal (meat and other animal products)
- Trip disruption costs, such as hotels, meals, rental vehicles, taxis
- Nonconsumptive value of the animal (intrinsic value, loss of recreational opportunities for viewing and hunting)
- Crash investigation and administrative expenses, such as insurance, police, legal costs
- Secondary collisions with predators or scavengers
- Wage, productivity, and employer losses
- Animal dispatch costs

Potential Strategies to Deactivate Mineral Licks

- Use reinforcing fabric and vegetate area
- Cover and mound with boulders or broken concrete
- Apply a lime treatment to dry up for remediation
- Patch pave
- Reroute hydrology and dry up the lick
- Install French drains
- Excavate and fill with noxious materials

too difficult for animals to reach down through the pile. Any form of habitat manipulation, however, must be implemented with extreme care to ensure that feature restructuring does not lead to the creation of new roadside habitat that is attractive to other animals.

Another option, according to Daniel E. Brown, P.E., estimating manager for Teichert Construction in Stockton, CA, is to spread a layer of lime or cement over the lick site and mix it into the wet soil to create a 15- to 60-centimeter (6- to 24-inch) layer that would cure and become a hard surface material. "This would likely reduce the attractiveness of the area to moose and deer," he says.

In extreme cases, paving the area with asphalt or concrete, after excavating down to more solid materials and adding an aggregate base to stabilize the structural section, could prove to be a more permanent but costly solution.

Since moose appear to be attracted primarily to wetter licks, rerouting site hydrology and drying up the lick would likely reduce its attractiveness. This option would involve rerouting ditches, culverts, and other channels to direct runoff water away from the lick. In some areas, workers could install French drains (also called a "farm drain") under or near the lick to ensure proper drainage and site drying. A French drain is a ditch filled with gravel or a perforated pipe used to drain surface water.

In addition, where new roads are constructed, engineers should take steps to ensure that grading, ditch building, and other construction activities direct runoff away from mineral lick areas or otherwise ensure that the sites are rendered unattractive to animals. Rerouting the runoff will ensure that excess moisture, minerals, and deicing agents from the road surface do not accumulate in the lick and further

Roy Rea

Many young animals fall victim to traffic as they follow their mothers back and forth in the transportation corridor in search of food, water, and minerals. This calf moose, not yet road savvy, was struck by a passing vehicle.

Maine's Report on Collisions With Large Wildlife

The Maine Department of Transportation studied occurrences of collisions with moose and other large animals in *Collisions Between Large Wildlife Species and Motor Vehicles in Maine, Interim Report*. The following strategies are among the State's recommendations for mitigating animal-vehicle collisions: using lighting more effectively, reducing animal populations, clearing rights-of-way, and installing audible warning devices. Also, incorporating awareness of the hidden dangers of wildlife on roadways into driver education programs would enable drivers to take a more proactive role in their own safety.

For more information, visit http://mainegov-images.informe.org/mdot/safety-programs/pdf/moosereport.pdf.

exacerbate the problem. If possible, rerouting the roadbed altogether during the planning, surveying, or road layout stages could facilitate leaving the wildlife feature intact and simultaneously avoid the possibility of animals using the roadbed to access minerals. For larger sites or those having ecological or national significance, such as the mineral springs associated with Yellowstone National Park, rerouting the road may be the best option. But for smaller sites, a few square meters in size, the most practical option may be to deactivate the site or build the road right over it.

"A robust campaign to reduce collisions will consider all possibilities and must leave no stone unturned," says Ken Child, regional environmental coordinator for BC Hydro (retired) and an authority on incidental moose mortality. "In an effort to develop effective countermeasures, research should focus on the biology of the animal and what it is doing in the corridor. If a moose is in the corridor to forage, countermeasures should focus on diminishing the availability or attractiveness of the forage base [by planting unpalatable species, building feeding stations away from the road, or adjusting the timing of vegetation control activities]. Likewise, if moose are there to access mineral lick materials, these materials must be either removed or rendered unattractive to eliminate or at least reduce moose activities in the corridor."

In some cases, exclusionary fencing or grade separations such as wildlife underpasses or overpasses should be considered where resources are available for such installations. (See also "Where the Wildlife Meet the Road" in the May/June 2005 issue of PUBLIC ROADS.)

Other countermeasures also have been used and recommended in areas where it is unclear why the animals are using roadsides or where use has been linked to more than one cause. Where roadside licks appear to be the cause, removal of the attractant may be the most feasible and least expensive strategy.

A combined approach of identifying and deactivating attractants while ensuring the conservation or creation of more remotely located and similar features, far from the motoring public, may be the most logical and ecologically minded approach where licks are concerned. If transportation agencies plan to make these critical features inaccessible or remove them from the corridors, alternatives need to be made available for the animals. Deactivation of roadside licks will involve coordinating with nearby land stewards to ensure that alternative natural licks in the area are protected from forestry and other land development activities. In the worst case scenario, stations containing livestock salt blocks could be set up a safe distance from roads in the same manner that feeding stations are employed to draw animals away from attractive roadside forages. Because it is unclear whether the mineral or salt content of licks attract the

Roy Rea

Installing new signage in areas with recurrent collisions could help alert motorists to potential threats. This sign, placed along the Trans-Canada Highway near Paddy's Pond, Newfoundland, cautions motorists that moose may wander onto the highway.

animals to these areas, diverting the wildlife to natural licks may prove a more effective substitute.

Jurisdictional Inventories And Interim Solutions

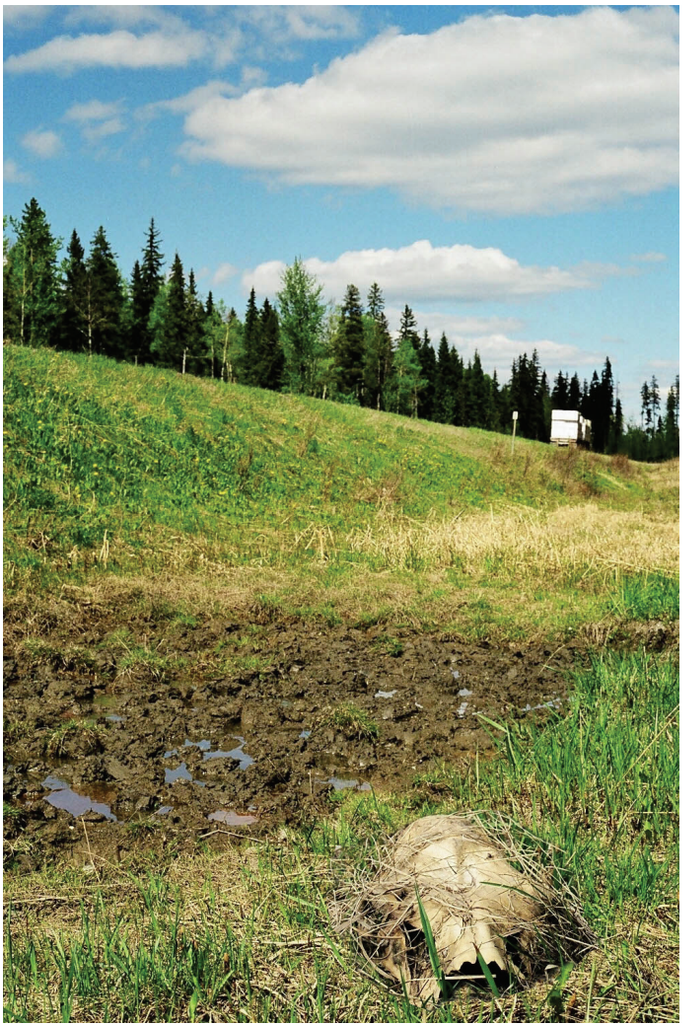
Regardless of the countermeasure, where agencies find that roadside mineral licks are attracting moose or other wildlife dangerously close to highways, researchers agree that action is necessary. "Simply hoping that moose will stay away from licks, and keeping our fingers crossed that animals will not end up in front of traffic, is like expecting children to stay clear of a well-stocked and easily accessible cookie jar," says Michelle Oster, program coordinator for the Northern Medical Program at the University of Northern British Columbia.

In jurisdictions where officials suspect that roadside mineral licks are contributing to recurrent ungulate-vehicle collisions, developing a plan of action can be as simple as asking transportation departments or road maintenance contractors to survey collision sites for trampled muddy areas with radiating trails.

Simple, inexpensive measures such as posting reduced speed limits or installing warning signage can offer interim solutions. Meanwhile, ongoing research may soon shed light on specific design solutions and provide recommendations for experimentally tested actions that transportation agencies can implement in the near future.

The project team plans to begin field testing proposed deactivation techniques in the summer of 2006 in the John Prince Research Forest. Researchers will monitor moose activity at deactivated mineral lick sites using several means, including remote cameras, throughout 2006 and 2007. In 2008 the team plans to recommend the most effective techniques to the Ministry of Transportation for implementation near collision hotspots on highways in British Columbia.

By field testing strategies for deactivating mineral licks, researchers aim to develop countermeasures that address the biology of the animals rather than try to alter the behavior of motorists attempting to get from point A to point B as quickly as possible. Developing a robust, operationally feasible, and effective long-term mitigation strategy aimed directly at saving the lives of motorists and moose is the ultimate goal.



Roy Rea

A moose skull found at a mineral lick site near Prince George, British Columbia, illustrates the potential fate awaiting animals that frequent these features near high-speed motorways.

Roy V. Rea, M.Sc., is a registered professional biologist and a senior laboratory instructor for the Ecosystem Science and Management Program at the University of Northern British Columbia (UNBC). Rea teaches animal physiology, field applications in resource management, and laboratories in plant systematics at UNBC. His research interests include plant-animal interactions, mitigation of ungulate-vehicle encounters through habitat manipulation, considerations for critical habitat features in forest management and planning, and science education through research. Rea worked in road construction for Oliver DeSilva Construction while earning a B.S. in biology from California State University, Stanislaus, which he completed in 1992. He received an M.Sc. in biology from UNBC in Prince George, British Columbia, in 1999.

Roy V. Rea Sr. is a senior project foreman for Teichert Construction in Stockton, CA. He is a member of the Operating Engineers Local Union No. 3 of the International Union of Operating Engineers (1962–1986 and 1993–2005). He is a licensed Class 'A' engineering contractor in California and has been involved in road building and construction since 1960.

For more information or to contribute to the research project, please contact Roy Rea at reav@unbc.ca. References for this article are available online at www.tfhrc.gov.

In STEP With Irving

by Linda Harper-Brown

A Texas community takes the bull by the horns to achieve its transportation goals.

In the late 1990s, as Dallas-Fort Worth (DFW) began experiencing a tremendous population boom, the city of Irving, TX, the population center of the DFW metropolitan area, saw its list of transportation needs growing and funding opportunities shrinking.

With a current population of more than 5 million, the DFW metropolitan area (known locally as the "Metroplex") added 1.2 million residents between 1990 and 2000, fueling a growth rate of 29 percent. Only Los Angeles and New York, with base populations approaching 15 to 20 million, added more residents in the 1990s. The city of Irving is home to nearly 200,000 people.

"About 7 years ago, we had three major freeways and a light-rail line undergoing preliminary design at the same time," says Jim Cline, director of Irving's Department of Public Works and Transportation.

(Above) In November 2004, Irving city officials, representatives from the Texas Department of Transportation, and other stakeholders dug their shovels into fresh soil in a ceremony commemorating the groundbreaking for the Highway 161 extension through Irving. With its Strategic Transportation Enhancement Program, or "STEP plan," Irving is helping ensure that its vital transportation projects move forward as smoothly as possible.
Photo: City of Irving, TX.

According to Cline, budget concerns were a top priority at all levels of government in Texas, with transportation, education, and health care all needing the scarce dollars. With nearly $5 billion in needed transportation improvements and limited funding, city officials recognized the need for a plan.

In light of the region's continued growth and acknowledgement that a functional transportation infrastructure is necessary for sustained economic development, Irving implemented an innovative strategy to meet its transportation needs without detracting from other important services. Carefully analyzing internal and external influences on project development, funding opportunities, and areas of greatest need, Irving developed a Strategic Transportation Enhancement Program, known as the "STEP plan."

Formally completed in September 2004 and dubbed the *Mobility Plan for City of Irving Major Transportation Projects*, the Irving Department of Public Works and Transportation's STEP plan outlines a forward-thinking and collaborative approach to tackling important transportation projects and ensuring the safety and mobility of Irving's citizens.

What Is the STEP Plan?

The STEP plan represents several years of ongoing research and analysis to prioritize Irving's transportation needs and to identify prospective funding options, according to the goals of both the city and its neighboring communities.

"The plan sets the framework for what we're going to achieve and identifies who we need to work with on projects," Cline says. "We tried to take a holistic, big-picture approach to streamlining the project development process."

In developing the plan, city officials asked themselves a number of questions. How does a project fit in with other projects that need funding? Does the project represent a local need or a political issue? Do we need to provide matching funds for rights-of-way? The plan is designed to help the city prioritize its projects and establish the political and logistical framework for moving forward once the right pieces are in place.

For example, Cline explains that another line on a proposed light-rail project connecting to Dallas needs to be completed before Irving can build its own segment. "We can holler and scream that this project needs to be finished," Cline says, "but the bottom line is that we can't do it until the other line is complete."

Although the STEP plan is an internal document for the Irving Department of Public Works and Transportation, other agencies and partners, from the Federal to the State and local levels, helped develop the strategy. In addition to providing guidance, these other organizations helped identify funding

programs and unique opportunities such as quiet zoning for trains.

Prioritizing Projects

Numerous major transportation projects in Irving are in various phases of development by State, regional, and city of Irving transportation providers. The development of these projects and their funding and construction need to be closely coordinated to maintain mobility both within the boundaries of the city and in the adjacent areas of Dallas. The limited availability of funding for transportation projects makes it essential to prioritize the planning, design, and initiation of construction.

Traffic volume on the various highways, streets, and roads classified as arterial facilities in Irving exceeds 1 million vehicles per day. In creating the STEP plan, the city selected as priorities those projects deemed important in terms of moving people and vehicles into, out of, and through the city. The schedule of priorities took into account a number of criteria. First is the relative importance of each project or segment. Naturally, certain projects demanded a greater sense of urgency due to heavy traffic volumes or safety concerns.

Next, city officials needed to assess the availability of funding to pay for the cross section of priority projects. "When approaching the council of governments and other partners for funding, you have to strike a balance between an unreasonably high request and shooting too low," Cline says.

Another factor was construction time. To sustain mobility for residents and commuters, city officials looked at projects that would not hinder existing traffic flow or at least would minimize disruptions. The city attempted to avoid circumstances in which simultaneous projects might place an unnecessary burden on motorists.

External projects and influences also factored into the prioritization process. Irving officials looked at two scenarios under which projects outside Irving might affect mobility within the city limits. One scenario involved the inability of external transportation providers (those outside the city) to improve a transportation facility that connected with a proposed or existing facility in Irving. Increased traffic on the Irving road would create a real or virtual blockage on the external facility. In the second scenario, an external transportation provider constructs a facility up to the Irving city boundary without a corresponding improvement made within the city to accommodate the increased capacity. The increased traffic from outside the city would cause a significant increase in congestion on the Irving facility.

Based on these criteria, and in coordination with the North Central Texas Council of Governments (NCTCOG, acting as the metropolitan planning organization for the DFW Metroplex) and other partners, Irving developed a table listing nine major transportation projects with estimated dates for letting the construction contracts and beginning construction. The STEP plan outlined the characteristics and planning details unique to each of the projects, such as public policy issues, key agencies involved, key assumptions, political actions required, impacts on mobility, design and construction issues, and the components for which the city will be responsible (building codes, design review, utility relocation, and construction phasing).

Identifying the Key Players

An important line item in the development of the STEP plan was identifying the agencies and organizations that would be the key partners in moving each of the proposed transportation projects forward. Given that Federal, State, and local organizations represent decisionmaking authorities and stakeholders in the planning process as well as potential sources of funding, Irving took the initiative to involve them from the beginning by inviting them to attend planning meetings to discuss the initiation of new projects.

Irving identified the primary transportation providers in the DFW Metroplex as the following: the Texas Department of Transportation (TxDOT), NCTCOG, Dallas Area Rapid Transit (DART), Fort Worth Transportation Authority (known locally as the "T"), North Texas Tollway Authority, Dallas-Fort Worth International Airport, Dallas Love Field Airport, and nearby city and county governments.

At the national level, the Federal Highway Administration, Federal Transit Administration, Federal Railroad Administration, and U.S. Army Corps of Engineers also play a role

City of Irving, TX

In October 2002, the city of Irving completed a project to eliminate the grade crossing at Grauwyler Road. The project, which is the result of a cooperative quiet-zoning initiative between Irving and DART, will not only reduce train whistle blowing but also will improve both rail and roadway operations and traffic flow. Here, a train passes over the underpass during construction of the roadway beneath the rail lines.

in approving and funding projects. In addition, other State and Federal agencies, such as the Texas Commission on Environmental Quality, Texas Historical Commission, U.S. Environmental Protection Agency, U.S. Coast Guard, and Federal Emergency Management Agency, weigh in on transportation decisions as they relate to the respective missions and responsibilities of these organizations.

To avoid delays, the STEP plan acknowledged that the city will need to monitor the decisionmaking and approval processes and ensure that the appropriate level of authority approves project decisions through long-range plans, preliminary engineering and environmental documentation, right-of-way acquisition, authorization of contracting, and construction. City officials may need to exercise public policy actions, such as ordinance changes, to avoid lapses between authorizations, minimize delays between steps, and ensure that funding is available when required. Close cooperation with stakeholders also may prove essential to overcome reluctance to using innovative strategies, sharing costs, or selecting aesthetic treatments.

The level of participation from outside agencies and organizations depends on the project and "a whole lot of common sense," Cline says. "On one project, we're rebuilding a highway to put light rail under it. That will involve DART and nearby property owners because we'll need to determine where we're going to put the stations."

Halff Associates Inc.

This artist's rendering shows a proposed highway facility in Irving that combines both toll lanes and free lanes. Adding a toll component through a comprehensive development agreement with a concessionaire will facilitate designing, constructing, and opening the facility 10 years sooner than might have been possible otherwise.

Identifying Sources Of Funding

After identifying and prioritizing the projects, Irving's next step was to explore the best possible means of completing them. For each project, the city identified the Metroplex's primary transportation providers and all local, State, and Federal agencies that might serve as sources of funding..

Depending on the nature and location of the project, potential sources of funding may include NCTCOG, DART, the "T," TxDOT's Dallas District and State office, the U.S. Congress (through the Federal-Aid Highway Program), and the Texas Transportation Commission (TTC). Because pooling funds from different agencies is an ongoing and dynamic process, Irving needs to work continuously with the various stakeholder agencies.

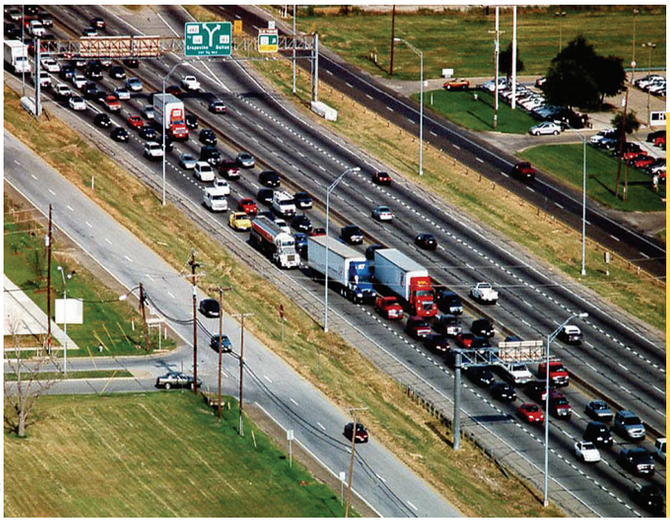
In times of tight budgets, establishing partnerships and working together can mean the difference between striking out and hitting a home run. According to the TxDOT publication *Texas Transportation Priorities: 1st Session of the 108th Congress*, the department estimates that it has only about 30 percent of the funding necessary to address the mobility needs of the State highway system in Texas. Scarce funding can mean intense competition for funding, not just between transportation projects, but between agencies responsible for all public services.

"We're in competition for funding with larger cities like Dallas and Fort Worth," Cline says. "We need to look at how we can address multiple projects successfully and do things in a manner that fits the region. If there is only a certain amount of money to go around, we need to figure out how you can raise the tide for all ships."

The STEP plan is Irving's approach to understanding the questions it will need to ask of potential partners. "The key is communication as much as anything," Cline says. "The goal is to approach these other agencies and deal with them on policy and project issues to get the best for your community."

In creating the plan, Irving did its homework to develop a strategy for how to interface with NCTCOG because the metropolitan planning organization is an important source of funding for local transportation projects. "NCTCOG now serves as an implementation partner," says Mike Sims, senior program manager with the NCTCOG. "It's a cooperative process, where we look at funding schedules and revenue streams to determine the best way to piece together a project."

Sims describes a proposed project that involves placing a transit rail line through the Los Colinas area. Irving officials sought to convince DART to



Halff Associates Inc.

Traffic is shown backed up on State Highway 183 near Texas Stadium during the morning commute. Irving's STEP plan aims to address congestion like this and improve mobility in and around the city.

opt for a different alignment that would maximize economic development for the city. To seal the deal, DART needed assurances from Irving that funds would be available when the time came to build the project. "NCTCOG worked with Irving to award funds and then delay their use to meet the DART implementation schedule," Sims says.

Transportation Summit

An important venue for exchanging information with partner agencies as well as other experts in the transportation industry is the Texas Transportation Summit, held annually in Irving. Topics covered at the 2005 event included tolling, multimodal travel forecasting, international freight movement, transit-oriented development, intelligent transportation systems, regional mobility, and surface transportation safety.

To address the backlog of transportation projects, U.S. Representative Eddie Bernice Johnson (D-Texas) suggested hosting the first summit, which took place in 1998. The goal was to raise awareness of important transportation projects and identify issues that would need to be addressed in order to get the projects underway.

"Doing a transportation summit is part of [the Department of Public Works and Transportation's] strategy," Cline says, "because there's only so much money to go around. There's only so many ways you can keep carving up the same pie. We found that by raising awareness we can focus more on the specific projects and issues. The summit opens up new opportunities."

One such opportunity was the chance to participate in a pilot project involving environmental streamlining, sponsored by FHWA and the American Association of State Highway and Transportation Officials (AASHTO). In fact, Irving's Loop 12/Interstate Highway 35 East project played a pioneering role in the development and evaluation of environmental streamlining for transportation projects, which is a process that expedites completion of environmental clearances. The $1 billion, 21.7-kilometer (13.5-mile) Loop 12 project will include a mix of widened highways, reversible high-occupancy vehicle lanes, commuter or light-rail lines, and bicycle and pedestrian improvements.

For the pilot project, Irving and TxDOT participated in a working group that facilitated continuous collaboration and coordination to streamline the environmental evaluation and approval process. Particularly, the project faced environmental hurdles relating to air quality impacts and river crossings. As challenges arose, the working group provided a forum for achieving interagency cooperation and community consensus. For example, one segment of the project required access to frontage roads from public streets. A new TxDOT policy would not have provided adequate access to the frontage roads from adjacent properties, but because of participation in the working group, Irving was able to secure approval from TTC in a timely manner.

"AASHTO identified 10 projects to streamline," Cline says, "and we had the most significant project in terms of cost. We shaved off about 40 percent of the time that it usually takes to complete the environmental assessment."

City of Irving, TX

U.S. Senator Kay Bailey Hutchison (R-Texas) chats with Collin County Judge Ron Harris at the 2004 Texas Transportation Summit in Irving. The city held its first summit in 1998 as a means to share information on transportation-related topics of interest to local, regional, State, and Federal stakeholders.

RTKL Associates Inc.

Irving officials are working with TxDOT and other stakeholders to develop future uses for Texas Stadium when the Dallas Cowboys move out after 2008. One proposed use is an eco-community, shown here in this artist's rendering, with an abundance of green and public spaces.

Tips for Developing Strategic Plans

Mike Sims from NCTCOG recommends that municipalities think more strategically about their long-term goals and how to achieve them. "Often city officials tend to focus on the problem in front of their noses, like a pothole that needs to be fixed," he says. "They don't look at developing a long-term vision to implement a whole solution instead of many tiny solutions. If you aren't going to think strategically for your city, then your city will be left behind on something, whether it's transportation, development, or education."

Below are some tips to help local governments develop implementation plans for their transportation projects.

- Secure the support of elected officials.
- Identify all key players that can influence local transportation projects, including Federal, State, and local departments of transportation, metropolitan planning organizations, and resource agencies.
- Secure the involvement of sponsor agencies.
- Organize a coalition of local entities, including county and city officials.
- Set regular meeting times.
- Establish a list of priority projects and research both internal and external factors that might influence implementation.
- Enlist the support of interested citizens who are well respected in their communities.
- Do not shy away from those with whom you disagree. Aggressively seek out problem areas early.
- Conduct parallel reviews of project submittals by resource agencies.

Although the agencies still perform the same number of environmental analyses, the reviews are now completed concurrently to prevent long delays for priority projects. "We didn't skip any steps," he says. "We just did them smarter."

With projects in various stages of progress, ranging from planning and environmental documentation to construction design, city officials credit the STEP plan for expediting its transportation goals. "As a result of Irving's diligence and involvement in innovative practices such as the environmental streamlining initiative," says Irving City Manager Steve McCullough, "many of the city's priority projects are moving along more quickly."

Being Proactive

Integral to the STEP plan is the concept of being proactive. "Look for trouble and address it as you go," Cline says. "We actively look for potential problem issues. If we think a project might affect [U.S. Department of Housing and Urban Development] Section 8 housing outside Irving, instead of waiting to see if residents show up at a public meeting, we go to them. If you do everything early, the public hearings at the end are almost nonevents and you avoid trouble or having to redesign a project."

Sometimes being proactive can pay off in unexpected ways. For decades Irving has been home to the Dallas Cowboys football team. But Irving recently learned that after 2008 the team will move out of Texas Stadium. Typically this kind of news would be a negative thing for a municipality, Cline says, but something positive may come out of it. "Because of all the work we've been doing on the Loop 12 interchange and the three highways surrounding the stadium," he says, "we are in a position to work with the State to incorporate a few changes to the project to enhance our ability to redevelop the stadium down the road."

Environmental impact statements, utilities, and right-of-way acquisitions are the top three things that slow down projects, he adds. "Because we've been proactive, we are in a position to start looking at providing access for light rail, and we've been working with property owners on right-of-way issues."

According to Sims from NCTCOG, many local governments are passive about participating in State and Federal transportation projects that are being constructed in their cities. "Irving has not made that mistake," he says. "The city jumps into design and planning issues, spends its own money on analyzing potential situations upfront, and is able to look at roadways not as stand-alone issues but considering how it might promote different styles of development. Irving identifies transportation as well as land use and zoning goals to devise a coordinated strategy."

Improved Communications

Another example of Irving's involvement with innovative strategies to improve transportation policy is the city's participation in monthly meetings with TxDOT to discuss progress on major projects. By coordinating with Federal and State agencies, Irving is improving communication and facilitating a more fluid project development process. "The meetings provide a forum for ongoing review of plans with real-time issue resolution," Cline says.

Nasser Askari, project manager with the TxDOT Dallas District, adds that Irving played a major role in assisting TxDOT in the development of the schematic design and public involvement process for two major transportation projects within the city: the Loop 12/Interstate Highway 35 East project and State Highway 183. "At the beginning of each project, we established a project

City of Irving, TX

State Representative Linda Harper-Brown and a local contractor discuss the details of work on State Highway 183 and MacArthur Boulevard in Irving.

City of Irving, TX

The Irving Department of Public Works and Transportation is installing four-quadrant gate systems like this one that block an entire railroad crossing and prevent vehicles from driving around the lowered gate arms. This safety measure enables Irving to create railroad quiet zones in the city, where trains are not required to sound their horns when crossing public highway rail crossings. An automated trackside horn will sound only if it detects a failure in the gate system. Here, a motorist waits behind the lowered gates for a train to pass.

coordination work group for the purpose of meeting at monthly or quarterly intervals to review progress, advise the project team, share ideas, and coordinate efforts," Askari says. "Staff from Irving's Department of Public Works and Transportation participated in all of the meetings and provided TxDOT with their comments and input throughout project development. The city of Irving's cooperation and involvement in early project development resulted in on-time completion of these projects."

One example of a project that developed through improved communication with outside agencies is a recent citywide effort to create railroad quiet zones. A new Federal law requires trains to sound their horns when approaching and traveling on public highway rail crossings unless the crossing is located in a quiet zone and approved safety measures are in place. The city of Irving recently passed an ordinance to create quiet zones, required under Texas law.

Trinity Railway Express equipped four of the city's busiest rail crossings with four-quadrant gates, which block the entire crossing and prevent vehicles from driving around the gate arms. The exit gate management system can detect a vehicle stuck on the tracks as a train approaches. If a vehicle is present, one exit gate on each side of the four-quad gate will remain upright, allowing a motorist to exit. An automated horn system lets motorists approaching the crossing know that a train is coming. The automated trackside horn will sound only if it detects a failure in the gate system.

According to Cline, Irving is one of the first cities in the country with a plan to become completely "quiet zoned" at all major railroad crossings. "Installation of the four-quadrant system is safer than conventional two-gate crossings and means the trains will no longer have to blow their whistles as they approach these intersections."

Communicating with the public also is essential for success. During implementation of the STEP plan, Irving created the Irving Citizens Advisory Committee (ICAC), which assists the city in determining the most appropriate design features of projects, including points of entry and exit, within the city limits. The ICAC provides a sounding board for ideas and a forum to discuss project issues—such as potential impacts on communities or neighborhoods—well in advance of the traditional public involvement process.

A Blueprint for Success

City officials have been working on the STEP plan for the past several years but only recently put it together formally in a binder. The selection of a binder as the means to organize the plan implicitly reflects the document's formal yet flexible nature. Section 1 concludes by stating that the plan represents a *guide* for scheduling projects but recognizes that variability in key assumptions—such as the availability of funding, ability of lead agencies to secure reviews and approvals in a timely manner, and public acceptance of project designs—could affect the timelines for projects and their completion.

According to the plan, "These projects are considered essential to the development of employment opportunities and economic development in this portion of Dallas County. The prioritization of . . . projects is based on the issues identified in the various sections of the discussion presented in this development plan, with the understanding that key assumptions can and will change over time. For this reason, this document is considered a 'living document' [that] must be updated when circumstances and events occur [that] may change the . . . assumptions."

Irving's STEP plan enabled the city to better focus its efforts on the areas of greatest need as opposed to those that seemed most likely to receive earlier funding. By emphasizing the needs and aggressively pursuing the means for meeting them, Irving has taken a significant "STEP" toward creating a safer, more efficient transportation system for its citizens.

Linda Harper-Brown, a former Irving city councilwoman, is in her second term as a State representative in the Texas House of Representatives for District 105. She serves on the Higher Education Committee and the Local and Consent Calendars Committee. She is the vice chairperson of the House Committee on Land and Resource Management.

A Better *Design* For Box Culverts?

by Kornel Kerenyi, J. Sterling Jones, Kevin Goeden, Richard Phillips, and Paul Oien

FHWA and the South Dakota Department of Transportation recently partnered to study the effects of inlet geometry on water flow in cast-in-place and precast structures.

(Above) The South Dakota Department of Transportation (SDDOT) installed this triple-barrel box culvert, made from precast concrete, under a median crossover on Interstate 29 in Minnehaha County, just north of Sioux Falls, SD. FHWA and SDDOT recently conducted a study of various inlet section configurations for box culverts with the goal of updating industry design software and coefficients. *Photo: Corey Haeder, Cretex Concrete Products West, Inc.*

Understanding hydraulics and hydrology is a necessity for designing drainage structures such as culverts that control the flow of water near highway infrastructure. The size and shape of a culvert not only determine the structure's effectiveness, especially during extreme weather events such as major floods and washouts, but they also significantly affect the overall construction costs of a project.

"Culverts that are designed using older, more conservative inlet coefficients tend to be oversized," says Mark Clausen, division bridge engineer with the Federal Highway Administration's (FHWA) South Dakota Division. Oversized culverts equate to higher costs than are necessary to do the job effectively, especially for construction materials such as concrete.

"This extra expense means that there will be fewer construction

projects for State DOTs [departments of transportation] and county highway agencies," Clausen says. "In these times of budget constraints, getting more efficient designs and making the tax dollar go as far as possible is the goal for States and counties."

State DOTs are interested in culvert hydraulics because they install a large number of culverts every year. Based on 2001 Form FHWA-47 data (which catalogs materials and labor used by contractors on highway construction projects involving Federal funds), more than 769,443 meters (2.5 million linear feet) of pipe materials between 45 centimeters (18 inches) and 560 centimeters (220 inches) in diameter were installed per year on Federal-aid projects that cost more than $1 million each. That equates to roughly 7,700 kilometers (4,780 miles) over a 10-year period. Although this statistic includes all pipes, culverts represent a high percentage of the total in this size range. Further, this statistic does not include field-cast concrete culverts, but it does reflect the order of magnitude of culvert installations in the United States.

To design and analyze culverts, most State DOTs rely on FHWA's Hydraulic Design Series (HDS–5), *Hydraulic Design of Highway Culverts* (FHWA-IP-85-15), and the companion computer program, HY8 Culvert Analysis (Version 6.2). First published in 1985, HDS–5 is based primarily on research that was sponsored by the Bureau of Public Roads (the predecessor to FHWA) in the late 1950s and early 1960s and industry-supported research conducted during the 1970s.

Since the initial publication of HDS–5, researchers, especially in the precast industry, have developed a number of alternative configurations for box culverts, which are usually square or rectangular reinforced concrete structures with single or multiple openings. New culvert configurations and designs raise questions about the effectiveness of subtle differences or changes in the geometry or configuration of the inlet (edges of the culvert). To answer some of these questions, FHWA and the South Dakota Department of Transportation (SDDOT) partnered to conduct a study in the FHWA Hydraulics Laboratory located at the Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA.

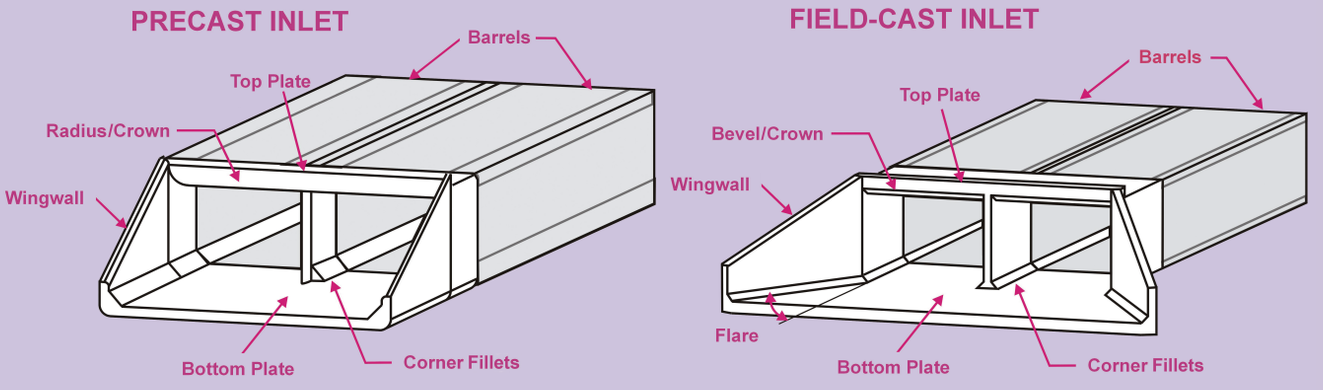
In South Dakota, as in other States, engineers have the option of using precast or cast-in-place concrete for box culverts. Precast inlets generally have straight (zero-degree) wingwalls, while field-cast inlets may feature straight or flared wingwalls. (In a straight inlet, the wingwalls extend straight out from the end of the barrel section. With a flared inlet, the wingwalls flare outward, creating a sort of funnel shape before the barrel section.) According to Clausen, the current inlet coefficients used in computer models frequently specify larger openings for the precast options than needed, leading to oversized and conservative designs for straight inlets.

The FHWA-SDDOT research project, Effects of Inlet Geometry on Flow Capacity of Single and Multiple Barrel Box Culverts, therefore examined the coefficients for straight and flared inlets. "The gap between the coefficients for the two inlet types is not as large as once thought," Clausen says. "The data from this study soon will be incorporated into current hydraulic design software, and box culvert designs should become more cost effective and efficient in the future."

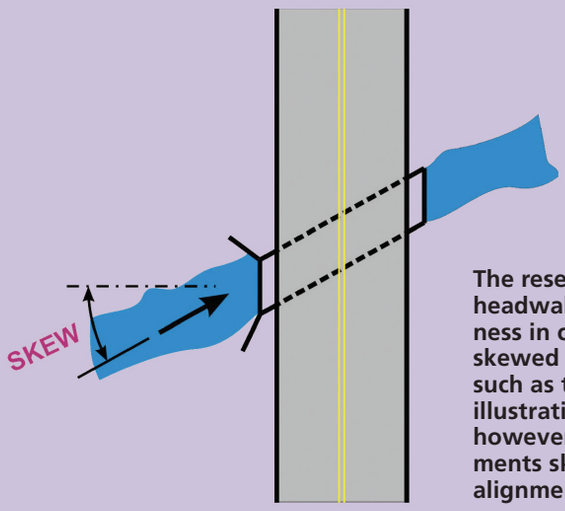
Research Considerations

The precast industry can produce a variety of edge treatments for culverts once the forms are fabricated. Therefore, the first factor that the research team considered was the effect of streamlining the bevels on the top plate and wingwalls at the culvert entrance. The researchers expected to find that by streamlining the edges of straight wingwalls they could yield enough hydraulic gain to compare favorably with the hydraulic performance of flared wingwalls, which are common among cast-in-place installations in the field.

Other factors investigated in the study include corner fillets (fabricated corners filled slightly to avoid concentrating stress in sharp turns), multiple barrels (a culvert unit composed of two or more barrels adjacent

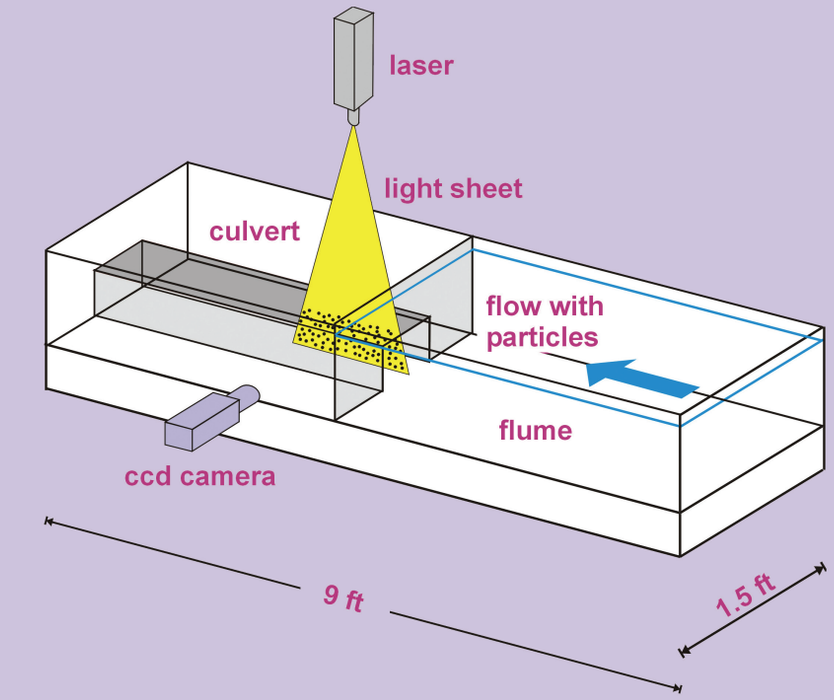


These box culvert diagrams show the key components of double-barreled precast (left) and field-cast (right) inlets, including the top and bottom plates, crowns, wingwalls, and corner fillets. A primary difference between the two inlets is that the precast type features a straight wingwall, whereas the field-cast version has a flared wingwall, which helps the culvert act more like a funnel. *Source: FHWA.*



The researchers tested skewed headwalls for their effectiveness in controlling flow through skewed highway alignments such as the one shown in this illustration. The study did not, however, test culvert alignments skewed to stream alignments. *Source: FHWA.*

to each other), extended inner walls, span-to-rise ratios, skewed crossings, submerged and unsubmerged inlets, and two different barrel slopes. The factors were tested under a wide range of flow conditions to determine how they affect the design coefficients used to evaluate culvert performance for both outlet control and inlet control situations. The design coefficients derived in this study were the entrance loss coefficients, which are the numbers multiplied by the velocity head to estimate the entrance energy loss for a culvert operating in outlet control where the headwater depth is influenced by tail water and friction in the culvert as well as the entrance loss. A lower entrance loss corresponds with a lower headwater at the upstream side of the highway embankment. The design coefficients are a set of regression coefficients relating headwater depth to discharge intensity for each inlet configuration for culverts operating in inlet control, where the headwater depth is influenced by the inlet geometry but not by friction in the culvert or the tail water.



This diagram shows components of the miniflume and setup for particle image velocimetry. From the right-hand side, the particle-laden water flows from the flume and enters the culvert. A laser mounted above the flume directs a sheet of light down through the culvert, where a charge-coupled device (CCD) camera collects information about the velocity of the entrained particles passing through the culvert. *Source: FHWA.*

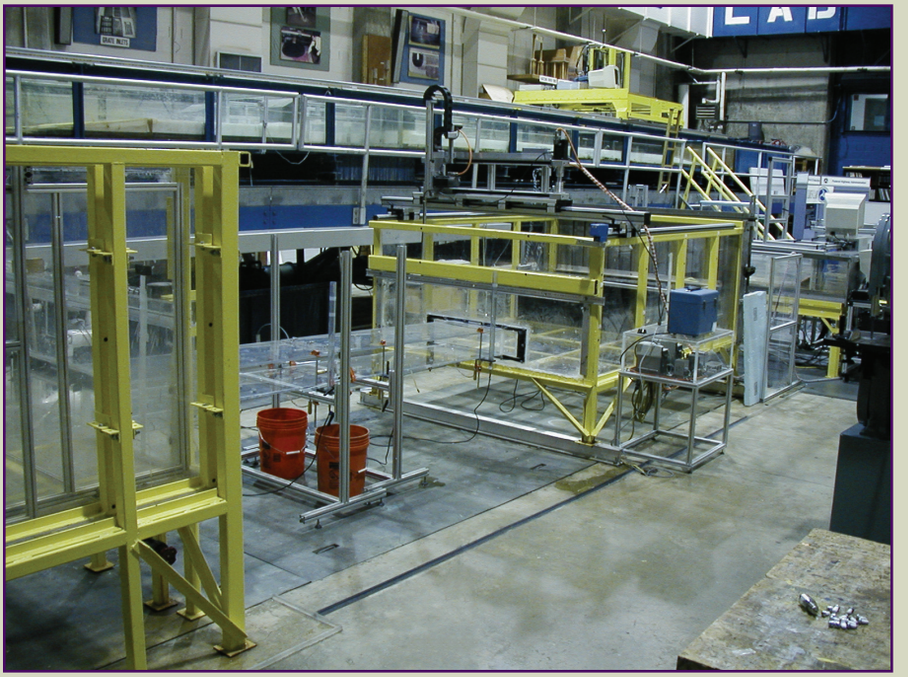
Although engineers traditionally treated culverts with multiple barrels as a combination of single-barrel units, the research team sought to challenge the adequacy of that assumption. Intuitively, the researchers expected that a multiple-barrel installation might perform slightly better than a number of adjacent single-barrel culverts because the inner barrels do not have much flow contraction.

The inner walls of a multiple-barrel installation are usually flush with the headwall, but the researchers questioned whether there might be an advantage to extending the inner walls onto the approach apron, just as the wingwalls are extended. "The precast industry tends to use combinations of single-barrel and double-barrel components to make triple- and quad-barrel installations," says Corey Haeder, chief engineer with Cretex Concrete Products West, Inc. By placing the two culverts side by side, the inner wall becomes thicker. He adds, "That practice leaves one double-thick inner wall, which is a detriment, but to what degree?"

Further, because highway alignments are not always perpendicular to streams, culverts should be skewed to the highway embankment, as opposed to attempting to change the direction of the stream. Although the authors have observed a number of installations where the culvert did change the flow direction, the tests conducted in this study were limited to cases where the highway alignment and culvert wingwalls, but not the culvert barrel, were skewed to the flow direction.

Setting Up the Experiment

Researchers conducted approximately 700 tests at the TFHRC Hydraulics Laboratory, with the physical modeling for the culvert study occurring in two phases. The first set of experiments optimized the



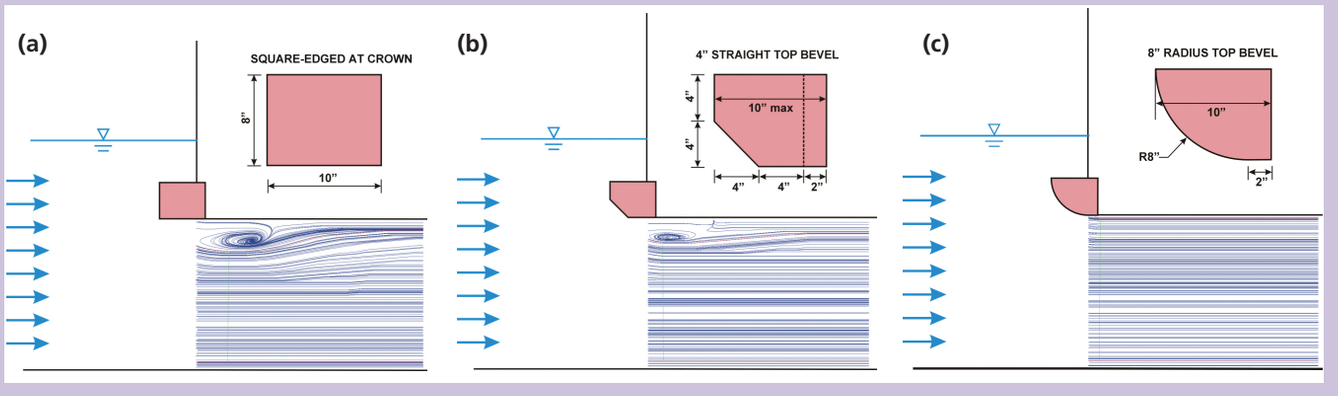
This photo shows the culvert setup in the FHWA Hydraulics Laboratory, with the model barrel between the head and tail boxes.

bevel edge of the wingwalls and top edge using two-dimensional particle image velocimetry (PIV) in a 2.75-meter (9-foot)-long and 0.46-meter (1.5-foot)-wide flume, an artificial channel for measuring water flow. This technology uses a laser and particles of silver-coated and hollow glass spheres to make the flow visible. Cameras are used to measure instantaneous velocity vectors in a flow field.

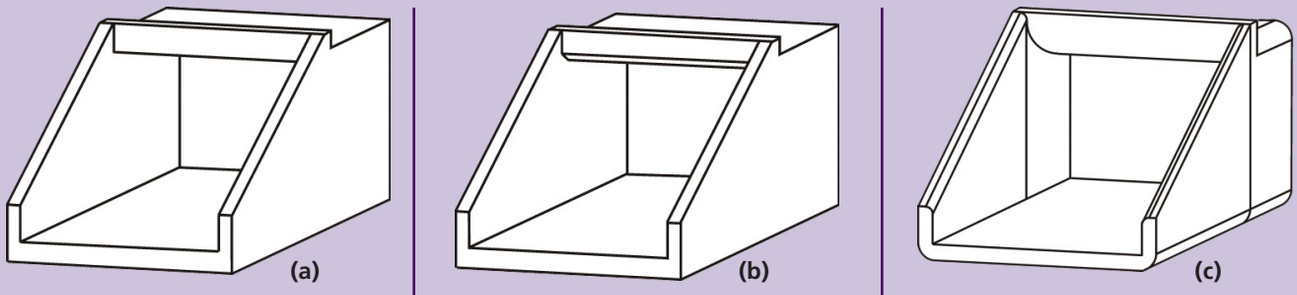
The researchers tested several bevel edge conditions, including straight top bevels (square edge), beveled edge (45 degree bevel), and radius top bevels. The criterion they used to determine the best bevel performance was the contracted distance outside the viscous boundary layer, or the effective flow depth at the vena contracta (where the flow depth is lowest inside the barrel section). The researchers used integrated streamlines, which indicate the speed and direction of flow, to visualize the contracted area (the area where water flow narrows from a wider flow) inside the culvert.

A second phase of experiments consisted of a culvert setup with a head box measuring 2.4 meters (8 feet) long by 2.4 meters (8 feet) wide by 1.2 meters (4 feet) high, and a tail box measuring 2.4 meters (8 feet) long by 1.8 meters (6 feet) wide by 0.9 meter (3 feet) high. The boxes were connected by Plexiglas® model culvert barrels with various inlet configurations. Plexiglas was used because it has similar friction to that of concrete in the model scale, yet unlike concrete would enable researchers to view the behavior of the water flow. The inlet models were designed as modular clip-in parts (wingwalls, center walls, and top plates) that could be changed easily to test various configurations. Two sets of model fillets—12.7 millimeters (0.5 inch) and 25.4 millimeters (1 inch)—were fabricated using polyvinyl chloride (PVC) material.

Electronic pressure sensors installed in the floors of the head and tail boxes measured the headwater and tail water depths. The researchers installed as many as 40 pressure sensors in the culvert barrels to measure the hydraulic and energy grade lines that were necessary to compute loss coefficients. An automated tailgate (a gate that regulates water flow depth in the flume) at the downstream end of the tail box helped maintain control of the tail water. The barrels were tested for two different slope settings. The steep slope (3 percent) accounted for inlet control conditions. The flat



This series of figures illustrates the effective flow depth at vena contracta for three bevel patterns: (a) square-edged bevel at crown, (b) 102-millimeter (4-inch) straight top bevel, and (c) 203-millimeter (8-inch) radius top bevel. The first two patterns tended to generate eddies at the top of the flow column, indicating disrupted flow. The 8-inch radius top bevel, however, offered the optimal geometric orientation, as illustrated by the undisturbed flow pattern. *Source: FHWA.*



HDS–5 Inlet	Field-Cast Model	Precast Model
0° flared wingwalls	0° flared wingwalls	0° flared wingwalls
Square-edged at crown	4-inch straight top bevel	8-inch radius top bevel
No wingwall bevel	No wingwall bevel	4-inch radius wingwall bevels
No corner fillets	No corner fillets	No corner fillets

The researchers studied the effects of bevels on three types of models: (a) an HDS–5 inlet, (b) a field-cast model, and (c) a precast model. *Source: FHWA.*

slope (0.7 percent) correlated with outlet control conditions and low tail water depths.

Test Results

Postprocessing of PIV results provided streamlines that the researchers could interpret visually to show the shape that produces the maximum effective flow depth at the vena contracta. This shape is likely to have the least headloss (loss of energy in a hydraulic system) when incorporated into the inlet geometry, meaning water will flow through faster and more effectively because of the shape of the bevel. The results show that the 203-millimeter (8-inch) rounded bevel edge produces the optimal geometric configuration.

The PIV miniflume tests helped identify the best shape, but the researchers also wanted to know how much gain the shape produced in the hydraulic performance. To answer this question, they tested two types of models: precast and cast-in-place. The precast models were fabricated with the optimum radius on the top plate and rounded bevels with a 102-millimeter (4-inch) radius on the wingwall edges. The field-cast models featured SDDOT's standard straight bevel (45 degrees) on the top plate and no bevels on the wingwall edges. The researchers conducted additional tests using a model of the closest HDS–5 inlet, which has wingwalls with a zero-flare angle and no bevels on either the top plate or the wingwalls.

Based on their findings, the researchers concluded that there is almost no gain due to edge bevel shapes for unsubmerged inlet control flow, which is understandable because the top edge with the primary bevel is not exposed to the flow. The gain shows up in the submerged section and increases to approximately 10 percent less headwater with the 203-millimeter (8-inch) radius top plate at the highest discharge intensity tested. The precast inlet with the optimum top plate bevel proved to be the best performer when the inlet was submerged, because the streamlined curve of the bevel provides a better path for the water flow. Although the researchers did not attempt to verify their results using actual field data during this study, they contend that the results correlate well with previous studies and coefficients currently in HDS–5.

To understand the effects of using multiple barrels, the researchers sought to answer two questions. First, is it reasonable to assume that multiple barrels control flow in the same way as multiples of a single-barrel culvert with the same type of inlet? Second, is there a hydraulic advantage to extending the center walls onto the apron?

After testing a number of field-cast and precast models, the researchers found almost no difference in the performance of multiple barrels and single-barrel culverts for unsubmerged flow during inlet control conditions. They noted, however, that a slight advantage exists for multiple barrels compared to single barrels for submerged flow for the field-cast models and a significant hydraulic advantage for the precast models with the optimum bevel on the top plate, especially for headwater depths greater than 1.5 times the culvert height. All of the inlet control results indicate that the common practice of using single-barrel coefficients for multiple-barrel culverts is conservative for inlet control conditions. In other words, the same coefficient can be used for both single barrels and multiple barrels for unsubmerged inlet control.

The researchers found that the outlet control results were somewhat inconsistent. The values for the entrance loss coefficient for the

field-cast models with straight wingwalls were almost identical for the single-, double-, triple-, and quad-barrel models and averaged 0.52. Similarly, the outlet control coefficient values for the field-cast models with 30-degree flared wingwalls were close to an average value of 0.31 for the single-, double-, triple-, and quad-barrel models. These results support the practice of using the single-barrel coefficients for multiple-barrel analyses for outlet control, as well as inlet control, conditions for field-cast box culverts.

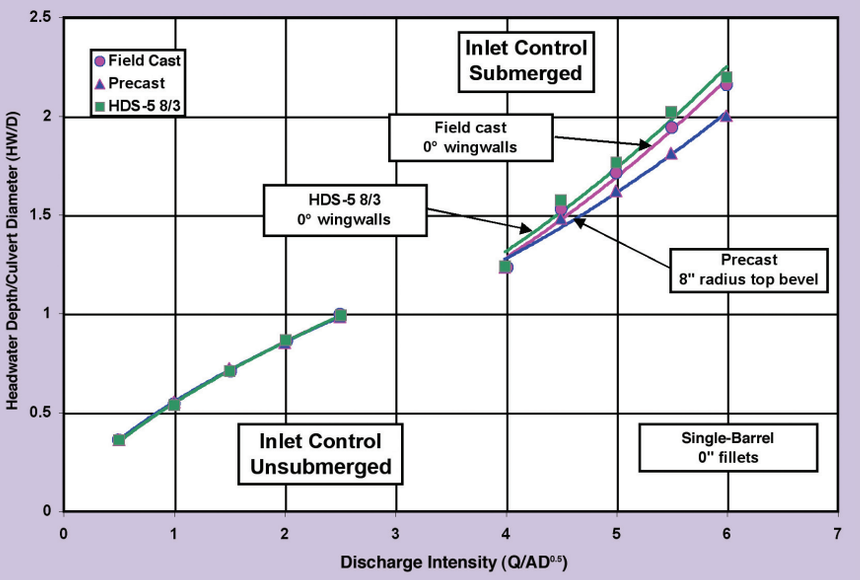
For the precast models, however, this is not the case. The average entrance loss coefficient increased from 0.33 for the single barrel to 0.49 for the double barrel to 0.54 for the triple barrel to 0.59 for the four-barrel model, suggesting that the efficiency decreases with the number of barrels for precast box culverts operating in outlet control conditions. The researchers explain the decrease in part by the double-wall thickness that results from setting two sections side by side to yield the triple- and four-barrel configurations, but they could not explain why the double barrel showed a higher loss coefficient than the single barrel.

The results for inlet and outlet control showed no hydraulic advantage or disadvantage to extending the inner walls of multiple-barrel culverts onto the apron. Further, the researchers noted a significant increase in headwater for a given discharge intensity for skewed headwalls, which are sometimes used to accommodate highway alignments that are not perpendicular to the stream flow.

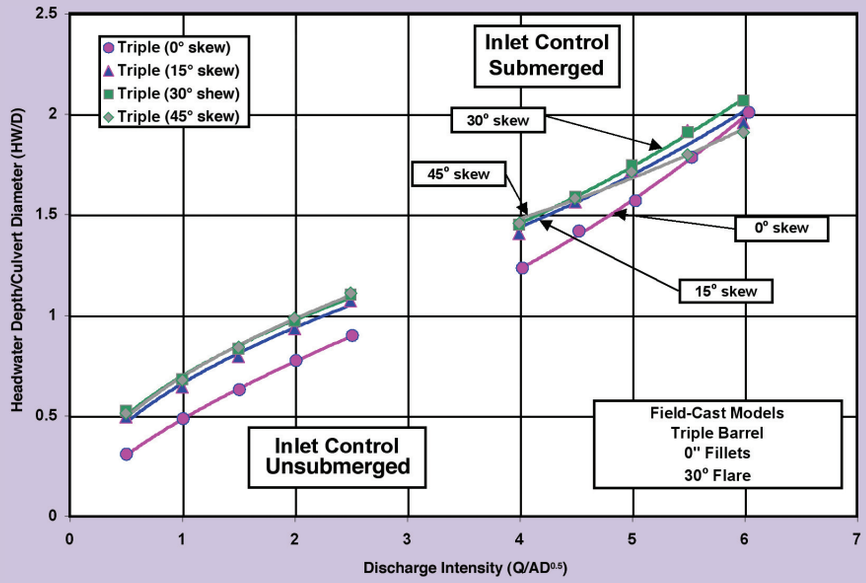
Significant Findings

All of the inlets tested in the study were variations of inlets covered in HDS–5, with different combinations of entrance improvements. The following are among the significant findings:

- Based on the PIV flow visualization technique developed in the TFHRC laboratory, the researchers determined that the optimum edge treatment for the top plate, or crown, of a culvert is a rounded radius of 203 millimeters (8 inches), which happens to be the full thickness of the top plate for the models tested.
- A distinct difference in performance exists between square-edged crowns, beveled crowns, and rounded crown plates for box culvert models with straight wingwalls under submerged conditions. The rounded crown plate performed the best under submerged inlet conditions; the square edge performed the worst.
- Multiple barrels had a slight, but negligible, hydraulic advantage over single-opening culverts for the inlet control tests, except for the precast models with submerged inlets and headwater depths greater than 1.5 times the culvert height, where there was a significant advantage over the multiple barrels. However, the researchers noted that highway agencies seldom design for headwater depths greater than 1.5 times the culvert height. Multiple-barrel models with flared wingwalls, on the other hand, were slightly less hydraulically efficient for the outlet control tests where the entrance loss coefficient varied from 0.26 for the single-barrel models to 0.34 for the worst multiple-barrel model. The researchers noted, however, that the entrance loss is a relatively small part of the total losses controlling the headwater for culverts operating under outlet control. Further, they concluded that it is reasonable to use the single-barrel coefficients for multiple-barrel culverts.
- Wide span-to-rise models acted similarly to multiple barrels, except there was a slight hydraulic disadvantage (rather than advantage) in the coefficients for the wide-span models compared to the 1:1 span-to-rise models for both the inlet control tests and the outlet control tests.
- There was no hydraulic advantage or disadvantage to extending the inner walls of multiple-barrel culverts onto the apron.
- Skewed headwalls have a detrimental effect on culvert hydraulics.



This graph shows inlet control performance curves for HDS–5, field-cast, and precast inlets. The y-axis plots headwater depth divided by the culvert diameter, and the x-axis shows the discharge intensity for the three models—one with the optimum top plate, one with the straight cut bevel, and one with the square edges. The lower curves in the chart indicate better performance, meaning that the inlet operates with less headwater for a given discharge intensity. The inlet with the optimum top plate bevel was clearly the best performer when the inlet was submerged. When the inlet was unsubmerged, all three curves were on top of one another, indicating that the bevels made almost no difference. *Source: FHWA.*



Inlet control comparison for multiple-barrel, field-cast skew tests with 30-degree flared wingwalls. The graph is a plot of headwater depth divided by culvert diameter on the y-axis versus discharge intensity on the x-axis for the four models with various headwall alignments skewed to the stream flow direction. The lower curves in the chart indicate better performance, meaning that the inlet operated with less headwater for a given discharge intensity. The zero skew angle clearly was the best performer for both submerged and unsubmerged flow. The curves for the other skew angles tested—15, 30, and 45 degrees—could be merged into a single curve without much loss in accuracy.
Source: FHWA.

A big concern for SDDOT was not only achieving the research results but also incorporating the results into culvert design software. To facilitate transferring the data to the software, the researchers presented inlet and outlet control loss coefficients in a format consistent with HDS–5 and developed fifth-order polynomials (regression curves to fit the experimental data) to be coded into the design software. The authors understand that many users would prefer to use the design software on a Windows® operating system and have the architecture modified to facilitate incorporating new test results when they become available from reliable research laboratories.

The timing of revisions to HDS–5 and the design software will be driven by selected contributions from this study as well as a major parallel study sponsored by the National Cooperative Highway Research Program (NCHRP) at Utah State University, where researchers are investigating a number of environmental considerations that engineers frequently encounter in culvert design.

Kornel Kerenyi is a hydraulic research engineer in the FHWA Office of Infrastructure Research & Development (R&D). He coordinates FHWA hydraulic and hydrology research activities with State and local agencies, academia, and other partners and customers. He also comanages the FHWA Hydraulics Laboratory. Previously he was a research engineer for GKY and Associates, Inc. and supervised the support staff in collecting and analyzing the data for this study. Kerenyi holds a Ph.D. in fluid mechanics and hydraulic steel structures from the Vienna University of Technology in Austria.

J. Sterling Jones is a hydraulic research engineer in the FHWA Office of Infrastructure R&D. He manages the FHWA research program in hydrology and hydraulics and comanages the Hydraulics Laboratory. He oversaw data collection and analysis and the reporting of results for this study. He is a registered professional engineer in Virginia.

Kevin Goeden is the bridge design engineer for the SDDOT Office of Bridge Design. He served as a technical panel member for the research. Goeden has been involved in highway structure design activities in the Office of Bridge Design for more than 23 years and is the engineering supervisor in charge of the bridge design and hydraulics sections. He holds a B.S. in civil engineering from South Dakota State University and is a registered professional engineer in South Dakota.

Richard Phillips is the bridge hydraulics engineer for SDDOT. He manages hydrologic and hydraulic design of large culverts and bridges for State route projects and reviews hydraulic design for federally funded local government projects. He provided input into developing the statement of work for this study, participated in project meetings, and reviewed reports. He collaborated with Sterling Jones in a joint presentation on preliminary results from the study at the 2004 FHWA National Hydraulic Engineering Conference in Asheville, NC. He is a registered professional engineer in South Dakota.

Paul Oien is a project engineer with the SDDOT Office of Research. He served as the project monitor for this study. He coordinates SDDOT research activities with other State agencies, construction industry representatives, manufacturing representatives, promotion boards, and other stakeholders to ensure that projects are completed as stated in research proposals. He holds a B.S. in civil engineering from the South Dakota School of Mines and Technology.

To access the HDS–5 report, please visit www.fhwa.dot.gov/engineering/hydraulics/pubs/hds5si.pdf. For more information on this study, see the laboratory report, Effects of Inlet Geometry on Hydraulic Performance of Box Culverts, *which is scheduled to be published in 2006.*

Along the Road

Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation (USDOT) sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Policy and Legislation

FHWA Develops Guidance on Work Zone Final Rule

The Federal Highway Administration (FHWA) is developing guidance documents that will help State departments of transportation and other transportation agencies understand and implement the provisions of the updated rule on work zone safety and mobility.

Published in September 2004 in the *Federal Register* (23 CFR 630 Subpart J), the rule will help States consider the broader safety and mobility impacts of work zones and to guide implementation of appropriate strategies to manage these impacts during project delivery. All State and local governments that receive Federal-aid highway funding are required to comply with the rule's provisions by October 12, 2007.

The forthcoming guidance documents will provide sample approaches for implementing the rule, share examples from States currently using successful practices, and list sources for more information. The documents will cover topics including developing work zone policies, assessing the impacts of work zones, preparing transportation management plans for work zones, and developing public information and outreach plans.

For more information about the rule and the guidance documents, downloadable fact sheets and a brochure are available at www.ops.fhwa.dot.gov/wz/resources/final_rule.htm. The guidance documents will be uploaded to the site as they become available in fall 2005.

For more information, contact Tracy Scriba in the FHWA Office of Operations at 202-366-0855 or tracy.scriba@fhwa.dot.gov.

Public Information and Information Exchange

Alaskan Way Viaduct EIS Recognized For Environmental Excellence

The environmental impact statement (EIS) for the Alaskan Way Viaduct and Seawall Replacement Project in Seattle, WA, recently won an award for environmental excellence from the National Association of Environmental Professionals (NAEP). In addition to receiving an award in the category National Environmental Policy Act, the project also was named the "best of the best" among entries received in all categories. NAEP presented the award in spring 2005 at its national conference in Washington, DC.

Compiled jointly by FHWA, the Washington State Department of Transportation (WSDOT), and the Seattle Department of Transportation, the EIS explains the need to replace the earthquake- and saltwater-damaged structure.

The EIS is the first to showcase WSDOT's new emphasis on preparing more reader-friendly environmental documents. The introduction, for example, responds directly to several of the public's most frequently asked questions on the project, including "Why was the Alaskan Way Viaduct and Seawall Replacement Project initiated?" and "Who will decide what will replace the viaduct and seawall, and how can I be involved in this decision?"

WSDOT

The environmental impact statement for a project to replace the Alaskan Way Viaduct in Seattle, WA, recently was recognized by the National Association of Environmental Professionals. The aging seawall, shown here, stands in the soft, poor-quality soils that the viaduct and much of the waterfront are built on.

The EIS also includes a "purpose and need statement" that includes the function of the replacement, the reasons it is needed—to address deficiencies in roadway design and enhance traffic safety—and the objectives that the project will attain. Residents can submit comments via e-mail or through one of several public hearings in the Seattle area.

For more information, visit www.wsdot.wa.gov/projects/viaduct/DEIS.htm.

WSDOT

U.S. to Assist Thailand in Collecting Traffic Data

U.S. Transportation Secretary Norman Y. Mineta recently pledged to help the government of Thailand reduce traffic-related deaths and injuries by developing a better system to collect information about traffic incidents. The United States, working with other Asia-Pacific Economic Cooperation countries, will help Thailand develop, implement, and maintain a new, reliable system for collecting data on crashes. The goal is to reduce nonreporting or underreporting of traffic incidents.

The rapidly increasing number of motor vehicles in Thailand and the rate of traffic fatalities underscore the importance of improving traffic-safety data. Between 1987 and 1997, the number of registered vehicles nearly quadrupled, from 5 million to 18 million. In addition, more than 13,000 people are killed and 70,000 injured in crashes annually, according to the Thai government. These totals, however, may not reflect the full extent of the problem, given the limited scope of Thailand's current system for collecting crash data.

A team of experts representing USDOT's National Highway Traffic Safety Administration and highway agencies from other countries will work with the Thai government to develop a master plan for improving its traffic data. The plan will include data and procedural manuals (which may eventually be adapted for use in

other countries), development of new software, and use of new and emerging technologies, such as event data recorders and global information systems.

In a separate announcement, Secretary Mineta said that the U.S. Government would work with Thailand to identify intelligent transportation systems (ITS) technologies—including traffic signal controls and electronic toll collection—that could ease highway congestion and enhance safety for commuters traveling to Bangkok's new Suvarnabhumi Airport, scheduled to open in 2006.

For more information, contact Bill Mosley at 202-366-4570.

Texas DOT Opens New JFK Causeway Section in Corpus Christi

The Texas Department of Transportation (TxDOT) recently held a ribbon-cutting ceremony at the Laguna Shores turnaround to celebrate the newly constructed John F. Kennedy (JFK) Causeway elevated project near Corpus Christi, TX. Because much of the JFK Causeway was at an elevation of less than 0.91 meter (3 feet) above the mean high tide, flooding caused by storms or tidal conditions used to affect traffic flow on the causeway, temporarily closing one or more lanes.

A joint effort by the city of Corpus Christi, Nueces County, the Corpus Christi metropolitan planning organization, and TxDOT, the project involved raising a portion of the JFK Causeway/Park Road 22 to a minimum of 2.7 meters (9 feet) above mean sea level between the mainland and the islands.

The JFK Causeway serves as the only nonferry evacuation route for more than 10,000 full-time residents of Padre and Mustang Islands, and the elevated roadway will provide a safe and efficient island evacuation route during high tides and tropical storms. The causeway also will better accommodate the 50,000 to 200,000 visitors who travel each day to Padre Island for recreation.

For more information, visit www.dot.state.tx.us/CRP/projects/JFKcauseway/project.htm.

TxDOT

Oregon Motorcycle Safety Program Rated Top in Nation

Oregon's motorcycle safety program is the best in the Nation, according to preliminary results of a study sponsored by the National Highway Traffic Safety Administration (NHTSA). Oregon scored highest among the 47 States surveyed in the categories of program administration, rider education courses, and motorcycle licensing, according to a study of best practices conducted for NHTSA by the American Institutes for Research. The *Journal of Safety Research* (Volume 36, Issue 1) recently published the preliminary results.

"This is confirmation that the Team Oregon motorcycle safety program is providing riders exactly what they need to ride safely in Oregon's unique geography," says Stan Porter, motorcycle program coordinator for the Transportation Safety Division at the Oregon Department of Transportation (ODOT).

The Team Oregon program derives its name from the group of motorcycle rider organizations and educational and government agencies that originally sat on the Oregon Governor's Advisory Committee on Motorcycle Safety. Team Oregon was developed through collaboration between in-State riders and Oregon State University, which conducts rider education courses through a grant from the ODOT Transportation Safety Division. Oregon's program is notable because its State-specific safety curricula for beginning, intermediate, and advanced riders rely on extensive assistance from nationally known experts and practitioners in motorcycle safety.

The Driver and Motor Vehicle Services (DMV) division of ODOT administers the motorcycle licensing program. Individuals applying for a "motorcycle endorsement"—a required document that motorcycle users must obtain in conjunction with a regular driver's license—may substitute a basic course certificate from the Team Oregon program as an alternative to taking the DMV knowledge and skills tests.

For more information, contact David House at 503-945-5270 or david.j.house@odot.state.or.us, or visit http://teamoregon.orst.edu.

ODOT

VTrans Receives Public Space Award For Route 9 Construction

In spring 2005, Vermont Governor Jim Douglas honored the Vermont Agency of Transportation (VTrans) with the State's 2004 Public Space Award for reconstruction of State Route 9 (S.R. 9) in southern Vermont. Recently named a Vermont scenic byway, S.R. 9 serves as the primary corridor linking Brattleboro and Bennington.

Completed in 2004, the reconstructed 5.9-kilometer (3.7-mile) stretch from Searsburg to Wilmington incorporated a construction design that successfully minimized the impact on the Deerfield River and left large segments of riparian and wooded vegetation untouched. The alignment of S.R. 9 with the existing topography, however, presented difficult design challenges because the road is wedged between steep, wooded slopes and the Deerfield River and Harriman Reservoir.

The VTrans landscape architect and project manager worked closely with regulatory agencies to develop solutions using plants native to the area. In sections where slopes needed to be cleared to the water's edge, VTrans placed stone fill on the steep slopes to improve stability and applied native soils to promote revegetation.

Established in 2002, the Public Space Awards recognize exterior or interior public spaces in Vermont that have been defined or enriched by design or planning to promote positive public uses. The awards are sponsored jointly by the Vermont Chapter of the American Society of Landscape Architects, Vermont Planners Association, Vermont Section of the American Society of Civil Engineers, and Vermont Chapter of the American Institute of Architects.

For more information, contact Ian Grossman at 802-828-1647 or ian.grossman@state.vt.us.

VTrans

NATIONAL HIGHWAY INSTITUTE

Training Update

New Course Targets Highway Runoff

Stormwater runoff that results from development and urbanization is a significant source of pollutants that can have an adverse effect on nearby bodies of water and ecosystems. Highway surfaces and adjoining areas collect a variety of contaminants that contribute to runoff, including heavy metals, inorganic salts, aromatic hydrocarbons, and suspended solids that accumulate on the road surface as a result of regular highway operation and maintenance activities, such as deicing and herbicide applications. These pollutants can significantly affect the physical, chemical, and biological characteristics of receiving waters.

In 1972 the United States passed the Federal Water Pollution Control Act as the first national legislation to control pollution and manage the quality of water in the Nation's waterways. As amended in 1977, the law became commonly known as the Clean Water Act. To restore and maintain the integrity of the Nation's waters, the Act set a national goal that all U.S. waters should be fishable and swimmable.

The Clean Water Act regulates discharges into waterways through a permitting program known as the National Pollutant Discharge Elimination System (NPDES). Stormwater discharges associated with urban areas and certain industrial activities, including transportation facilities, fall under the purview of the NPDES permitting program. Therefore, transportation officials and environmental specialists need to understand the legal responsibilities, terminology, and general roles of players in the regulatory process in order to properly plan, budget, and implement measures to manage water quality.

Federal, State, and local officials continue to refine watershed planning processes to characterize stormwater quality and evaluate the effectiveness of alternative best management practices and the impact they have on the receiving waters. To help transportation engineers, natural resource agencies, and others understand, identify, and mitigate the impacts of highway runoff on water quality and ecosystems, the Federal Highway Administration's (FHWA) National Highway Institute (NHI) recently developed a new course called Water Quality Management of Highway Runoff (#142047). Environmental stewardship—providing a safe, efficient, and environmentally friendly surface transportation system—is a major priority for FHWA.

Developed in concert with representatives from FHWA, the U.S. Environmental Protection Agency, and State departments of transportation, this introductory course provides a basic understanding of how highway runoff affects ecosystems and outlines Federal requirements for protecting water quality. In addition, the course highlights best management practices that the transportation community can implement during the project development process to mitigate the impacts of highway construction and maintenance on water quality.

After completing the course, participants will be able to identify and characterize the quantity and quality of highway runoff, select appropriate mitigation strategies from a watershed perspective, and describe design objectives and considerations to use when selecting and locating best management practices for controlling runoff. Further, attendees will learn the value of inspecting, monitoring, and evaluating the performance of mitigation strategies.

Each participant should bring a calculator that will be used in group exercises and case studies.

For more technical information, contact Patricia Cazenas at 202-366-4085 or patricia.cazenas@fhwa.dot.gov. To host a session of this course, contact the NHI Training Team via e-mail at NHITraining@fhwa.dot.gov or call 703-235-0534, or visit the NHI Web site at www.nhi.fhwa.dot.gov.

Maryland State Highway Administration

On this highway project, the Maryland State Highway Administration used a comprehensive maintenance program to locate, inspect, evaluate, remediate, and enhance all of the stormwater management facilities to improve water quality and protect sensitive wetlands and water resources. The retention pond is surrounded by a vegetated fringe that promotes ecological diversity, enhances water quality, and fits harmoniously with the local environment.

Internet Watch

By Keri A. Funderburg

FHWA Revamps Web Site On Emergency Operations

The transportation network is critical to emergency response. Regardless of whether transportation facilities are directly affected by a disaster, emergency responders rely on the Nation's transportation infrastructure to deliver them to the scene, transport the ill and injured to medical facilities, and move the public out of harm's way. Surprisingly, however, few of the State, local, and regional emergency management plans recently surveyed by the Federal Highway Administration (FHWA) fully integrate transportation concerns. According to FHWA, fewer than 50 percent of plans include details on media coordination, traveler information, and asset protection. Only 10 percent address transportation coordination with a nearby emergency operations center. And few utilize intelligent transportation systems. In addition, transportation responders may be unfamiliar with handling terrorist threats or lack training on how to work with other responders under an incident command structure.

To help FHWA maintain its commitment to effectively managing emergencies that affect or take place on or within the U.S. transportation system, the agency's Office of Operations recently updated its "Emergency Transportation Operations" (ETO) Web site at http://ops.fhwa.dot.gov/opssecurity.

A Timely Update

The Web site was developed following the terrorist attacks on September 11, 2001, and was unveiled in June 2003. Aside from the occasional addition of new informational documents, the site had not been updated since its launch. The ETO program, however, has grown significantly during the past 5 years, and program leaders since have learned more about their stakeholders' needs and how other agencies can help meet them.

"A reassessment and reengineering of the Web site was needed to transmit this new knowledge," says Vince Pearce, team leader for the Emergency Transportation Operations Initiative and one of the Web site developers.

The updated site categorizes information and materials according to the components of emergency operations—prevention, preparedness, response, and recovery. Emphasizing both theoretical and practical resources, the site includes new tools for assessing a particular network's level of readiness, new references on protecting critical assets, and recently developed guides to improving emergency preparedness and mitigation. The Office of Operations expanded several existing areas of the site, including those that define the role of transportation during disasters and others that explain how to maintain operations during a crisis.

New Features

According to Pearce, a few user-friendly sections of the site are particularly helpful for planners and other transportation professionals who may be navigating the process of upgrading their emergency operations systems. A "Current News" section provides updates on pertinent legislation, technologies, operational upgrades, and success stories from across the United States. Almost

daily, the site managers post new material that they receive from sources including the Transportation Research Board and *Risk Management* magazine.

The section on preparedness, in particular a subsection on assessments, provides to-the-point tips on determining whether a system will be able to survive a natural disaster, infrastructure malfunction, or terrorist attack. A link to "Additional Resources" contains case studies on transportation systems that were recently affected by emergency situations, including New York City during the August 2003 blackout and Baltimore following the fire in the Howard Street Tunnel on July 18, 2001.

"These case studies are incredibly detailed and provide insight into how surface transportation is impacted by and works during disasters," says Pearce.

A section on funding offers links to information on obtaining funding from agencies such as FHWA and the U.S. Department of Homeland Security (DHS).

To help FHWA stakeholders and other site users understand how the ETO program collaborates with other agencies and programs, the new site features materials that explain the Transportation Security Administration's role in emergency operations and provide information on training and exercises offered by the DHS Office for Domestic Preparedness. Among the briefing materials and background information, DHS provides a full report on its recent Top Officials 3 exercise, a full-scale simulation of a coordinated terrorist attack involving biological and chemical weapons.

In addition, the site provides links to FHWA programs in traffic incident management, planned special events, and regional operations coordination and cooperation. Although these programs do not necessarily involve managing disasters, their Web sites provide information on key concepts—such as institutional coordination—that are necessary for success in emergency transportation operations.

A Tool for Many Stakeholders

In keeping with the spirit of interagency collaboration, the redesigned Web site reflects inputs received from several key groups, including the American Association of State Highway and Transportation Officials' Special Committee on Transportation Security Items, the Intelligent Transportation Society of America's Public Safety Advisory Group, and the National Traffic Incident Management Coalition. Further, the site's basic structure and many of its features echo the ETO program's coordination with DHS regarding several key presidential directives on homeland security, such as management of domestic incidents and critical infrastructure identification, prioritization, and protection.

Although FHWA updated the site with State and local emergency operations and transportation security officials in mind, Pearce notes that a broad spectrum of users are accessing the site, including consultants and representatives from public safety and emergency management agencies.

For more information, visit http://ops.fhwa.dot.gov/opssecurity, or contact Vince Pearce at 202-366-1548 or vince.pearce@fhwa.dot.gov.

Keri A. Funderburg is a contributing editor for PUBLIC ROADS.

Communication Product Updates

Contributors: Zac Ellis (RD&T) and Joanne Sedor (Freight Management)

Below are brief descriptions of products recently published online by the Federal Highway Administration's (FHWA) Office of Research, Development, and Technology. Some of the publications also may be available from the National Technical Information Service (NTIS). In some cases, limited copies are available from the Research and Technology (R&T) Product Distribution Center.

When ordering from NTIS, include the NTIS publication number (PB number) and the publication title. You also may visit the NTIS Web site at www.ntis.gov to order publications online. Call NTIS for current prices. For customers outside the United States, Canada, and Mexico, the cost is usually double the listed price. Address requests to:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703–605–6000
Toll-free number: 800–553–NTIS (6847)

Address requests for items available from the R&T Product Distribution Center to:

R&T Product Distribution Center, HRTS-03
Federal Highway Administration
9701 Philadelphia Court, Unit Q
Lanham, MD 20706
Telephone: 301–577–0818
Fax: 301–577–1421

For more information on research and technology publications from FHWA, visit the Turner-Fairbank Highway Research Center's (TFHRC) Web site at www.tfhrc.gov, FHWA's Web site at www.fhwa.dot.gov, the National Transportation Library's Web site at http://ntl.bts.gov, or the OneDOT information network at http://dotlibrary.dot.gov.

Office of Research, Development, and Technology Fiscal Year 2004 Performance Report Publication No. FHWA-HRT-05-040

The FHWA Office of Research, Development, and Technology (RD&T) recently released its third annual performance report to the American public and its stakeholders in the transportation community. The report reflects the office's efforts to identify new and improved ways to provide high-quality research products and technology services to its customers.

Without a budget or long-term authorization in place for the fiscal year, the Research and Technology (R&T) Program overcame many challenges to attain the notable accomplishments highlighted in the report. Among its successes, the office developed more than 60 multiyear program plans to provide direction for future R&T activities, and created a new exhibit to showcase FHWA's priority market-ready technologies and innovations at the Transportation Research Board's annual meeting and the American Association of State Highway and Transportation Officials' Research Advisory Committee meeting.

The first section of the report describes the office's business philosophy and workforce composition, giving special attention to its role in the community and the impact it makes through outreach and special events. The report then highlights the strategic framework of RD&T, including its vision, mission, goals, and "vital few" priorities of safety, congestion mitigation, and environmental stewardship and streamlining. A third section features the results of the office's business endeavors, including delivering needed products and services and assessing the performance of each laboratory at TFHRC. The final portion of the document showcases techniques for performance management, such as conducting case studies on the benefits of research and obtaining feedback from customers. Several appendices provide additional information on RD&T services, outreach activities, technologies, and partnerships.

Manual for LS-DYNA Soil Material Model 147 Publication No. FHWA-HRT-04-095

This final report discusses the implementation of an FHWA soil model into the dynamic finite element code, LS-DYNA®. FHWA developed Soil Material Model 147 to predict the performance of foundation soil in which roadside safety structures are mounted, particularly in cases where those structures may be struck by a motor vehicle. The model is applicable for all soil types when one surface is exposed to the elements if the appropriate material coefficients are inserted. When the appropriate material coefficients are inserted, the model is applicable to all soil types when one surface is exposed to the elements.

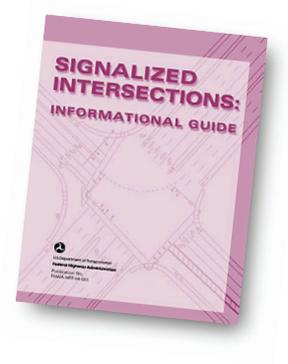
The researchers divided the report into three sections: (1) the research plan, which describes the justification and the detailed theory of the model; (2) the user's manual, which was submitted for inclusion in the LS-DYNA user's manual; and (3) examples that show the expected results of the model. The companion report to this manual is *Evaluation of LS-DYNA Soil Material Model 147* (FHWA-HRT-04-094).

Evaluation of LS-DYNA Soil Material Model 147 Publication No. FHWA-HRT-04-094

This report, the companion document for *Manual for LS-DYNA Soil Material Model 147* (FHWA-HRT-04-095), discusses the soil material model's performance and the accuracy of the results it produced when implemented in simulations using LS-DYNA for roadside safety applications. The evaluation concentrates on the use of parameters to derive optimal results from the model, highlighting the importance of obtaining appropriate parameter values through testing or analysis, providing an engineering understanding of the parameters, and determining

boundaries for the potential effects of varying the parameters. Although Model 147 requires further development before it can be used in most roadside safety applications, this report provides a springboard for future improvements.

Signalized Intersections: Informational Guide Publication No. FHWA-HRT-04-091



This guide provides a single, comprehensive information source on methods for evaluating the safety and operation of signalized intersections and tools to remedy deficiencies. The treatments featured in the guide range from low-cost measures, such as improvements to signal timing and signage, to higher cost measures, such as intersection reconstruction and grade separation.

The guide covers the fundamental principles of user needs, geometric design, and traffic design and operation; safety and operational analysis techniques; and a variety of treatments to address existing or projected problems, including individual movements and approaches, pedestrian and bicycle treatments, and corridor techniques. In addition, the document covers alternative strategies that improve intersection performance through the use of indirect left turns and other treatments. With the description of each treatment, the guide also presents discussions of safety, operational performance, multimodal issues, and physical and economic factors that practitioners should consider. Although the guide focuses primarily on high-volume signalized intersections, many treatments are applicable for lower volume intersections as well.

The information contained in the guide is based on the latest available research on treatments and best practices in use by jurisdictions across the United States. Additional resources and references are highlighted for students, practitioners, researchers, or decisionmakers who want to learn more about a particular subject.

The Freight Technology Story: Intelligent Freight Technologies and Their Benefits Publication No. FHWA-HOP-05-030

The freight transportation industry and its customers use information technologies and telecommunications to improve efficiency and productivity, increase global connectivity, and enhance security against common threats and terrorism. In short, these technologies help practitioners operate the transportation system more intelligently. Most importantly, they do so in ways that improve safety.

The Freight Technology Story discusses advancements in these technologies and describes how they work and the benefits they deliver, including results from the U.S. Department of Transportation's field operational tests and other initiatives involving intelligent freight technology. The report also discusses the implementation of freight technologies and the technical and institutional barriers to their acceptance.

Intelligent freight technologies are currently deployed in several areas:

- *Asset tracking*. Mobile communications and global positioning systems, bar codes, and radio frequency identification (RFID) tags track the location of trucks, containers, and cargo to improve efficiency and ensure the safety and security of shipments.
- *Onboard status monitoring*. Sensors record vehicle operating conditions, check the condition of cargo, and detect tampering or intrusion.
- *Gateway facilitation*. Nonintrusive inspection technologies, such as scanners and RFID tags, are used at terminals, inspection stations, and border crossings to search for contraband and enhance national security.
- *Freight status information*. Web-based technologies facilitate the exchange of information on freight shipments and improve data flows.
- *Network status information*. Cameras, road sensors, and display technologies monitor congestion, weather conditions, and incidents.

The report highlights the benefits of deploying intelligent freight technologies, not only for the private and public sectors, but also for the economy as a whole.

For more information or to view the report, visit the Office of Freight Management and Operations Web site at www.ops.fhwa.dot.gov/freight/intermodal or contact Mike Onder at michael.onder@fhwa.dot.gov.

Reporting Changes of Address

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Conferences/Special Events Calendar

Date	Conference	Sponsor	Location	Contact
Nov 1–3, 2005	6th National Conference on Transportation Asset Management	Federal Highway Administration (FHWA), Transportation Research Board (TRB), American Association of State Highway and Transportation Officials (AASHTO)	Kansas City, MO	Francine Shaw-Whitson 202–366–8028 francine.shaw-whitson@fhwa.dot.gov www.trb.org/conferences/preservation-asset
Nov 3–5, 2005	Society of Women Engineers National Conference 2005	Society of Women Engineers (SWE)	Anaheim, CA	Jeanne Elipani 1–800–892–2858 jeanne.elipani@swe.org www.swe.org/2005
Nov 3–6, 2005	Fifth International Conference On Plain Language	Center for Plain Language and Plain Language Association International	Washington, DC	Sarah Cooper 202–833–4456, ext. 103 sarah@natalieshear.com http://centerforplainlanguage.org/pl_conf.htm
Nov 6–10, 2005	12th World Congress on Intelligent Transport Systems	Intelligent Transportation Society of America (ITSA)	San Francisco, CA	Sandra Fitzgerald-Collier 202–721–4214 scollier@itsa.org www.itsworldcongress.org
Nov 15–17, 2005	Second International Conference On Driver Behavior and Training	Driving Research Unit, Cranfield University	Edinburgh, UK	Lisa Dorn +44 (0)1234 750111, ext. 5232 l.dorn@cranfield.ac.uk www.cranfield.ac.uk/soe/drive
Nov 16, 2005	Freight Models: State of the Practice	FHWA Office of Freight Management and Operations and Office of Planning	Webcast	Carol Keenan 202–366–6993 carol.keenan@fhwa.dot.gov http://talkingfreight.webex.com
Dec 14, 2005	Considerations of Freight In Disaster Planning	FHWA Office of Freight Management and Operations and Office of Planning	Webcast	Carol Keenan 202–366–6993 carol.keenan@fhwa.dot.gov http://talkingfreight.webex.com
Jan 22–26, 2006	TRB 85th Annual Meeting	TRB	Washington, DC	Linda Karson 202–334–2362 lkarson@nas.edu www.trb.org
Mar 13–16, 2006	World of Asphalt 2006 Show & Conference	Asphalt Pavement Alliance, Asphalt Institute, National Asphalt Pavement Association, State Asphalt Pavement Associations	Orlando, FL	Megan Tanel 800–867–6060 mtanel@aem.com www.worldofasphalt.com
Jun 4–7, 2006	North American Travel Monitoring Exhibition & Conference	TRB	Minneapolis, MN	Thomas Palmerlee 202–334–2907 tpalmerlee@nas.edu www.trb.org/conferences/preservation-asset

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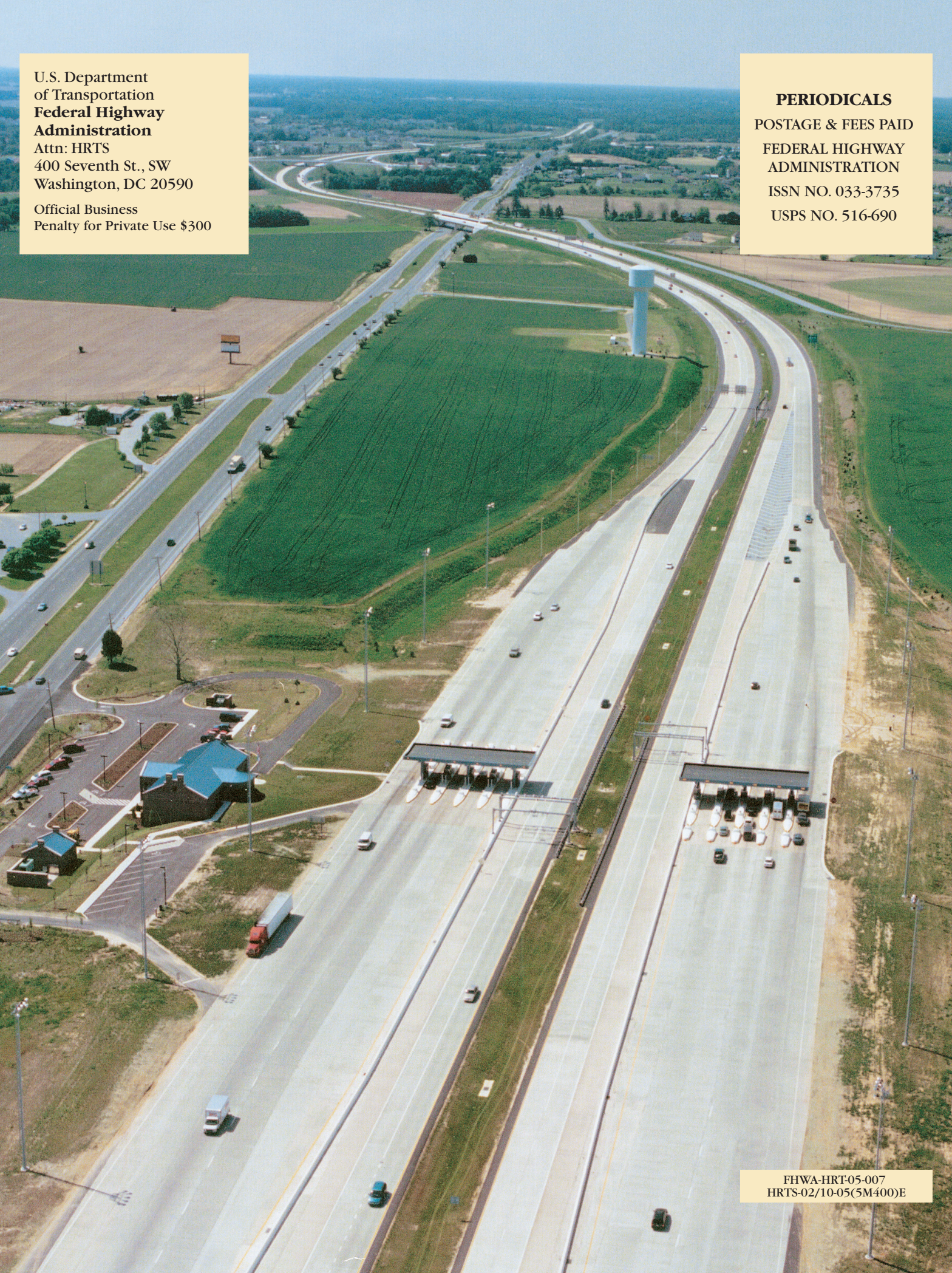

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