OREGON DEMONSTRATION PROJECT: ALTERNATE PROJECT DELIVERY AND ACCELERATED BRIDGE CONSTRUCTION ON OR 38, DRAIN TO ELKTON

Final Report
June 2013

HIGHWAYS FOR LIFE
Accelerating Innovation for the American Driving Experience.

U.S. Department of Transportation
Federal Highway Administration

FOREWORD

The purpose of the Highways for LIFE (HfL) pilot program is to accelerate the use of innovations that improve highway safety and quality while reducing congestion caused by construction. **LIFE** is an acronym for **L**onger-lasting highway infrastructure using **I**nnovations to accomplish the **F**ast construction of **E**fficient and safe highways and bridges.

Specifically, HfL focuses on speeding up the widespread adoption of proven innovations in the highway community. "Innovations" is an inclusive term used by HfL to encompass technologies, materials, tools, equipment, procedures, specifications, methodologies, processes, and practices used to finance, design, or construct highways. HfL is based on the recognition that innovations are available that, if widely and rapidly implemented, would result in significant benefits to road users and highway agencies.

Although innovations themselves are important, HfL is as much about changing the highway community's culture from one that considers innovation something that only adds to the workload, delays projects, raises costs, or increases risk to one that sees it as an opportunity to provide better highway transportation service. HfL is also an effort to change the way highway community decisionmakers and participants perceive their jobs and the service they provide.

The HfL pilot program, described in Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Section 1502, includes funding for demonstration construction projects. By providing incentives for projects, HfL promotes improvements in safety, construction-related congestion, and quality that can be achieved through the use of performance goals and innovations. This report documents one such HfL demonstration project.

Additional information on the HfL program is at www.fhwa.dot.gov/hfl.

NOTICE

1. Report No.	2. Government Accession No	3. Recipient's Catalog No
3. Title and Subtitle Oregon Demonstration Project: Alternate Project Delivery and Accelerated Bridge Construction on OR 38, Drain to Elkton		5. Report Date June 2013 6. Performing Organization Code
7. Authors Ahmad Ardani, P.E., Jagannath Mallela, Gary Hoffman, P.E., R.L.S.		8. Performing Organization Report No.
9. Performing Organization Name and Address Applied Research Associates, Inc. 100 Trade Centre Drive, Suite 200 Champaign, IL 61820		10. Work Unit No. (TRAIS) C6B 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Infrastructure Highways for LIFE Federal Highway Administration 1200 New Jersey Avenue SE Washington, DC 20590		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code
15. Supplementary Notes Contracting Officers Technical Representative (COTR): Byron Lord, Mary Huie		

16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration under the Highways for LIFE (HfL) program, the Oregon Department of Transportation (ODOT) applied for and was awarded a $1 million grant to showcase and demonstrate the use of alternate project delivery and innovative accelerated bridge construction (ABC) in removing and replacing five bridges on Oregon 38 between the towns of Drain and Elkton. This report documents the entire work, including the use of all the innovative ABC techniques employed by ODOT in rapid removal and replacement of the bridges.

Also included in this report are construction details of the bridge superstructures built next to the old bridges on temporary supports over Elk Creek, prefabricated and cast-in-place bridge components, an innovative staged construction technique, the use of a temporary bridge, and the substructures built under the old bridges without interfering with traffic flow. Overall, the innovative features and accelerated elements of the ODOT HfL project included the following:

- Innovative public outreach program
- Design-build method of project delivery
- Construction of superstructures next to old bridges
- Construction of substructures without interfering with traffic flow
- Context-sensitive and sustainable solutions
- Rapid bridge replacement technique using a hydraulic sliding system
- Use of a temporary bridge
- Use of prefabricated bridge components

Removal and replacement of the bridges on OR 38 was a great success and ODOT was able to meet the HfL program requirement related to the project goals of safety, construction congestion, quality, and user satisfaction.

17. Key Words	18. Distribution Statement
accelerated bridge construction, full lane closure, Highways for LIFE, hydraulic sliding system, prefabricated bridge elements and systems, project performance goals	No restriction. This document is available to the public through the National Technical Information Service 5285 Port Royal Road Springfield VA 22161

Security Classif. (of this report)	19. Security Classif. (of this page)	20. No. of Pages	21. Price
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ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of Federal Highway Administration (FHWA) Highways for LIFE (HfL) Team Leader Byron Lord and Program Coordinators Mary Huie and Kathleen Bergeron, who served as the technical panel on this demonstration project. Their vast knowledge and experience with the various aspects of construction, technology deployment, and technology transfer helped immensely in developing both the approach and the technical matter for this document. The team is also indebted to Oregon Department of Transportation (ODOT) Project Manager Steve Narkiewicz and Assistant Project Manager Alan Beane, who were instrumental in making this project a success, and Mike Morrow of the Oregon FHWA Division for his tireless effort in coordinating activities with HfL and ODOT.

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ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
CS^3	context-sensitive and sustainable solutions
D-B	design-build
D-B-B	design-buid-build
dB(A)	A-weighted decibel
DOT	department of transportation
FHWA	Federal Highway Administration
HfL	Highways for LIFE
HSS	hydraulic sliding system
IRI	International Roughness Index
ODOT	Oregon Department of Transportation
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
RCDG	reinforced concrete deck girder
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users

INTRODUCTION

HIGHWAYS FOR LIFE DEMONSTRATION PROJECTS

The Highways for LIFE (HfL) pilot program, the Federal Highway Administration (FHWA) initiative to accelerate innovation in the highway community, provides incentive funding for demonstration construction projects. Through these projects, the HfL program promotes and documents improvements in safety, construction-related congestion, and quality that can be achieved by setting performance goals and adopting innovations.

The HfL program—described in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—may provide incentives to a maximum of 15 demonstration projects a year. The funding amount may total up to 20 percent of the project cost, but not more than $5 million. Also, the Federal share for an HfL project may be up to 100 percent, thus waiving the typical State-match portion. At the State's request, a combination of funding and waived match may be applied to a project.

To be considered for HfL funding, a project must involve constructing, reconstructing, or rehabilitating a route or connection on an eligible Federal-aid highway. It must use innovative technologies, manufacturing processes, financing, or contracting methods that improve safety, reduce construction congestion, and enhance quality and user satisfaction. To provide a target for each of these areas, HfL has established demonstration project performance goals.

The performance goals emphasize the needs of highway users and reinforce the importance of addressing safety, congestion, user satisfaction, and quality in every project. The goals define the desired result while encouraging innovative solutions, raising the bar in highway transportation service and safety. User-based performance goals also serve as a new business model for how highway agencies can manage the highway project delivery process.

HfL project promotion involves showing the highway community and the public how demonstration projects are designed and built and how they perform. Broadly promoting successes encourages more widespread application of performance goals and innovations in the future.

Project Solicitation, Evaluation, and Selection

FHWA issued open solicitations for HfL project applications in fiscal years 2006, 2007, 2008, and 2009. State highway agencies submitted applications through FHWA Divisions. The HfL team reviewed each application for completeness and clarity, and contacted applicants to discuss technical issues and obtain commitments on project issues. Documentation of these questions and comments was sent to applicants, who responded in writing.

The project selection panel consisted of representatives of the FHWA offices of Infrastructure, Safety, and Operations; the Resource Center Construction and Project Management team; the Division offices; and the HfL team. After evaluating and rating the applications and supplemental information, panel members convened to reach a consensus on the projects to recommend for approval. The panel gave priority to projects that accomplish the following:

- Address the HfL performance goals for safety, construction congestion, quality, and user satisfaction.
- Use innovative technologies, manufacturing processes, financing, contracting practices, and performance measures that demonstrate substantial improvements in safety, congestion, quality, and cost-effectiveness. An innovation must be one the applicant State has never or rarely used, even if it is standard practice in other States.
- Include innovations that will change administration of the State's highway program to more quickly build long-lasting, high-quality, cost-effective projects that improve safety and reduce congestion.
- Will be ready for construction within 1year of approval of the project application. For the HfL program, FHWA considers a project ready for construction when the FHWA Division authorizes it.
- Demonstrate the willingness of the applicant department of transportation (DOT) to participate in technology transfer and information dissemination activities associated with the project.

HfL Project Performance Goals

The HfL performance goals focus on the expressed needs and wants of highway users. They are set at a level that represents the best of what the highway community can do, not just the average of what has been done. States are encouraged to use all applicable goals on a project:

- **Safety**
    - Work zone safety during construction—Work zone crash rate equal to or less than the preconstruction rate at the project location.
    - Worker safety during construction—Incident rate for worker injuries of less than 4.0, based on incidents reported via Occupational Safety and Health Administration (OSHA) Form 300.
    - Facility safety after construction—Twenty percent reduction in fatalities and injuries in 3-year average crash rates, using preconstruction rates as the baseline.

- **Construction Congestion**
    - Faster construction—Fifty percent reduction in the time highway users are impacted, compared to traditional methods.
    - Trip time during construction—Less than 10 percent increase in trip time compared to the average preconstruction speed, using 100 percent sampling.
    - Queue length during construction—A moving queue length of less than 0.5 mile (mi) (0.8 kilometer (km)) in a rural area or less than 1.5 mi (2.4 km) in an urban area (in both cases at a travel speed 20 percent less than the posted speed).

- **Quality**
    - Smoothness—International Roughness Index (IRI) measurement of less than 48 inches per mile.

- Noise—Tire-pavement noise measurement of less than 96.0 A-weighted decibels (dB(A)), using the onboard sound intensity (OBSI) test method.

- **User Satisfaction—**An assessment of how satisfied users are with the new facility compared to its previous condition and with the approach used to minimize disruption during construction. The goal is a measurement of 4-plus on a 7-point Likert scale.

REPORT SCOPE AND ORGANIZATION

This report documents the Oregon Department of Transportation's (ODOT) HfL demonstration project, which involved alternate project delivery, innovative staged construction, and innovative removal and replacement of five bridges on Oregon 38 between the towns of Drain and Elkton. The report presents project details relevant to the HfL program, including innovative contracting techniques, superstructure and substructure design and construction highlights, innovative staged construction, rapid removal and replacement of bridges using a hydraulic sliding system (HSS), context-sensitive and sustainable solutions (CS^3), HfL performance metrics measurement, and economic analysis. Technology transfer activities that took place during the project and lessons learned are also discussed.

PROJECT OVERVIEW AND LESSONS LEARNED

PROJECT OVERVIEW

The Oregon HfL project consisted of removing and replacing five bridges on an 11-mi stretch of OR 38 between the towns of Drain and Elkton. These bridges, built in the late 1920s and early 1930s, were near the end of their useful life and required immediate attention. They were selected for replacement under the Oregon Transportation Investment Act State Bridge Program for a variety of reasons, including (1) structural and functional deficiencies resulting in repair costs that exceeded one-half of the replacement cost, (2) substandard bridge width, and (3) load ratings insufficient to carry permit vehicle loads.

After exploring many alternatives and evaluating the project and user costs, ODOT selected the use of the design-build (D-B) method of project delivery in concert with incentive and disincentive clauses that included innovative staged construction and accelerated bridge removal and replacement techniques. Removal and replacement of the bridges on OR 38 was a great success, and ODOT was able to complete the project more than a year ahead of schedule.

Strategies that helped ODOT achieve its goal included the following:

- Use of the D-B method of project delivery, which combined the design and construction phases of the project into a single contract and allowed for overlapping of some design and construction. This dramatically reduced the time required to complete the project.

- Offsite construction of the entire superstructure of two bridges (crossings 3 and 4) on temporary supports, which included girders, decks, curb, gutter, and side railings. The total lengths of these structures were 340 feet (ft) for crossing 3 and 240 ft for crossing 4.

- Construction of substructures beneath crossings 3 and 4 and outside the bounds of OR 38 with little or no disruption of OR 38 traffic.

- Dramatically minimizing traffic disruption and maintaining normal traffic flow without altering the present roadway configuration through the use of an innovative, emerging technology: the hydraulic sliding system (HSS). HSS made it possible to remove the old crossings 3 and 4 and replace them during two weekend closures, reducing user costs, improving motorist and worker safety, and increasing user satisfaction.

- Implementation of an innovative public information and outreach program that went beyond conventional public meetings.

- Implementation of a context-sensitive and sustainable solutions (CS^3) approach that minimized environmental impacts and put communities and stakeholders at the heart of decisionmaking.

DATA COLLECTION

Safety, construction congestion, quality, and user satisfaction data were collected before, during, and after construction to demonstrate that the D-B method of project delivery coupled with innovative accelerated bridge construction (ABC) technologies can be used to achieve the HfL performance goals in these areas.

For ODOT, safety of the workers and the traveling public was more than a performance goal; it was a requirement under the Oregon Transportation Investment Act program. During the construction of the bridges on OR 38, few worker injuries were reported and these injuries were minor in nature. All site personnel, field crews, designers, inspectors, and owner's representatives received site-specific orientation and safety training before working on this project. In addition, all construction workers received quarterly safety training and attended mandatory weekly safety meetings.

During construction, the contractors took extraordinary steps to assure that incidents were kept to a minimum. The many safeguards put in place to prevent crashes during construction were effective. These included procurement of Oregon State Police during major traffic changes and peak construction periods. Other effective measures included scheduled open houses, regular news releases, and establishment of a dedicated phone line and Web site. A review of the individual crashes showed that only three occurred in the vicinity of the project's bridge sites. However, as reported by ODOT, none of the crashes was attributed to the construction activities.

The performance goal established by ODOT on motorist delay was that no vehicle should be delayed by contractor operations more than 20 minutes beyond its normal travel time. The contractor easily met this goal. Based on a travel time study conducted by HfL consultants, a delay of 5 to 9 minutes was computed for each vehicle during daytime hours. For the most part, the approach adopted was to maintain two lanes of uninterrupted traffic throughout the construction period, except for 6 weeks on crossing 5, which required the use of a temporary bridge, and two separate weekend closures for removal and replacement of crossings 3 and 4. The primary focus of the Oregon HfL project was crossings 3, 4, and 5 because of their exceptional complexity and innovative features. For the most part, crossings 1 and 2 were built using traditional methods of construction, so they are not addressed in great detail in this report.

Under conventional construction, the residents and the traveling public using OR 38 would have had to deal with delays, lane closures, and construction activities for well over 3 years. However, with the adoption of an alternate method of project delivery, rapid bridge removal and replacement techniques, and innovative staged construction, ODOT was able to complete the entire project in less than 18 months.

Although the quality of the replaced crossings on OR 38 potentially was improved because the work was done in a controlled environment and prefabricated bridge components were used, the replacement process had no impact on the noise and smoothness of the pavement surface.

Beginning at the project planning stages, ODOT undertook an aggressive and comprehensive effort to communicate with affected residents and businesses along the corridor and near the bridges, keeping them abreast of all activities before, during, and after construction. User satisfaction surveys designed and distributed to neighboring residents by Lois D. Cohen Associates clearly demonstrated a high level of public satisfaction with the construction approach and the final product. ODOT exceeded the HfL customer satisfaction expectation by a large margin.

ECONOMIC ANALYSIS

The benefits and costs of the innovative features of the project were compared with projects of similar size and scope with a more traditional delivery approach. ODOT supplied all of the cost figures for the as-built project and the cost assumptions for the traditional approach.

Based on an economic analysis conducted by ODOT using the StartBENCOST analysis model approach, ODOT realized a total cost savings of about $2.4 million over conventional construction practices. These savings stemmed from reduced construction duration, mobilization costs, reduced delay cost, and the use of innovative bridge removal and replacement techniques. Overall, the savings to ODOT represent about 5 percent of the total project cost.

LESSONS LEARNED

The removal and replacement of the five crossings on OR 38 was a great success, resulting in a quality project completed substantially ahead of schedule while maintaining freight mobility and reducing impact on motorists, residents, and businesses. Through this project, ODOT gained insight on proven innovative construction features and innovative public outreach practices and learned many valuable lessons that can be incorporated into similar future projects in Oregon. These lessons include the following:

- **Public involvement—**A key contributor to the success of the OR 38 project was an unprecedented degree of public involvement at the community level. During the planning and construction phases of the project, ODOT proactively engaged in an outreach program that effectively kept residents, businesses, and commuters along the OR 38 corridor abreast of all construction activities. Long before any heavy equipment or construction crews arrived on the jobsite, ODOT and its public involvement teams researched how the project would affect the community. The research resulted in a list of community members, government representatives, and key stakeholders that ODOT kept informed throughout the project. The outreach program included a dedicated phone line, scheduled open houses, regular media communication, and implementation of ODOT's award-winning "Trip Check" Web site.

- **Alternate method of project delivery—**Using a corridor-based approach, ODOT bundled (grouped) the design and construction of all five bridges into a single, seamless contract using the D-B method of project delivery. When a balance of time, quality, and price is desired, the D-B concept becomes more attractive than the traditional design-bid-build (D-B-B) method. By putting the D-B method of contracting to work, ODOT was able to transfer more responsibilities to the successful bidding firm for project quality, cost, and overall project management. As a result, ODOT was credited for accelerating project completion time, promoting innovation, maintaining mobility, and reducing user costs. By overlapping the design and construction and using innovative accelerated construction techniques, ODOT's design-builder was able to complete the project cost-effectively and more than a year ahead of schedule.

- **Hydraulic sliding system—**Because of the extreme nature of the topography at the project site, all of the bridges on OR 38 presented challenges, but two bridges (crossings 3 and 4) stood out for their exceptionally difficult site conditions. For the first time in its history, ODOT used an innovative yet proven technology to overcome this challenge. ODOT's approach was to build the new bridge superstructures on temporary supports next to the old structure. During a short-term closure (weekend), ODOT demolished the old structure and slid the new structure onto the same alignment using HSS. Using HSS enabled ODOT to dramatically minimize traffic disruption over the structures and maintain normal traffic flow without altering the present roadway configuration. In addition, the use of HSS substantially improved the safety of the traveling public and workers in the work zone. Because of the success and cost-effectiveness of rapid bridge removal and replacement techniques on OR 38, ODOT plans to use HSS on future projects.

- **Streamlining the environmental permitting process—**In addition to the use of the D-B approach, there was a significant focus on constructing the crossings using a process known as the context-sensitive and sustainable solutions (CS^3) approach. On this project, the CS^3 approach resulted in minimizing environmental impacts and development of a systematic permitting vehicle that streamlined the time-consuming environmental permitting process. According to ODOT, "through this process, we have been able to maintain our environmental stewardship while improving the program delivery process and outcomes."

- **Incentive and disincentive clauses—**ODOT learned that by incorporating incentive and disincentive clauses into its D-B contract it could accelerate the completion of three of the crossings. These include combined incentive/disincentive clauses of $20,000 for each day not exceeding 30 days for crossings 3 and 4 (maximum of $600,000) and $4,500 for each day not exceeding 30 days for crossing 5 (maximum of $135,000). The contractor used a temporary bridge and an innovative staged construction technique to complete the reconstruction of crossing 5 in less than 6 weeks instead of the originally scheduled 6 months. It also completed removal and replacement of crossings 3 and 4 in two separate weekends using HSS, reducing traffic exposure to construction activities from more than a year to 4 days. The contractor was awarded maximum incentives of $735,000 for crossings 3, 4 and 5.

CONCLUSIONS

From the standpoint of construction speed, user and agency costs, quality, worker and motorist safety, and community satisfaction, ODOT's project was a great success and unequivocally exemplified the principles of the HfL program. ODOT learned that using the D-B method of project delivery coupled with proven innovative technologies and incentive/disincentive clauses could accelerate construction, lessen the impact on the traveling public and environment, maintain mobility, and improve worker and motorist safety. A postconstruction stakeholder survey conducted by ODOT clearly demonstrated the satisfaction of local residents and businesses with the construction approach and final product.

PROJECT DETAILS

BACKGROUND

OR 38 is a mountainous two-lane route with large elevation changes that passes across Oregon's coastal range. Oregon's HfL project consisted of removing and replacing five bridges on an 11-mi stretch of OR 38 between the towns of Drain and Elkton. All five bridges (Figure 1) were built in the late 1920s and early 1930s and were approaching the end of their useful life. Although all of the bridges identified for replacement had challenging site conditions, two (crossings 3 and 4) stood out for their exceptionally difficult topographic and environmental conditions. Crossings 3 and 4, located at mileposts (MP) 39.64 and 39.97, respectively, are situated at each end of the Elk Creek Tunnel in Elk Creek Tunnel State Park.

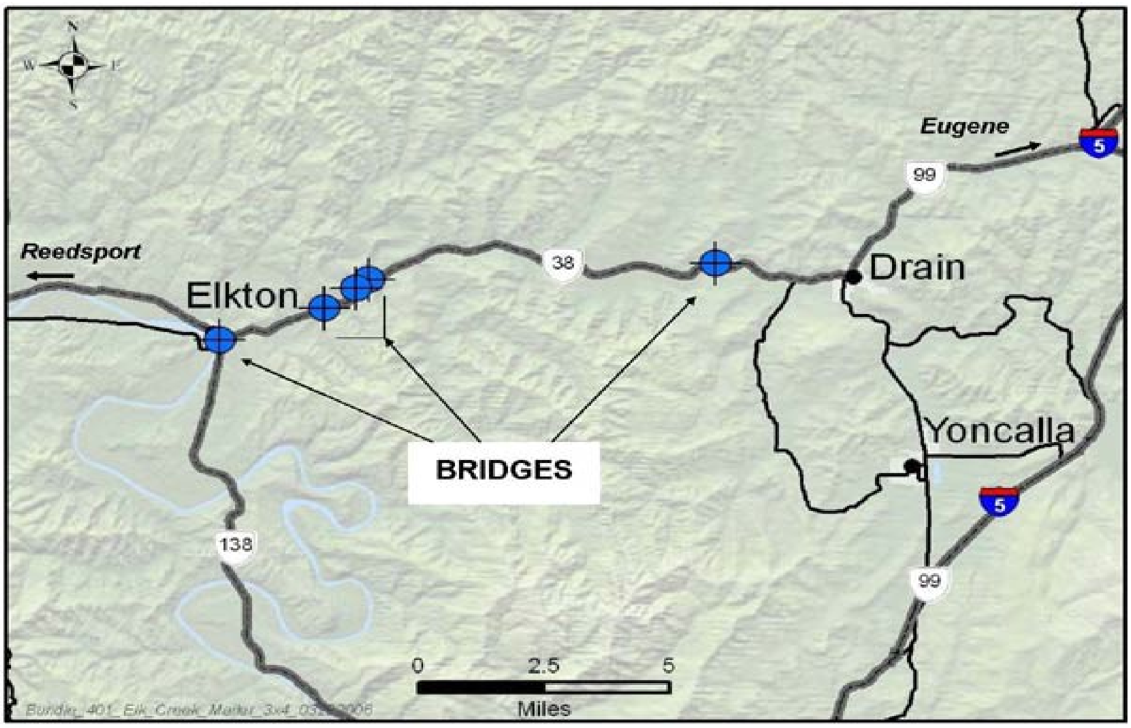

Figure 1. OR 38 bridge replacement project locations.

At the east end of the tunnel, only 30 ft separated the tunnel portal and the bridge abutment of crossing 4. At the tunnel's west end, that separation was only 70 ft for crossing 3. For staged construction, the transitions from the tunnel to a temporary roadway during construction would have been nearly impossible. To add to the site complexity, the tunnel width is only 25 ft, thereby restricting traffic lane shifts to accommodate wide loads. OR 38 is routinely and heavily used by logging trucks and commercial vehicles. Also, these two bridges fell within the northern spotted owl nesting and roosting habitat. As a result, replacement of these bridges required the use of construction activities that did not violate established noise standards between March 1 and July 7 of each year.

PROJECT DESCRIPTION

The project’s overall construction zone extends about 11.5 mi along OR 38 from MP 36.39 (the first crossing of Elk Creek next to Elkton) to MP 48.00 (Hardscrabble Creek). This stretch of OR 38 is posted with speed limits between 35 and 55 miles per hour (mi/h), depending on location. In 2004 average daily traffic (ADT) for the route ranged from 3,200 to 4,400 vehicles, with a projected ADT increase of 20 percent by 2020. The current percentage of truck traffic is estimated at 23 percent of ADT.

ODOT included many innovative, proven technologies and techniques to accelerate replacement of the five bridges, address the many environmental issues associated with the project, and minimize inconvenience to neighboring residents, businesses, and freight carriers. For the most part, ODOT's goals were to maintain two lanes of free-flowing traffic throughout the construction zone, minimize traffic interruptions and queue lengths, and, most important, improve safety and quality and achieve user satisfaction. The innovative features and accelerated elements of the ODOT HfL project included the following:

- Innovative public outreach program
- D-B method of project delivery
- Construction of superstructures next to old bridges
- Construction of substructures without interfering with traffic flow
- Context-sensitive and sustainable solutions
- Rapid bridge replacement technique using bridge rail sliding system
- Use of a temporary bridge
- Use of prefabricated bridge components

Each of these innovative elements is described in the following subsections.

Innovative Public Outreach Program

A critical element of ODOT’s project was to promote and maintain a cordial partnership with local communities and transportation stakeholders that went beyond conventional public meetings. Long before any heavy equipment or construction crews arrived on the jobsite, ODOT and its public involvement team communicated how the project would affect the local community. Generally speaking, ODOT’s communication with the community and stakeholders included the following:

- Scheduled open houses
- One-on-one meetings with community representatives and small group meetings
- Regular media communications
- Ongoing availability of project officials to make presentations to community groups
- Establishment of a dedicated phone line and commitment to respond to comments and questions on a daily basis
- Posting of construction information and schedules on ODOT’s award-winning "Trip Check" Web site

An innovative component of the public information and outreach program was a schools-based outreach program. Under this program students were provided with an opportunity to develop designs for the pylons surrounding one of the bridges. They did this after consulting with community members on what symbols they thought best reflect Elkton. Heading this effort was the project coordinator, Lois Cohen, who said, “We decided from the outset that we wanted to have an exceptional public involvement program.”

The primary communities affected by the bridge work were the towns of Drain, Elkton, and Reedsport. For each community, Cohen arranged an outreach program through the local schools. At Reedsport’s middle school, students built habitats for bats that will be placed under two of the bridges (Figure 2).

Figure 2. Habitat for bats by Reedsport students.

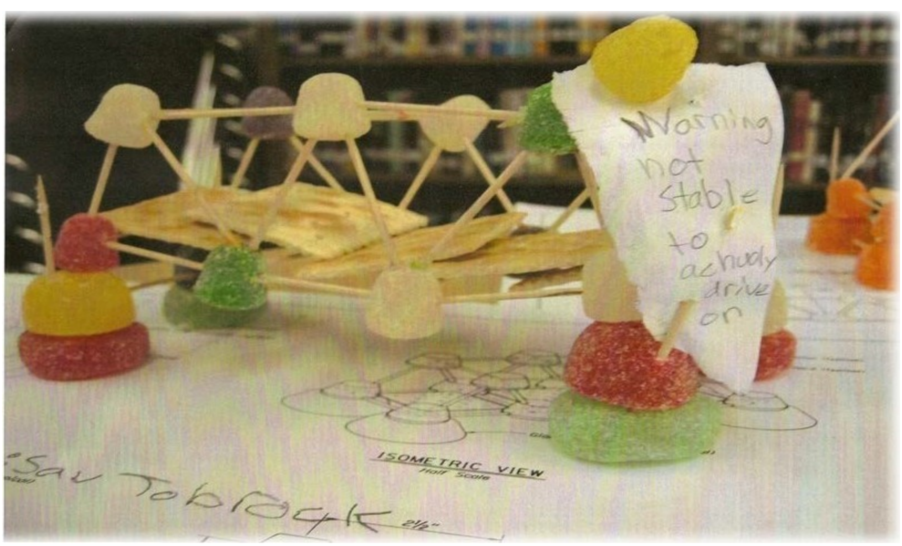

Figure 3. Gumdrop bridge.

In Drain, elementary school children collaborated on building bridges with gumdrops, saltines, and toothpicks (Figure 3). In Elkton, high school students got the opportunity to design decorative pylons to be placed at all four corners of the Elkton Bridge (crossing 1) with different carved symbols at the top of each pylon reflecting Oregon wildlife. These included the osprey, elk, salmon, and monarch butterfly (Figure 4).

Figure 4. Symbols on the pylons designed by students.

Design-Build Method of Project Delivery

One of the major factors in expediting the OR 38 project was to combine the replacement of all five bridges into a single contract using the D-B method of project delivery. D-B contracting is an alternative to the traditional design-bid-build (D-B-B) system, which in recent years has gained a lot of momentum at the national level. Many states either use D-B on selected contracts or implement this method of awarding contracts as a standard practice. The D-B procurement process combines the design and construction phases of a project into a single contract and allows for overlapping of some design and construction. In essence, construction can begin on parts of the project before design for the total project has been completed. The goals are to reduce project costs, shorten the overall project schedule, and construct a quality project.

ODOT's D-B contract required the successful contractor to use accelerated construction techniques to minimize the duration of construction, reduce vehicle delays, provide a safer environment for the traveling public and workers, and keep the community abreast of all major activities.

Figure 5 is a schematic comparing D-B and D-B-B.

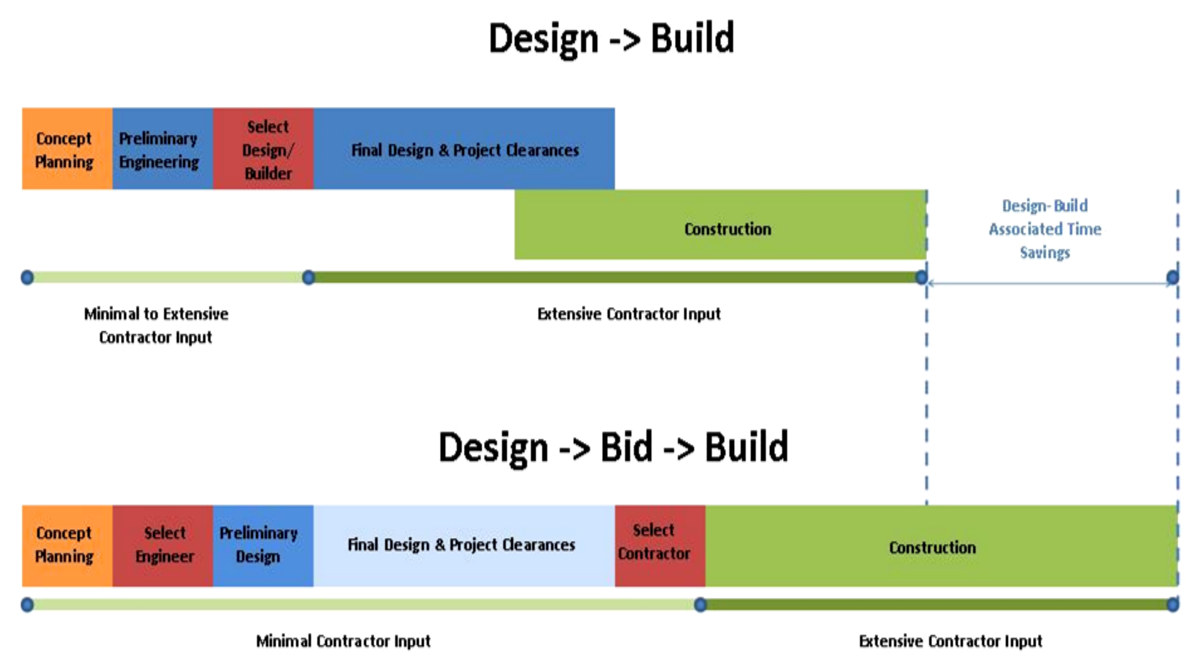

Figure 5. Design-build versus design-bid-build. (Source: Dr. Keith Molenaar)

Construction of Superstructures Next to Old Bridges

One of the main factors responsible for accelerating the ODOT's OR 38 project was the construction of the superstructures for two bridges (crossings 3 and 4) offsite, next to the old bridges. These two crossings, located at the east and west end of the Elk Creek Tunnel in Elk Creek State Park, presented extremely challenging site conditions. At the east end of the tunnel, only 30 ft separated the tunnel portal and the bridge abutment.

At the tunnel's west end, that separation was 70 ft. For staged construction, the transitions from the tunnel to a temporary bridge and roadway during construction would have been nearly impossible.

The contractor's approach was to build the two new superstructures on temporary piers next to the old structures and slide them into their final position during a weekend road closure.

The benefits of constructing the superstructures of crossings 3 and 4 offsite included the following:

- Dramatically minimizing traffic disruption over the structure on OR 38 and maintaining normal traffic flow without altering the present roadway configuration

- Providing a safer environment for the traveling public and workers by drastically reducing exposure to traffic and construction activities

- Potentially improving quality by prefabricating bridge elements in a more controlled environment

Construction of Substructures Without Interfering With Traffic Flow

Concurrent with the construction of the superstructures of crossings 3 and 4, substructures were constructed underneath the old bridges with absolutely no impact on OR 38 traffic. The construction of the substructures consisted of building drilled shaft foundations to support the cast-in-place columns and pier caps. The precast components included the wing walls, sleeper slabs, and approach concrete pavement panels.

Context-Sensitive and Sustainable Solutions

An essential consideration in developing and constructing highway and bridge projects in Oregon is satisfying CS^3 requirements. CS^3 is an innovative decisionmaking tool that combines the old context-sensitive design philosophy with the concept of sustainability, an approach unique to ODOT. The primary goals of Oregon's CS^3 program are the following:

- Stimulate Oregon's economy.
- Employ efficient and cost-effective delivery practices.
- Maintain freight mobility and keep traffic moving.
- Build projects sensitive to their communities and environment.
- Capitalize on funding opportunities.

Overall, CS^3 puts communities and stakeholders at the heart of decisionmaking. Listening to and responding to community and stakeholder needs are essential components in developing and completing transportation projects under the CS^3 process. On this project, the CS^3 approach resulted in minimizing environmental impacts and development of a systematic permitting vehicle that streamlined the time-consuming environmental permitting process.

According to ODOT, "through this process, we have been able to maintain our environmental stewardship while improving the program delivery process and outcomes."

Rapid Bridge Replacement Technique Using Hydraulic Sliding System

Crossings 3 and 4 were successfully removed and replaced during a weekend closure using HSS rapid bridge replacement technology. In this system of bridge relocation, hydraulic jacks mounted on a sliding rail lift the new superstructures and hydraulic pumps slide them into their final position. HHS was also used to slide the old superstructure onto temporary supports before sliding in the new superstructure. Using this method, traffic impact was dramatically reduced to 1 weekend for each crossing instead of 2 years under the standard staged construction approach. In addition, the use of HSS substantially improved the safety of the traveling public and workers in the work zone. The contractor was awarded a maximum incentive of $600,000 for crossings 3 and 4.

Use of Temporary Bridge

To facilitate the removal and reconstruction of the bridge over Hardscrabble Creek (crossing 5) at MP 48.00, a temporary single-lane detour was erected and used for about 6 weeks. The length of this detour was only 300 ft. Flaggers controlled traffic at this location 24 hours a day, 7 days a week. The new bridge was widened to 24 ft plus shoulders on improved alignment and with safer TL-4 bridge rails modified to improve aesthetic appearance.

By using the temporary bridge, the contractor was able to complete the reconstruction of crossing 5 in less than 6 weeks instead of the originally scheduled 6 months. As a result, ODOT awarded the contractor an incentive of $135,000 ($4,500 per day for a maximum of 30 days) for rapid removal and replacement of crossing 5.

Use of Prefabricated Bridge Components

The prefabricated components of OR 38 included sleeper slabs, approach pavement panels, wing walls (crossings 3 and 4), and precast concrete deck girders. All of the precast components were fabricated at the contractor’s yard and transported to the project site for installation.

REMOVAL AND REPLACEMENT OF OR 38 CROSSINGS

CROSSING 1 OVER ELK CREEK AT MP 36.39, NEAR ELKTON

The old bridge was a two-lane facility built in 1931. The 400-ft-long, six-span, reinforced concrete deck girder (RCDG) structure with steel truss served as the entrance to the town of Elkton (Figure 6). Figure 7 and Figure 8 depict the old and newly proposed typical sections for crossing 1.

Figure 6. Old bridge over Elk Creek near Elkton (crossing 1).

The new four-lane, 420-ft-long, three-span bridge was constructed next to the old structure using precast concrete deck girders, precast columns, and bent caps. Phasing of construction allowed traffic to continue using the old structure while the northern half of the new bridge and roadway approaches were being built. Traffic was then diverted to this portion of the new bridge and work on the southern half of the bridge commenced.

Figure 9 shows the completed northern portion of the bridge and the substructures of the southern portion. The old bridge was demolished and removed while work on the southern half of the new bridge and new roadway approaches continued.

Concurrent with the construction of the southern half of the new bridge, improvements were also made to the intersection of OR 38 and OR 138. This intersection is located at the edge of Elkton immediately west of the bridge. The contractor used drilled shafts to support the bents, eliminating the need for spread footings. Spread footings require cofferdams, which would have added cost and adversely impacted the environment.

The approaches to the bridge on both the east and west sides were stabilized using a stepped-down geogrid reinforcement system with well-graded aggregate (Figure 10).

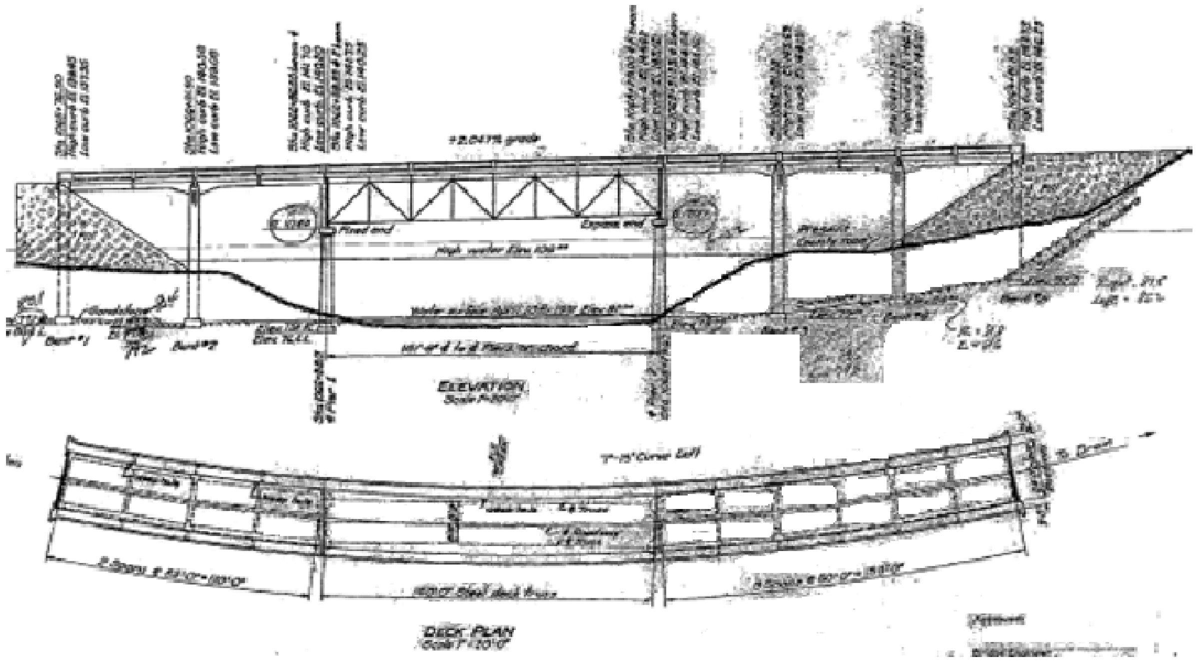

Figure 7. Crossing 1 old typical section.

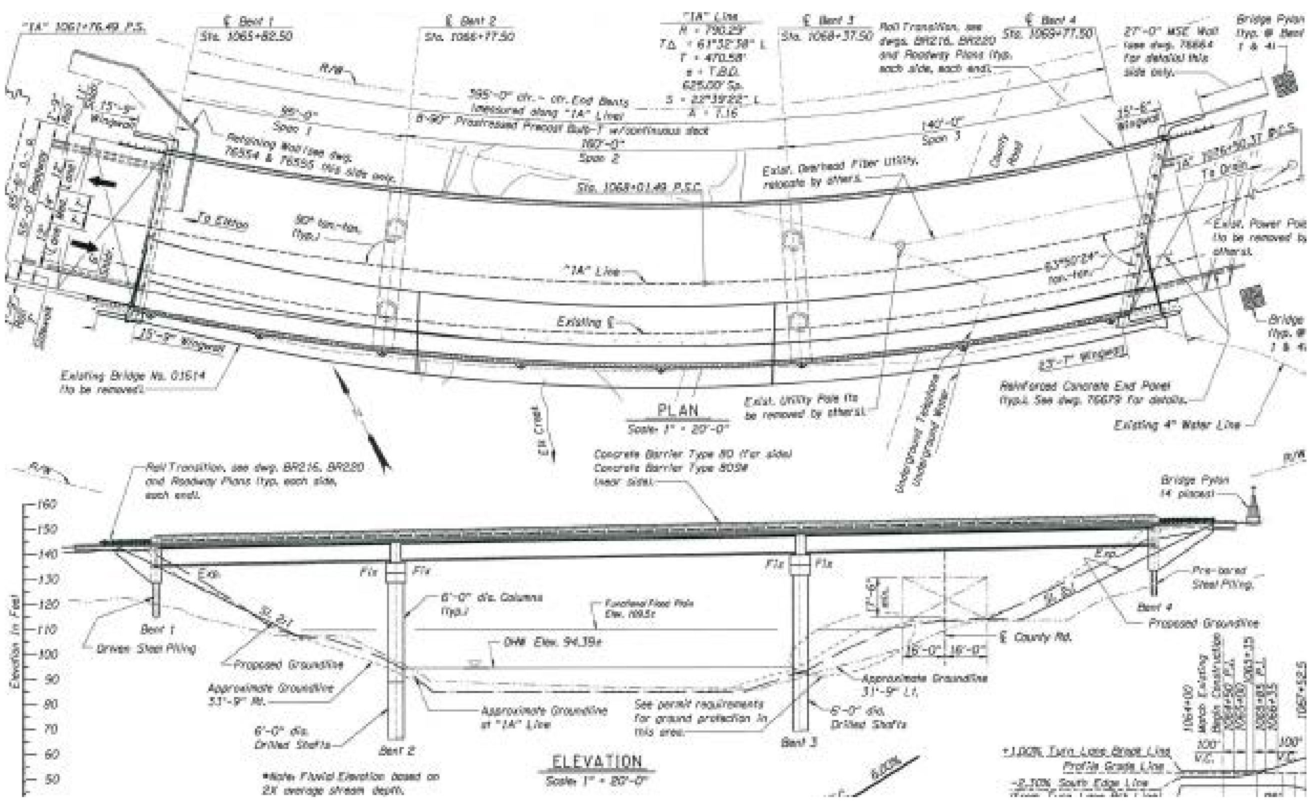

Figure 8. Crossing 1 proposed typical section.

Figure 9. Crossing 1 looking east.

Figure 10. View of stepped-down geogrid system at crossing 1.

CROSSING 2 OVER ELK CREEK AT MP 38.76

The contractor chose to change the alignment of OR 38 by building the entire bridge offline with minimal interference to traffic flow. The old bridge, built in 1932, was a 290-ft-long, six-span, RCDG structure. The old structure was replaced with a three-span bridge constructed with precast concrete deck girders on a new alignment to improve the permanent horizontal curvature of the roadway.

Figure 11 and Figure 12 depict old and proposed typical sections for crossing 2.

During construction, travelers continued to use the old bridge while the new bridge on a new alignment was being constructed next to the old bridge (Figure 13). Upon completion, traffic was shifted to the new structure and the old bridge and roadway approaches were dismantled and removed.

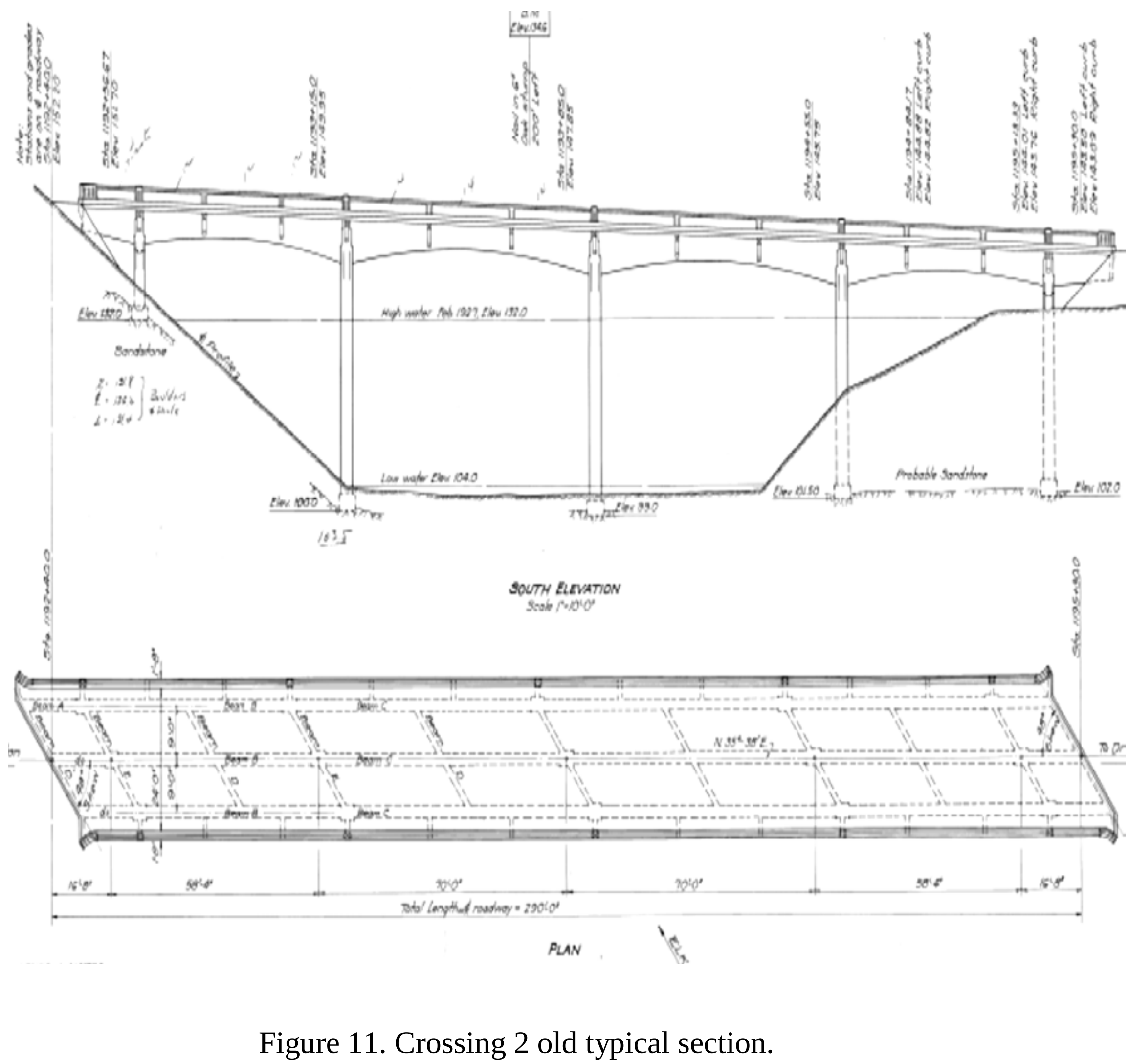

Figure 11. Crossing 2 old typical section.

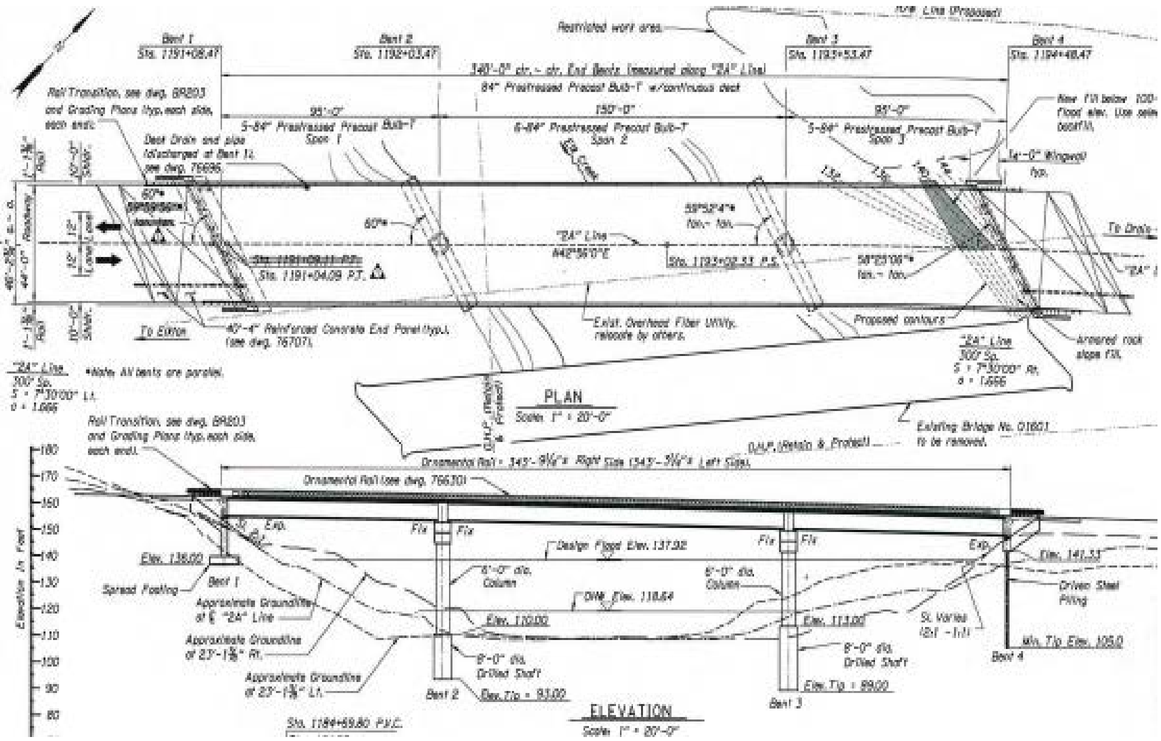

Figure 12. Crossing 2 proposed typical section.

Figure 13. View of old and new crossing 2 looking west.

CROSSINGS 3 AND 4 OVER ELK CREEK AT EAST AND WEST OF ELK CREEK TUNNEL AT MP 39.64 AND 39.97

The old crossings 3 and 4 were built in 1932 and 1931, respectively. Crossing 3 was a 340-ft-long, six-span, RCDG structure with steel truss residing at the western entrance of the Elk Creek Tunnel. The crossing 4 structure was a 240-ft-long, five-span, RCDG bridge with steel truss located at the eastern entrance of the Elk Creek Tunnel.

Replacement of crossings 3 and 4 presented ODOT with extremely challenging tasks because of their close proximity to tunnel entrances and the presence of Elk Creek.

Construction of detour bridges at this location was impossible since these bridges were only a short distance (50 to 70 ft) from either end of the Elk Creek Tunnel. With these severe limitations, the only viable alternative available was to remove and replace the bridges using HSS, an innovative rapid bridge replacement technique.

In general, rapid removal and replacement of bridges using HSS involves four stages. Figure 14 shows the conceptualization of the stages. The stages are as follows:

Stage 1

- Construction of the temporary support for the old superstructure
- Construction of the new substructure

Stage 2

- Construction of the temporary support system next to the old bridge to support the new superstructure
- Construction of the new superstructure

Stage 3

- Demolition of the approach panels to the old bridge and translation of the old superstructure sideways onto its temporary support using HSS
- Translation of the new superstructure onto its new substructure

Stage 4

- Placement of the backfill materials and installation of the prefabricated components of the bridge, including wing walls, sleeper slabs, and approach pavement panels
- Preparing the approach roadway for paving, installing the remaining guardrails, and striping the pavement and the bridge surface
- Dismantling and removing the old superstructure and temporary support systems and hauling them away

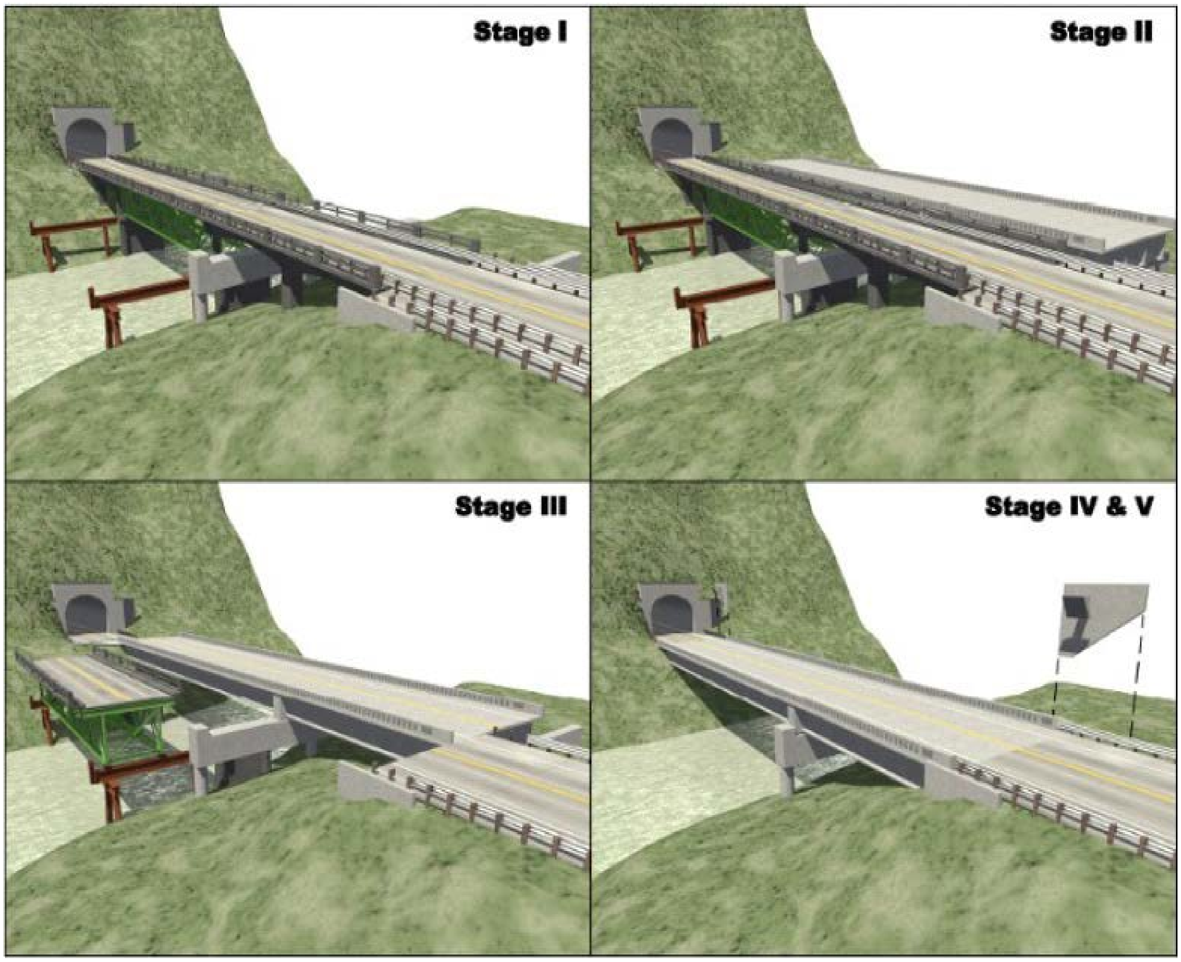

Figure 14. Conceptualized stages of rapid bridge removal using HSS.

The new bridge at the west portal of the tunnel (crossing 3) is a three-span structure constructed with steel deck girders with the overall length of 320 ft. The new bridge at the east portal of the tunnel is a two-span, 220-ft-long bridge constructed using precast concrete deck girders. Both new bridges were constructed on temporary support systems next to the old structures to permit continued use of the old bridges with no impact on traffic movement.

Concurrent with the construction of the new superstructures, substructures were constructed underneath the old bridge, which included installation of drilled-shaft foundations, columns, and bent caps. During a weekend road closure, each new bridge was lifted and translated sideways to its final destination by HSS.

HSS is equipped with giant hydraulic jacks mounted on a sliding rail capable of lifting massive weights. These hydraulic jacks are pushed on the rails by hydraulic pumps to translate bridges from one point to another. Figure 15 and Figure 16 depict the old and proposed typical sections for crossing 3. The old and proposed typical sections for crossing 4 are shown in Figure 17 and Figure 18. Figure 19 illustrates the entire HSS.

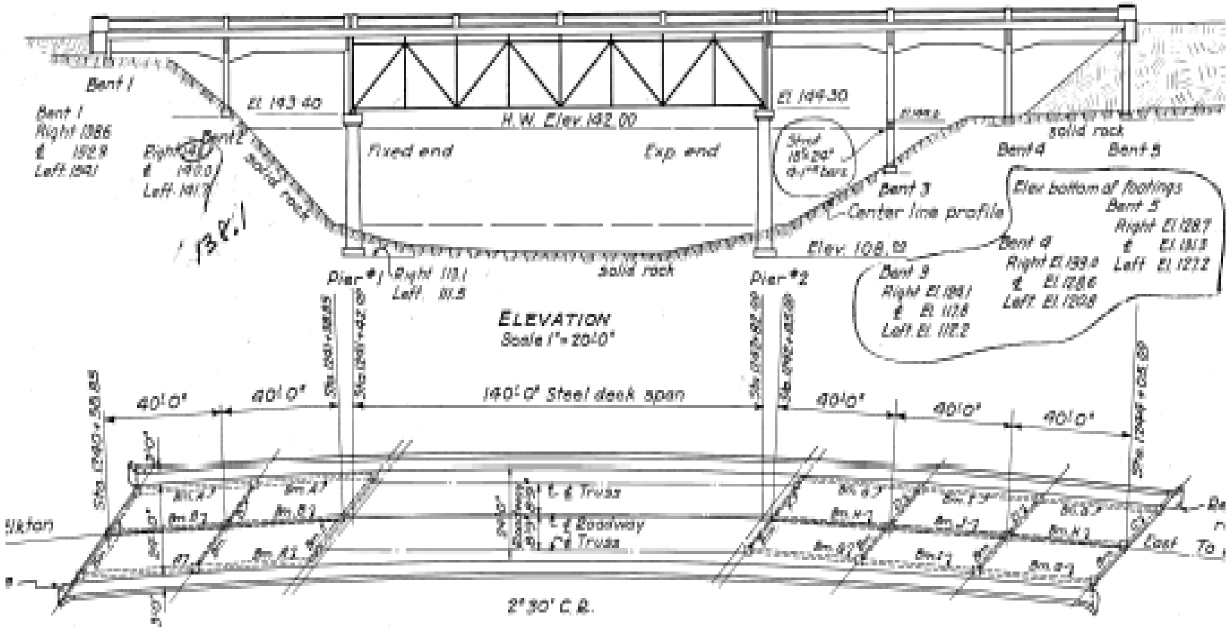

Figure 15. Crossing 3 old typical section.

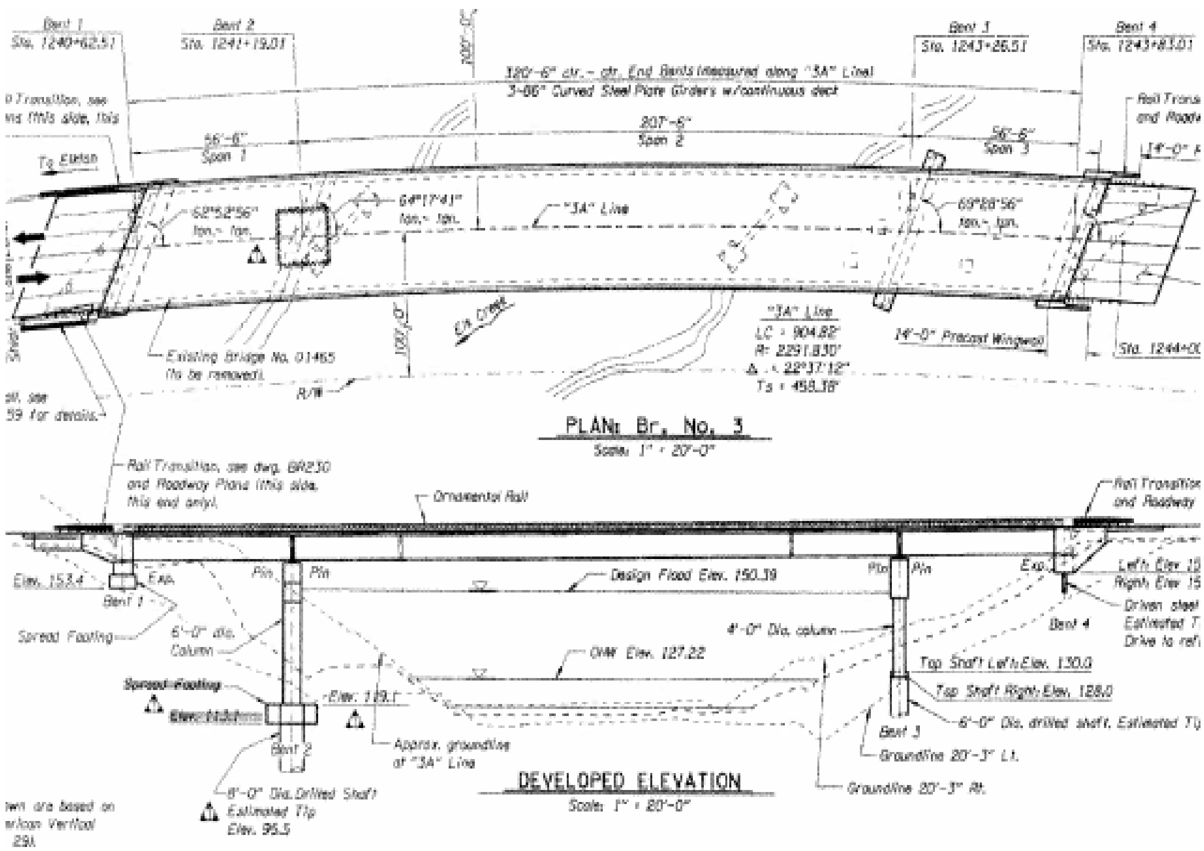

Figure 16. Crossing 3 proposed typical section.

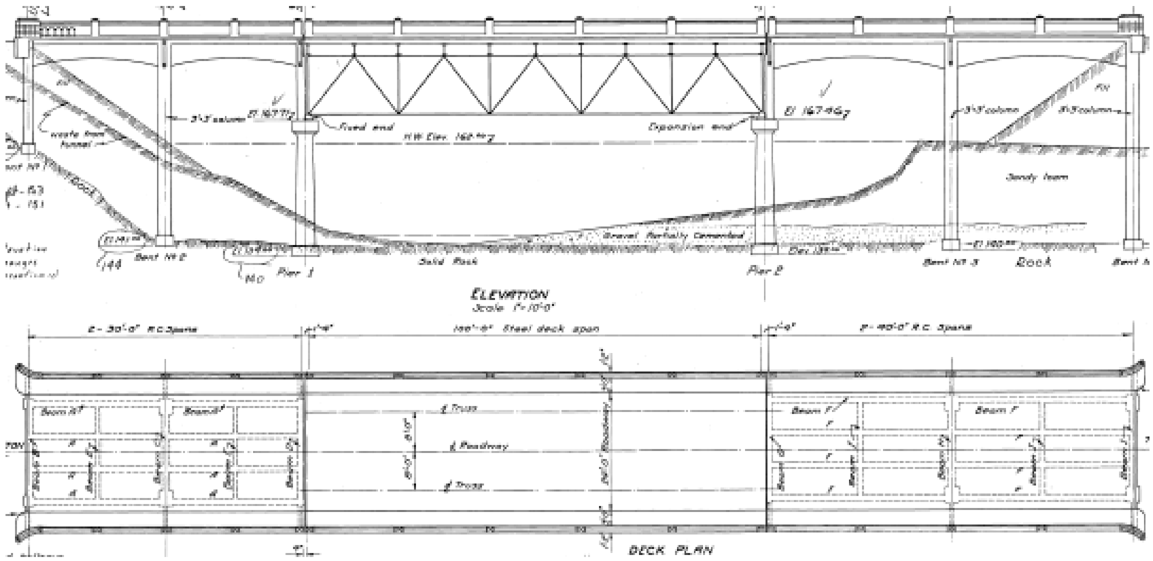

Figure 17. Crossing 4 old typical section.

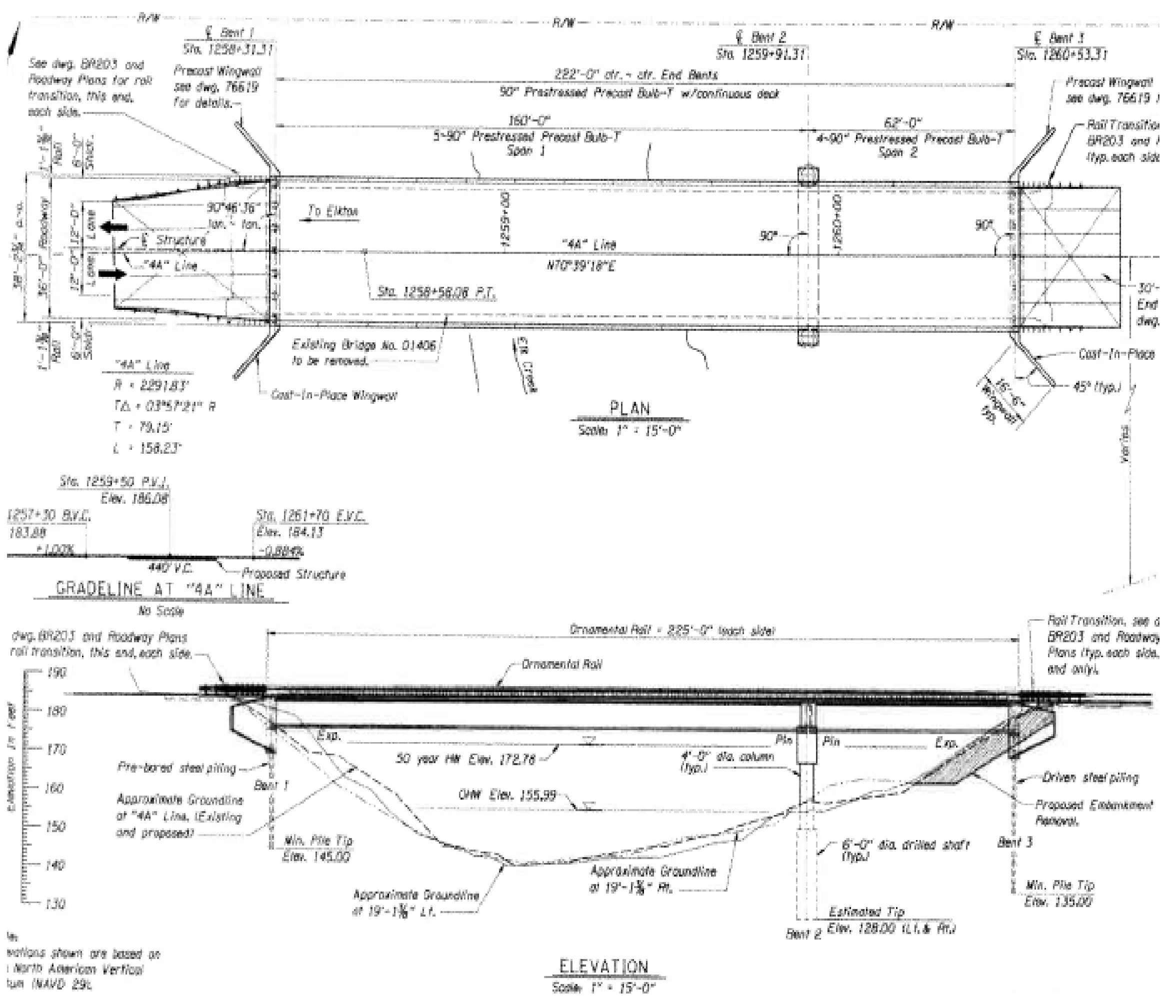

Figure 18. Crossing 4 proposed typical section.

Figure 19. View of a complete hydraulic sliding system, including hydraulic jacks, hydraulic pumps, and the railing system.

Traffic impact was confined to only 2 weekends for both bridges instead of 2 years under a standard practice staged construction. To ensure timely replacement of these bridges, incentive and disincentive provisions were included in the construction contract. The contractor substantially exceeded the criteria set by ODOT and received the maximum incentive valued at $600,000 ($20,000 for each day not exceeding 30 days).

Figure 20 through Figure 23 illustrates the entire process involved in rapid removal and replacement of crossings 3 and 4. This process required months of preparation, but significantly minimized the adverse traffic impacts on neighboring residents, businesses, and the traveling public.

ODOT closed OR 38 between Elkton and Drain on two separate Fridays in preparation for the removal and replacement of crossings 3 and 4. The surrounding communities were informed of the upcoming construction activities and lane closures through signs, news media, and the dedicated Web site. A detour was put in place during this 2-day closure. Motorists heading west from Interstate 5 to Reedsport were advised to take exit 136 (Sutherlin) and follow OR 138 to Elkton. Motorists traveling east from Reedsport to I-5 were advised to take OR 138 from Elkton and follow it to I-5.

To facilitate the removal of the old superstructure, some preliminary work had to be performed on the surface, including sawing and removal of the old asphalt overlay and demolition and removal of the bridge railings and approach slabs. This work was done on Friday evening after the 8 p.m. closure of OR 38 (Figure 20).

Figure 20. Demolition and dismantling of end panels.

On Saturday, the old superstructure was lifted and slid onto its temporary support to make room for the new superstructure. Figure 21 shows the old and the new superstructures and substructures side by side for crossing 3.

Figure 22 shows the new superstructure of crossing 3 after it was translated onto its final destination, including the prefabricated approach panels, the newly paved approach roadway, and the precast wing walls. The entire removal and replacement process took about 4 hours. The remaining time on Saturday and Sunday was spent on work on the approaches to the structures, which included the following:

- Installation of the prefabricated wing walls
- Backfilling behind the abutments and wing walls with choice backfill materials
- Placement of the precast sleeper slabs and approach pavement panels
- Preparing the approach roadways for paving and installation of the remaining guardrails
- Striping the surface of the roadway and the new bridge and reopening to traffic

Early Monday morning, the bridge was opened to traffic, as shown in Figure 23.

Figure 21. View of old and new superstructures at crossing 3.

Figure 22. Replacement of superstructure and end panels at crossing 3.

Figure 23. Completed crossing 4 after opening to traffic.

CROSSING 5 OVER HARDSCRABBLE CREEK AT MP 48.00

The old bridge, built in 1929, was a 90-ft-long, three-span, RCDG structure. This bridge was in very poor condition with delaminated concrete components and exposed corroded reinforcement. Because of extremely tight right-of-way clearances and the site's proximity to Elk Creek, ODOT stipulated replacing the bridge within a 180-day construction period. Typical sections for the old and proposed bridge are shown in Figure 24 and Figure 25.

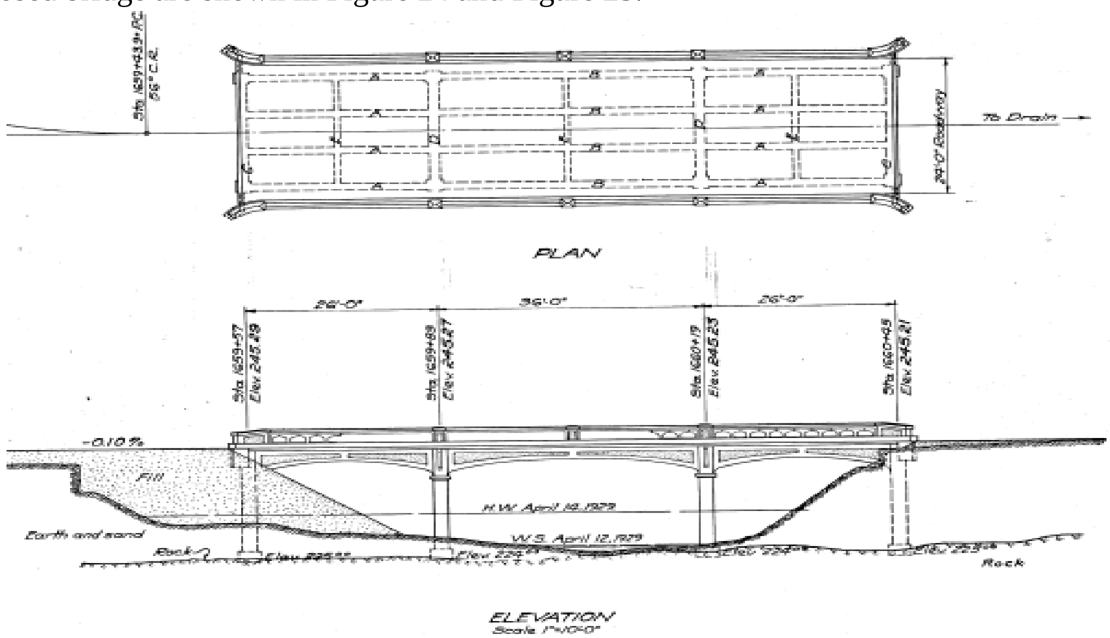

Figure 24. Crossing 5 old typical section.

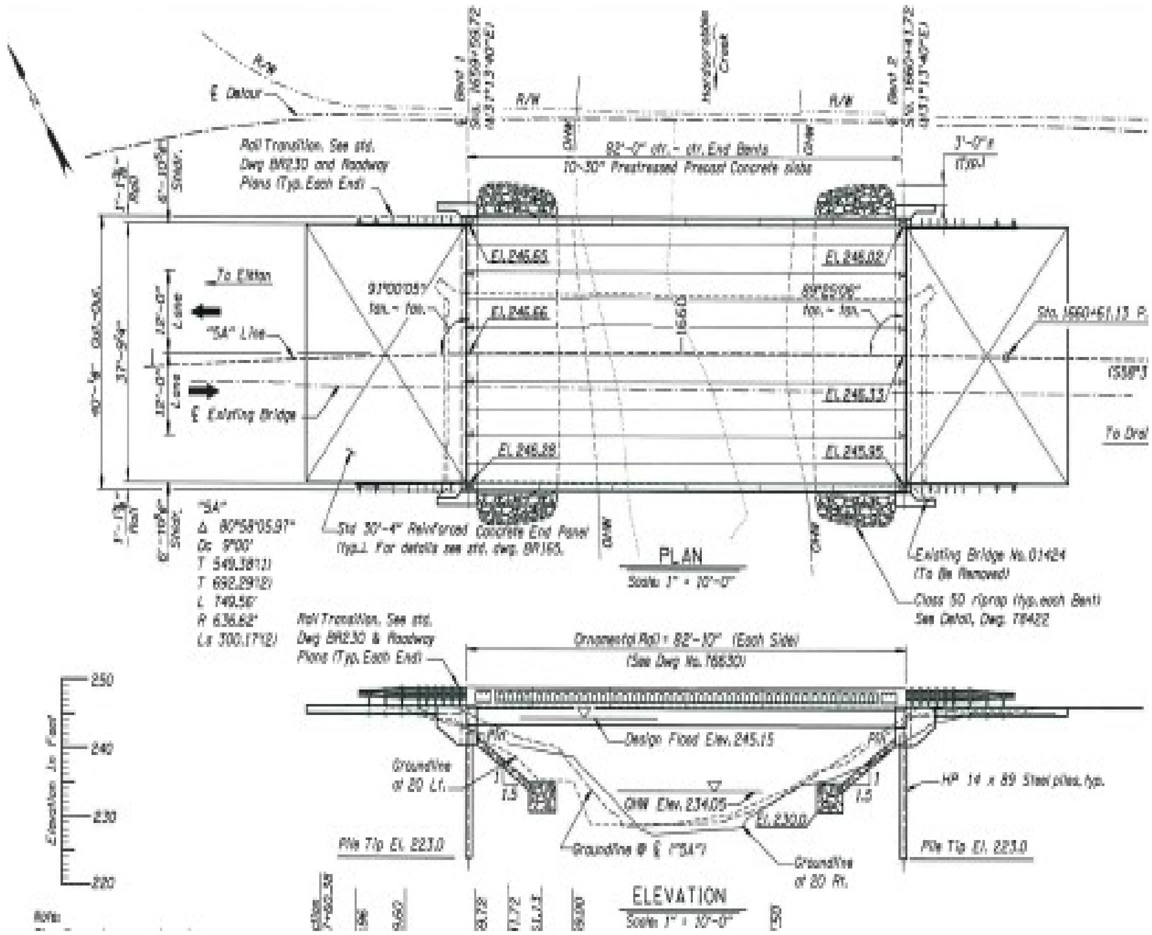

Figure 25. Crossing 5 proposed typical section.

Incentive and disincentive clauses ($4,500 per day for a maximum of 30 days) were included for the replacement of this bridge to encourage accelerated construction and minimize the duration of traffic disruption. ODOT awarded the contractor an incentive of $135,000 (maximum incentive) for rapid removal and replacement of crossing 5.

The proposed new structure consisted of a single-span bridge constructed with precast concrete deck members. To facilitate bridge construction and modification of the existing roadway alignment, a temporary single-lane detour bridge was erected and used for 6 weeks (Figure 26). Travelers and neighboring residents and businesses were informed of the upcoming detour by signs and through the public outreach program.

The total distance of this single-lane detour was only 300 ft. Detour use was controlled by flaggers at each end of the detour bridge 24 hours a day, 7 days a week. Traffic control signs were erected, flagger stations were illuminated for nighttime operations, and traffic speed through the work zone was reduced to 20 mi/h for the duration. Figure 27 shows completed crossing 5. No incidents were reported during the traffic control operation.

Figure 26. View of the temporary and old bridges looking east.

At the conclusion of the 6-week single-lane detour, the new bridge was opened to traffic in both directions and the detour bridge was dismantled and removed (Figure 27).

Figure 27. View of completed crossing 5 and dismantling of the detour bridge.

DATA ACQUISITION AND ANALYSIS

Data collection on the ODOT HfL project consisted of acquiring and comparing data on safety, construction congestion, quality, and user satisfaction before, during, and after construction. The primary objective of acquiring these types of data was to provide HfL with sufficient performance information to support the feasibility of the proposed innovations and to demonstrate that the D-B method of project delivery coupled with the use of accelerated bridge construction technologies can be used to accomplish the following:

- Achieve a safer environment for the traveling public and workers.
- Reduce construction time and minimize traffic interruptions.
- Deliver a better quality project because of the flexibility offered to the contractor.
- Produce greater user satisfaction.

This section discusses how well ODOT's project met the specific HfL performance goals in these areas.

SAFETY

The HfL performance goals for safety include meeting both worker and motorist safety goals during construction. For ODOT, safety of the workers and the traveling public was more than a performance goal; it was a requirement under the Oregon Transportation Investment Act program. All site personnel, field crews, designers, inspectors, and owner's representatives received site-specific orientation and safety training before working on this project. In addition, all construction workers received quarterly safety training and attended mandatory weekly safety meetings.

During the construction of the bridges on OR 38, few worker injuries were reported and these injuries were minor in nature. Ten incidents were reported over a 2-year period (i.e., 0.4 incident per month), including cases of lower back pain, scorpion bite, and poison oak exposure. None of these injuries resulted in loss of work for the workers. Overall, the contractor exceeded the HfL goal for worker safety (incident rate of less than 4.0 based on the OSHA 300 rate).

As for the safety of the traveling public, ODOT's foremost solution was to minimize traffic disruption and interaction with construction activities and workers. In the 3 years before construction began (2004–2006), data showed a crash rate slightly higher than the statewide crash rate for a rural principal arterial (i.e., 0.69 crashes per million vehicle-miles versus 0.67 crashes per million vehicle-miles statewide).

During construction, the contractors took extraordinary steps to assure that incidents were kept to a minimum. The many safeguards put in place to prevent crashes during construction were effective. These included procurement of Oregon State Police during major traffic changes and peak construction periods. Other effective measures included scheduled open houses, regular news releases, and establishment of a dedicated phone line and Web site. A review of the individual incidents showed that only three crashes occurred in the vicinity of the project's bridge sites. However, as reported by ODOT, none of these crashes was attributed to the construction activities.

Table 1 presents the post construction crash data provided by ODOT. The safety performance of the facility after construction was evaluated using pre and post construction crash rates. Table 2 presents total crash rates and fatality rates for both pre and post construction periods. The crash data on injuries and property damage was not available for the preconstruction period and thus a comparison based on these severity types could not be carried out. While the fatality rate significantly reduced by 70.8 percent after construction, due to the non-availability of preconstruction data, it is inconclusive as to whether the HfL goal for facility safety was achieved or not.

Table 1. Post construction crash data.

Period	Fatalities	Injuries	PDO	ADT
2008	1	2	3	2900
2009	1	13	3	3100
2010	0	8	2	3100
2011	0	9	6	3000
2012	0	1	1	3000*

* 2011 ADT assumed for 2012.

Table 2. Crash rates for pre and post construction periods.

	Preconstruction	Post construction	Difference
Total Crashes	0.690	0.780	11.7%
Fatalities	0.0534	0.0313	-70.8%
Injuries	N.A.	0.516	N.A.
Property damage only	N.A	0.234	N.A.

CONSTRUCTION CONGESTION

Expedited construction was a key HfL performance goal, which specifies a 50 percent reduction in the time highway users are impacted during construction compared to traditional practices. ODOT believes that, through overlapping design and construction using the D-B method of project delivery and using incentive/disincentive clauses and innovative accelerated construction technologies such as HSS, it was able to dramatically reduce the impact of construction activities on neighboring residents, businesses, and roadway users.

ODOT estimated that under conventional methods, the construction of crossings 3 and 4 would have taken an extra year to complete and the impact of construction-related activities on roadway users would have been dramatic. By putting to work an innovative and proven technology (HSS), ODOT dramatically reduced the impact on highway users to just two weekend closures. In addition, by using a temporary structure during the reconstruction of crossing 5, ODOT reduced construction time and impact on the traveling public from 6 months to only 6 weeks. With a well-thought-out staged construction plan for crossings 1 and 2, ODOT was able to eliminate the interference of construction activities on traffic flow.

QUALITY

Although the quality of the replaced crossings on OR 38 potentially was improved because most of the work was done in a controlled environment and prefabricated bridge components were used, the replacement process in general had no impact on pavement noise and smoothness.

USER SATISFACTION

As indicated in earlier sections, during the planning stages of the project, ODOT undertook an aggressive and comprehensive effort to communicate with affected residents and businesses along the corridor and near the bridges, keeping them abreast of all activities before, during construction, and after construction. The HfL requirement for user satisfaction included a performance goal of 4-plus on a Likert scale of 1 to 7 for the following two questions:

1. How satisfied are you with the results of the new bridges compared to the condition of the previous bridges?
2. How satisfied are you with the approach ODOT used (accelerated bridge construction techniques and other innovative features) to construct the new bridges in terms of minimizing disruption?

A postconstruction stakeholder survey conducted by ODOT clearly indicated that the neighboring residents and businesses were extremely satisfied with the construction approach and the final product. ODOT exceeded the HfL expectation by a large margin. The answers to questions 1 and 2 illustrate ODOT's overall performance during the project and stakeholders' overall satisfaction with the project results. A total of 376 respondents provided feedback to these questions.

Question 1

How satisfied are you with the new bridges between Drain and Elkton, compared to the previous bridges and roadway alignments? Are you (CHOOSE ONE):

88.3 percent	(332)	*Very satisfied*
6.9 percent	(26)	*Somewhat satisfied*
3.5 percent	(13)	*Neither satisfied nor dissatisfied*
0.0 percent	(0)	*Somewhat dissatisfied*
1.3 percent	(5)	*Very dissatisfied*

Question 2

How satisfied are you with the approach ODOT took in constructing the new bridges so as to minimize disruptions to the traveling public? Are you (CHOOSE ONE):

86.4 percent	(325)	*Very satisfied*
9.8 percent	(37)	*Somewhat satisfied*
2.4 percent	(9)	*Neither satisfied nor dissatisfied*
0.3 percent	(1)	*Somewhat dissatisfied*
1.1 percent	(4)	*Very dissatisfied*

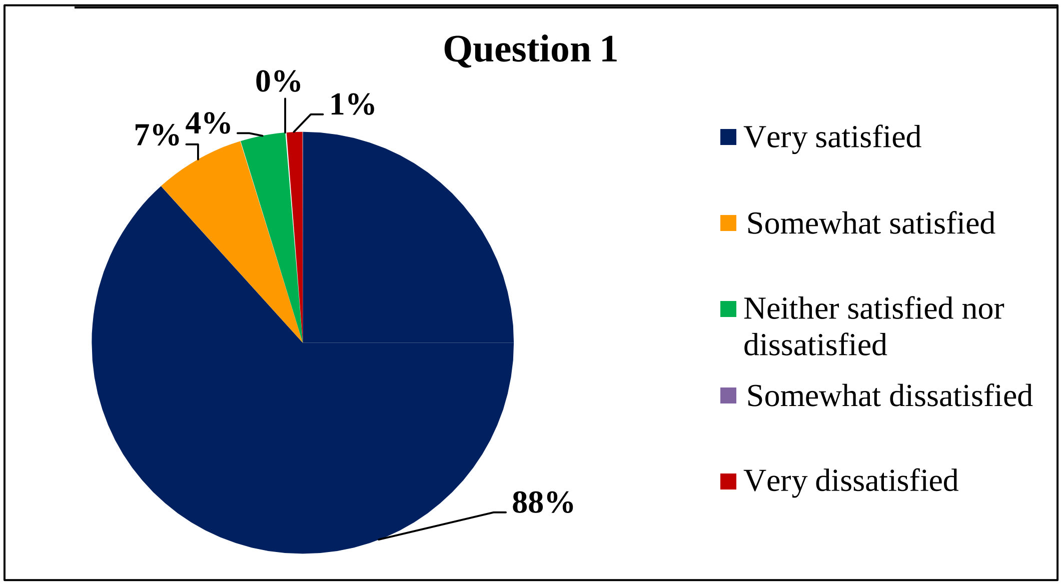

Figure 28. User satisfaction with the final product.

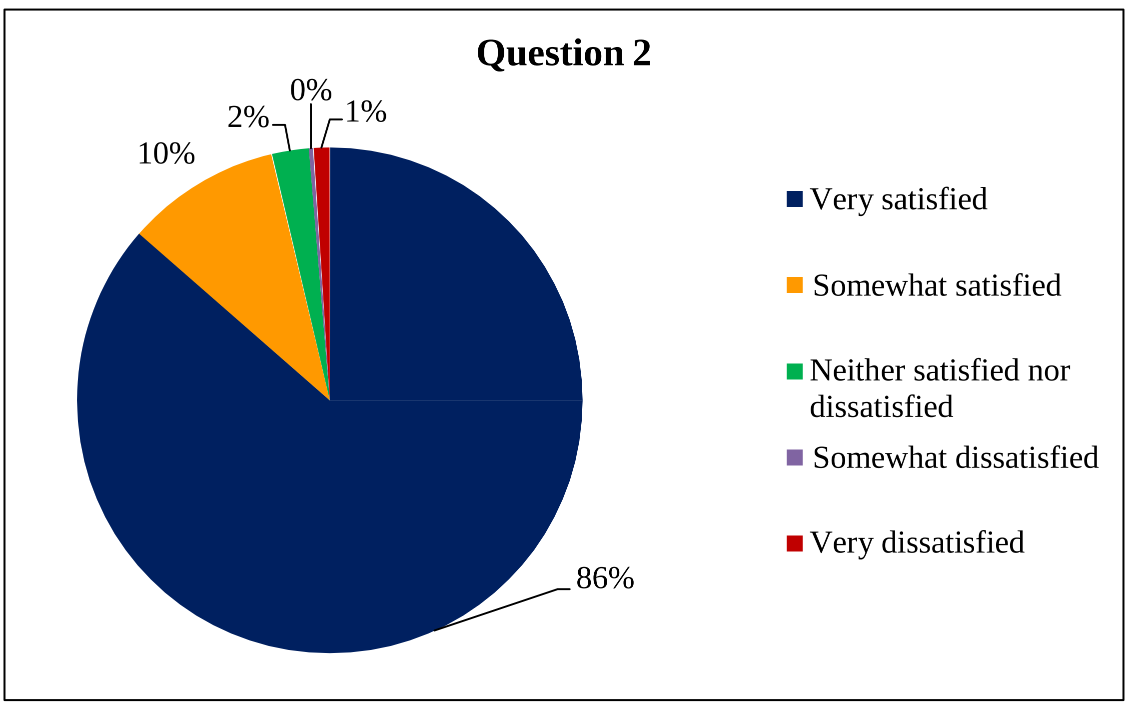

Figure 29. User satisfaction with the project approach.

Figure 28 and Figure 29 illustrate the 376 respondents' level of satisfaction with the project approach and the new bridges between Elkton and Drain. For comprehensive results of ODOT's user satisfaction survey, see Appendix A.

TECHNOLOGY TRANSFER

To accelerate the nationwide adoption of proven innovative techniques such as ABC, ODOT, in cooperation with FHWA's Oregon Division, sponsored a half-day workshop on the project (Figure 30). Many engineers from ODOT, FHWA, industry, and other governmental agencies attended the Friday, September 5, 2008, workshop in Cottage Grove, OR (20 miles from the project site).

The workshop featured presentations by representatives of ODOT, FHWA, the design consultant, and the contractor on the design and construction of the bridges, with emphasis on the project's innovative accelerated construction features. Speakers from the FHWA HfL team provided an overview of the HfL program and presented the national perspective on the use of innovative ABC techniques.

ODOT arranged a field trip on Saturday, September 6, for participants to view the replacement of the superstructure at crossing 3. In addition, many residents from the nearby neighborhood and representatives of the towns of Reedsport and Elkton witnessed the superstructure replacement.

Figure 30. ODOT-FHWA workshop.

The workshop agenda is in Appendix B.

ECONOMIC ANALYSIS

A key aspect of HfL demonstration projects is quantifying, as much as possible, the value of the innovations deployed. This entails comparing the benefits and costs associated with the innovative project delivery approach adopted on an HfL project (i.e., as-built) with those from a more traditional delivery approach on a project of similar size and scope. The latter type of project is referred to as a baseline case and is an important component of the economic analysis.

In addition to analyzing the baseline and as-built construction costs, ODOT used the StratBENCOST[1] analysis approach to demonstrate the cost savings that stemmed from improved traffic flow and reduced impact on highway users (i.e., user costs). This analysis is in the "User Costs" section.

CONSTRUCTION TIME

ODOT believes that, through overlapping the design and construction using alternate project delivery and using incentive and disincentive clauses and innovative accelerated construction technologies such as HSS, it was able to dramatically reduce the duration and impact of construction activities on neighboring residents, businesses, and roadway users. Although it took several months to complete the construction of the substructure and superstructure for crossings 3 and 4, the as-built construction impact on users was minimal until these structures were ready to be removed and replaced.

As stated earlier, during this removal and replacement time, full lane closures were established on only two weekends on the 11-mi stretch of OR 38 between Elkton and Drain. If a traditional approach had been used to remove and replace these crossings while maintaining traffic on OR 38, ODOT estimates that it would have taken an extra year to complete the project and the impact of construction-related activities on highway users would have been dramatic.

With the use of a temporary structure, ODOT was able to reduce the time for removal and replacement of crossing 5 to only 6 weeks from the original schedule of 6 months.

DETOUR

Overall, traffic was detoured on three occasions. During the removal and reconstruction of crossing 5, a detour was put in place using a temporary structure next to the old crossing. The total distance of this single-lane detour was only 300 ft. The detour use was controlled by flaggers at each end of the detour bridge 24 hours a day, 7 days a week for 6 weeks. Originally, the contractor was given 6 months to complete this bridge, but using a temporary structure enabled the contractor to reduce the impact on roadway users to only 6 weeks and receive an

[1] StratBENCOST is a benefit-cost analysis tool developed under National Cooperative Highway Research Program project 2-18(4) to evaluate highway investments at the strategic level (*NCHRP Research Results Digest 252,* March 2001).

incentive of $135,000. Because of the low ADT on OR 38, the impact on travel time was minimal.

Detours were also established on two separate weekend closures for the removal and replacement of crossings 3 and 4. Motorists were advised in advance to use highway 138, which added about 50 mi to their travel.

CONSTRUCTION COSTS

Table 3 presents the differences in construction costs between the baseline and the as-built alternatives for crossings 3 and 4. All of the as-built and baseline cost estimates were provided by the ODOT project engineer assigned to this job. The baseline cost estimate is inexact, and the information presented is a subjective analysis of the likely cost differential rather than a rigorous computation of a cost differential.

Table 3. Crossings and capital cost calculation.

Cost Category	Baseline Case	As-Built (ABC)
Crossing 3		
Design and Quality	$ 1,521,000.00	$ 2,299,000.00
Traffic Control	$ 458,000.00	$ 294,000.00
Environmental	$ 43,000.00	$ 282,000.00
Mobilization	$ 736,000.00	$ 1,120,000.00
Bridge Construction (Substructure, Superstructure, and Bridge Removal	$ 4,475,000.00	$ 6,052,000.00
Roadway and Earthwork	$ 727,000.00	$ 396,000
Detour/Stage Construction	$ 2,042,000.00	$ 802,000.00
Total	$10,002,000.00	$11,245,000.00
Crossing 4		
Design and Quality	$ 1,488,000.00	$ 1,907,000.00
Traffic Control	$ 336,000.00	$ 305,000.00
Environmental	$ 54,000.00	$ 197,000.00
Mobilization	$ 516,000.00	$ 660,000.00
Bridge Construction (Substructure, Superstructure, and Bridge Removal	$ 2,862,000.00	$ 2,752,000.00
Roadway and Earthwork	$ 504,000.00	$ 243,000.00
Detour/Stage Construction	$ 1,183,000.00	$ 569,000.00
Total	$ 6,943,000.00	$ 6,633,000.00
Grand Total	**$16,945,000.00**	**$17,878,000.00**

Note: As-built represents rapid replacement technique.

USER COSTS

Generally, three categories of user costs are used in an economic life-cycle cost analysis: vehicle operating costs, delay costs, and crash- and safety-related costs. The cost differential in delay costs was included in this analysis to identify the differences in costs between the baseline and as-built alternatives. The performance goal established by ODOT on motorist delay was that no vehicle should be delayed by contractor operations more than 20 minutes beyond its normal travel time. The contractor met this goal easily. Based on a travel time study conducted by HfL consultants, a delay of 5 to 9 minutes was computed for each vehicle during daytime hours. For the most part, the approach adopted was to maintain two lanes of uninterrupted traffic throughout the duration of construction except for 6 weeks on crossing 5, which required the use of a temporary bridge and two weekend closures for removal and replacement of crossings 3 and 4.

In conducting the user cost analysis, ODOT used the StratBENCOST model, an economic analysis tool widely used for analyzing large-scale transportation projects. This model, developed under a National Cooperative Highway Research Program study sponsored by FHWA, uses variables such as travel time cost, vehicle cost, crash cost, and environmental cost to determine economic savings from employing innovative features in a transportation project.

Table 4 presents user cost savings for all of the crossings except crossing 2. The contractor used no innovative features in reconstructing crossing 2, so there were no savings associated with that crossing.

Table 4. Results of user cost analysis for all crossings.

User Cost Analysis				
	Crossing 1	**Crossing 2**	**Crossings 3 and 4**	**Crossing 5**
Reduced Travel Time Cost	$52,174	0	$58,216	$48,518
Reduced Crash Cost	$ 8,925	0	$ 9,958	$ 8,299
Reduced Vehicle Operating Cost	$ 4,119	0	$ 4,596	$ 3,830
Reduced Environmental Cost	$ 3,432	0	$ 3,830	$ 3,192
Savings	$68,650	0	$76,600	$63,840
Total Savings = $209,090				

In addition to achieving the above savings, ODOT cut the time required to complete the project by a full year by using the D-B method of project delivery in place of traditional D-B-B and by using ABC techniques. The potential savings from reduced labor costs and escalation costs of materials due to inflation for a 12-month period was estimated at $1.596 million (or 3.3 percent of construction value). An extra mobility savings of $311,230 was also assessed for all crossings. In addition, ODOT saved $1 million by using ABC techniques, which eliminated the need for detours for crossings 3 and 4. An additional savings of $265,000 was realized on crossing 5 by building a smaller detour and not purchasing additional right-of-way.

COST SUMMARY

Table 5 represents a cost comparison summary of the as-built (accelerated construction) and baseline (traditional construction) alternatives for the entire project. The as-built cost of building crossings 3 and 4 is $933,000 more than the traditional method. However, under the as-built scenario, project completion was accelerated by about a year. This dramatically reduced labor costs, minimized traffic interference with construction activities, and resulted in reduced crashes, travel time, and vehicle operating costs. Considering these factors, ODOT achieved a net savings of $2,448,320, as shown in Table 5.

Table 5. Cost comparison of as-built and baseline alternatives.

Cost Category	Baseline Case	As-Built (ABC)	Accumulated Savings
Total Cost of Crossings 3 and 4	$16,945,000	$17,878,000	-$ 933,000
Savings From Rapid Construction of Crossings 3 and 4 (i.e., not building detours)	0	$ 1,000,000	$ 67,000
Savings from Crossing 5	0	$ 265,000	$ 332,000
Total Mobility Savings From All Crossings	0	$ 311,230	$ 643,230
Reduced Labor Due to Time and Escalation Cost Savings	0	$ 1,596,000	$2,239,230
Total User-Costs Savings	0	$ 209,090	$2,448,320

APPENDIX A. HfL/OREGON DOT USER SATISFACTION SURVEY

HIGHWAY 38: ELK CREEK TO HARDSCRABBLE CREEK BRIDGES

Report of Results

December 2008

Prepared by:
Lois D. Cohen Associates, LLC
For the Oregon Department of Transportation

Background

Project Background

In January 2007, the Oregon Department of Transportation began a project to replace five bridges along a 14-mile stretch of Highway 38 between Elkton and Drain. The bridges, built between 1929 and 1932, required replacement to ensure safe travel on this important route between the coast and the Interstate 5 corridor. To enhance traffic safety along this corridor, ODOT also added a left-turn lane from westbound Highway 38 to Highway 138 as a part of this project.

To minimize travel impacts, ODOT design-build contractor Slayden Construction used an innovative "rapid replacement" technique to build the two new bridges on the east and west sides of the Elk Creek tunnel. The successful use of this technique saved motorists six months of daily travel delays, reduced construction costs, minimized the cost of delayed freight, and limited negative impacts on several small businesses. Community input guided ODOT's decision to use the rapid replacement, or accelerated bridge construction, technique. Feedback from community residents also influenced the timing of the closures.

Narrow and winding Highway 38 serves as a lifeline route for the communities of Drain and Elkton, and to a lesser extent Reedsport. Replacing five bridges here was a complex undertaking. It required a great deal of communication with city leaders, area businesses, the freight industry, and the local communities. ODOT's team of outreach specialists used both traditional and nontraditional methods to connect with these stakeholders.

Outreach Activities

To reach out to the affected communities, ODOT's team used news releases, newsletters, weekly construction updates, a project Web site , one-on-one and small group meetings with elected officials and business and civic leaders, and public meetings. The project team regularly briefed local service clubs and professional engineering organizations. Open house meetings were held in Drain and Reedsport, and briefings were provided to the Reedsport City Council and officials in Elkton and Drain. The team also presented project information to the Reedsport/Winchester Bay Chamber of Commerce. In anticipation of detours, the team held several meetings with emergency service providers.

The project team also conducted school-based outreach programs in Drain, Elkton, and Reedsport. As a result of leading three interactive programs with students in these communities, the project team was able to connect with parents who might not otherwise have accessed project information. As part of this outreach, Elkton High School students were invited to participate in a contest to submit designs for the pylons at the four corners of the Elkton Bridge. After the winners were selected and the pylons completed, ODOT hosted a community celebration in Elkton, honoring the participating students and the adults in the community who guided their efforts. A time capsule built and filled by local students was embedded in the base of one of the pylons.

A “Rapid Replacement Primer” educational guide was also developed and distributed within the community so that residents would have the opportunity to learn about the fascinating and innovative technique employed by ODOT to replace two of the five project bridges.

Thus, ODOT used a variety of unique tactics and programs that engaged the affected communities.

Survey Design

Lois D. Cohen Associates, or LDC, was contracted to design and distribute a community survey to project stakeholders most affected by the bridge construction. This survey included three questions.

Seeking critical public input for ODOT to consider when planning future project outreach and implementation activities, the first two survey questions sought to measure levels of satisfaction regarding the new bridges and roadway alignments, and the approach used to minimize traffic disruptions. These two questions used the Likert scale, offering five selections ranging from *very satisfied* to *very dissatisfied*.

The survey also included one open-ended question. This question requested feedback regarding the effectiveness of outreach activities and procedures used to gather community feedback and provide project information.

The survey was designed in a postcard format. It included the three survey questions, a map of the project area, and a brief overview of the project activities and duration. LDC provided a return mail address and postage on the reverse of the survey postcard.

People were also given the opportunity to respond to the survey online using ODOT’s project Web site.

Survey Distribution and Collection

LDC distributed surveys to area stakeholders by mail and e-mail on Nov. 17, 2008. In total, 2,000 paper surveys were distributed.

LDC worked with a print-to-post vendor to distribute the survey by mail to residents and businesses affected by the bridge project. LDC used the bridge project stakeholder list, which includes contact information for key elected officials and organizations throughout the project corridor from Reedsport to Drain, and postal customers in Drain and Scottsburg. Additionally, the Elkton School District distributed 600 surveys with its regular mailing to all households in the district, whether or not they had students enrolled in the school system.

As of Dec. 13, 2008, LDC collected a total of 376 surveys, reflecting an 18.8 percent rate of return, with a margin of error of plus or minus 5 percent. LDC received 356 surveys by mail and 20 responses using the online survey.

Results Report

Question 1

How satisfied are you with the new bridges between Drain and Elkton, compared to the previous bridges and roadway alignments? Are you (CHOOSE ONE):

88.3%	(332)	*Very satisfied*
6.9%	(26)	*Somewhat satisfied*
3.5%	(13)	*Neither satisfied nor dissatisfied*
0.0%	(0)	*Somewhat dissatisfied*
1.3%	(5)	*Very dissatisfied*

95 percent of responses indicated that the public considers the new bridges between Elkton and Drain to be as good as or better than the previous infrastructure.

A total of 376 respondents provided feedback to this question.

The following chart illustrates the 376 respondents' level of satisfaction with the new bridges between Elkton and Drain.

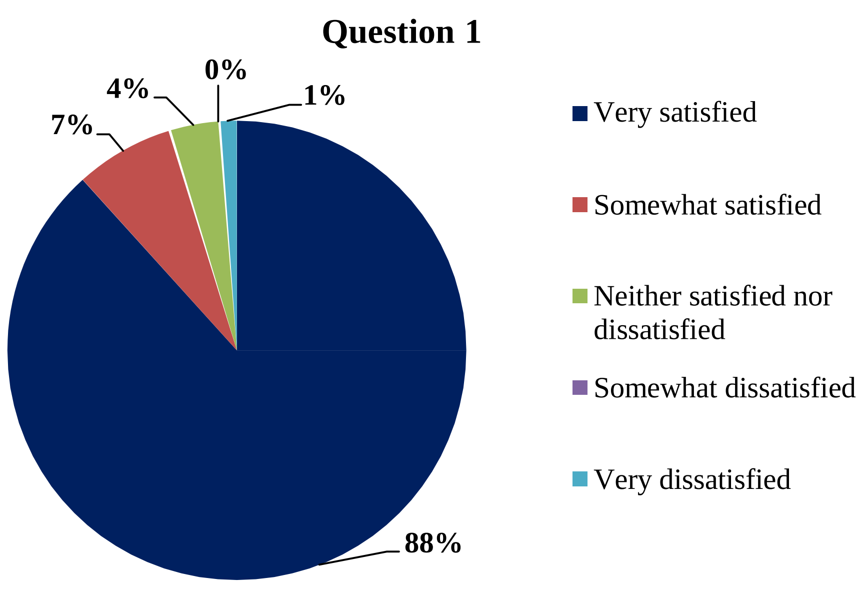

Figure A-1. User satisfaction with the final product.

Question 2

How satisfied are you that the approach to constructing the new bridges was selected so as to minimize disruptions to the traveling public?   **Are you (CHOOSE ONE):**

86.4%	(325)	*Very satisfied*
9.8%	(37)	*Somewhat satisfied*
2.4%	(9)	*Neither satisfied nor dissatisfied*
0.3%	(1)	*Somewhat dissatisfied*
1.1%	(4)	*Very dissatisfied*

More than 96 percent** of respondents rated their level of satisfaction with the approach to construction to be **somewhat satisfied or very satisfied.

A total of 376 respondents provided feedback to the second inquiry.

The following chart illustrates the 376 respondents' stated level of satisfaction with ODOT's approach to construction.

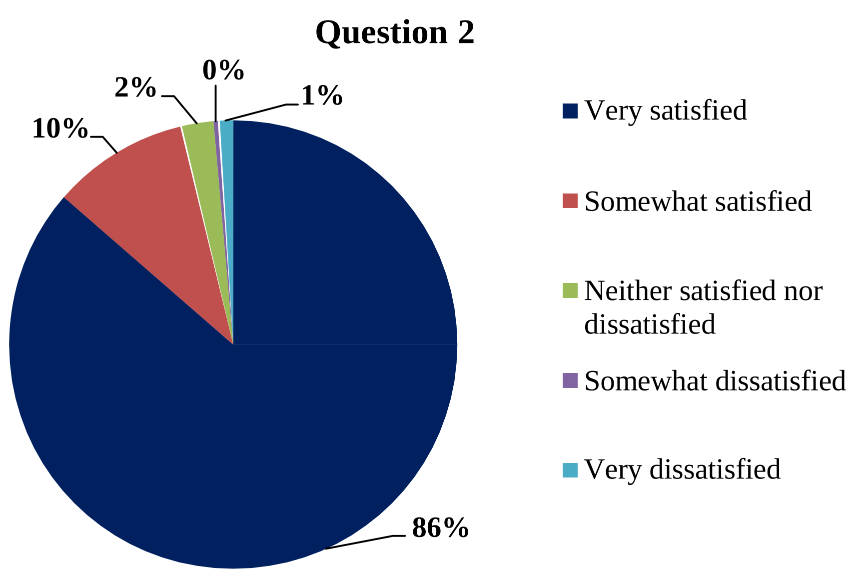

Figure A-2. Level of satisfaction with the approach.

Question 3

What improvements or changes would you recommend regarding activities and procedures used to gather community comments and provide project information?

Of the 376 surveys collected, 47 percent (178) of the respondents commented on this open-ended question.

This feedback provides insight into the public's perception of the success of the Highway 38 bridge project. Public responses can be categorized as follows (totals greater than 100 percent due to multiple responses):

1. Accolades: 80 percent (142 comments out of 178 responses)

The Accolades category encompasses congratulatory or otherwise complimentary statements made by those who responded to question 3.

Two examples from each category are listed below along with their corresponding reference number:

- *Response 2: "Great job keeping the traffic flowing! Bridge improvements are wonderful! Fantastic job all around. Thank you very much!!"*
- *Response 14: "You did an outstanding job in every category."*

2. Recommended Changes: 25 percent (44 comments out of 178 responses)

The Recommended Changes category encompasses feedback that suggests areas for improvement in project delivery.

Two examples from this category are listed below:

- *Response 81: "Could you not have staggered these projects to avoid frustration of 4 major construction sites/delays within the short distance of 16 miles between Elkton and Drain? Actually 5 if you count the bridge at Elkton all at once."*
- *Response 157: Send out more information flyers through the mail. Great job otherwise—keep it up!"*

3. Other Road Improvements Needed: 13 percent (23 comments out of 178 responses)

This category encompasses all feedback that suggests additional roadway improvements.

Two examples from this category are listed below:

- *Response 23: "FIX THE SCOTTSBURG BRIDGE!"*
- *Response 150: "Would like more passing lanes between Elkton and Drain but guess that would be hard to do, it sure would be nice though."*

4. Other: 8 percent (15 comments out of 178 responses)

The Other category encompasses all feedback not captured in categories 1 through 3. These comments varied greatly.

Two examples from this category are listed below:

- *Response 148: "A lot of people complain while work is being done, but it's so nice after you finish."*
- *Response 169: "We need more public trans and less improvements centered on auto and truck transportation. The gasoline/energy 'crisis' is never going to be over!"*

Figure A-3 illustrates the distribution of comments in the above-mentioned four categories, Accolades, Recommended Changes, Other Road Improvements Needed, and Other.

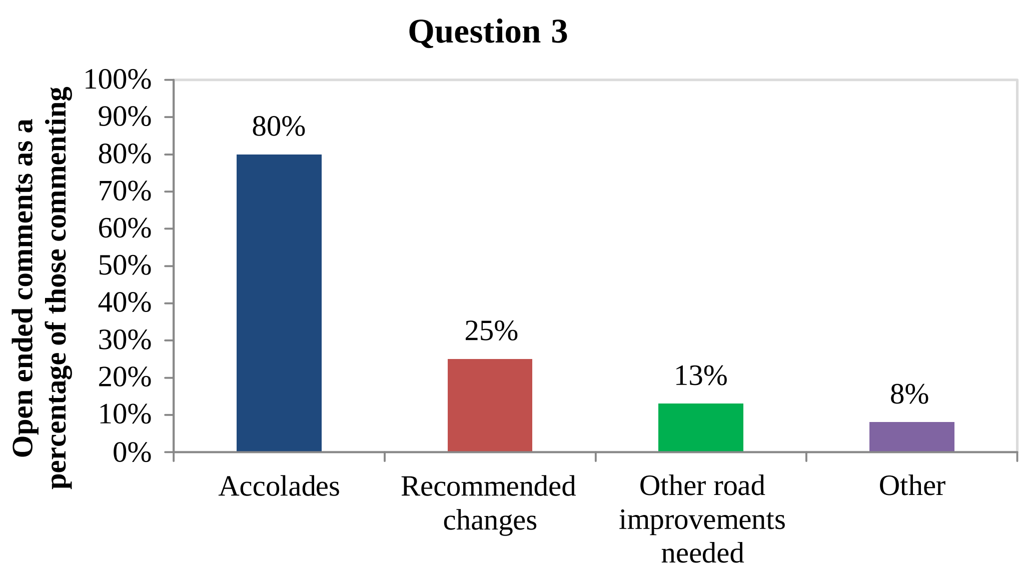

Figure A-3. Distribution of comments in all four categories.

In each of the following categories—Accolades, Recommended Changes, and Other Road Improvements Needed—specific themes emerged. The following section delves deeper into this critical public feedback.

Accolades

Eighty percent of the 178 survey participants who responded to Question 3 provided positive feedback, highlighting five areas of particular success, as shown in Table A-1.

Table A-1. Distribution of comments in Accolades category.

Accolades (142 total positive comments received)	Number of Positive Comments Per Category	Percent of Positive Comments Per Category
General Project	83	58%
Outreach Tactics	28	20%
Workers' Professionalism	18	13%
Traffic Management	6	5%
Project Design	6	4%

Of the 142 comments captured in the Accolades category, more than 58 percent gave positive feedback about the overall success of the Highway 38 bridge project. Twenty percent of the comments gave positive feedback regarding the public outreach tactics and information provided throughout the duration of the project (Outreach Tactics). Thirteen percent of comments noted the professionalism of workers (Workers' Professionalism); respondents were most emphatic about the good work of Slayden Construction Group's flaggers.

Respondents commented on the success of both the design of the project and its implementation. Several comments cited improvements to the roadway, such as rumble strips and the upgrades to the junction of Highway 38 and Hardscrabble Creek Road (Project Design). Additionally, 5 percent of comments complimented the minimal impact on traffic by construction work (Traffic Management).

Figure A-4 illustrates the distribution of comments within the Accolades category.

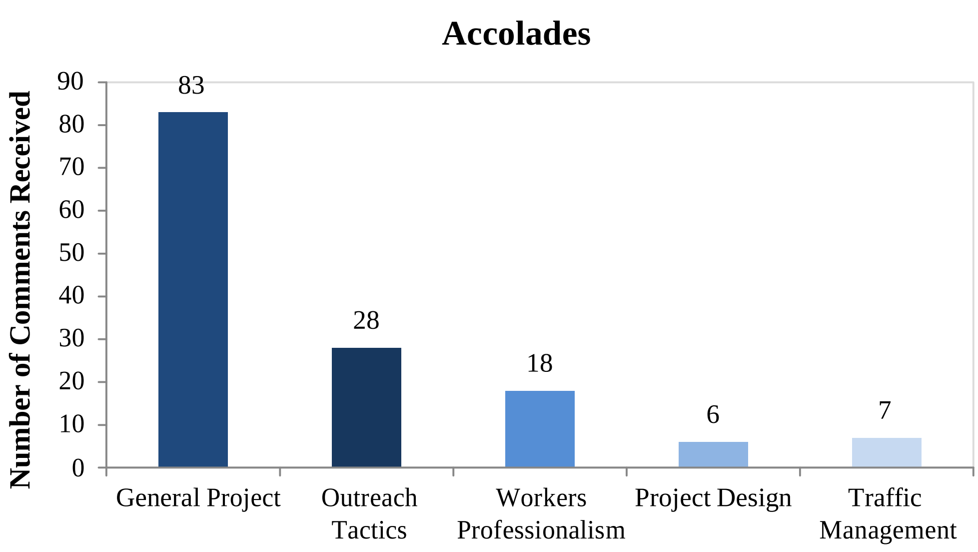

Figure A-4. Distribution of comments in Accolades category.

Recommended Changes

The Recommended Changes category encompasses 25 percent of public feedback to Question 3. Respondents' feedback highlights the five subcategories listed in Table A-2.

Table A-2. Recommended Changes category.

Recommended Changes (44 total comments received)	Number of Comments Per Category	Percent of Comments Per Category
Outreach Tactics	18	41%
Project Design	12	27%
General Project	7	16%
Traffic Management	6	14%
Workers' Professionalism	1	2%

Forty-four comments in the Recommended Changes category addressed potential avenues for improving project delivery. Forty-one percent of these comments requested additional measures for public outreach, such as more mailers and surveys (Outreach Tactics). Eight comments were about the "aggressive" rumble strips present in the project area, the sharp turns on the highway, and the physical appearance of the bridge in relation to the creek below (Project Design).

Seven comments suggested improvements to the overall project, such as use of more local subcontractors, quicker removal of traffic control devices and staggering the work to limit delay (General Project). Six comments suggested traffic management improvements, such as increasing the visibility of flaggers and signs and using electronic traffic management measures such as traffic signals (Traffic Management).

Figure A-5 illustrates the distribution of comments within the Recommended Changes category.

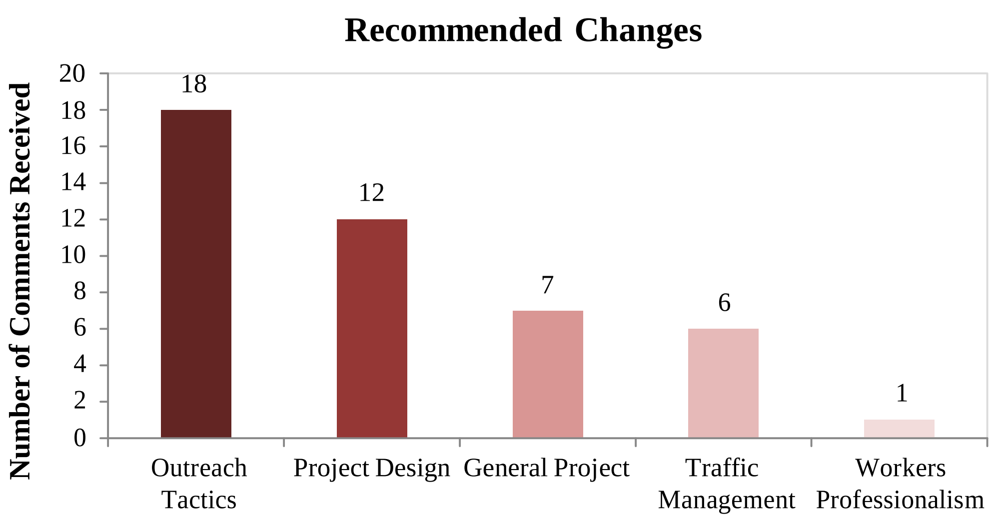

Figure A-5. Distribution of comments in Recommended Changes category.

Other Road Improvements Needed

The Other Road Improvements Needed category encompasses 23 comments submitted in response to Question 3. Public feedback highlights the desire of respondents to provide input about the condition of roads and bridges in their community. This feedback applies to the following two categories shown in Table A-3.

Table A-3. Comments related to other needed road improvements.

Other Road Improvements Needed (23 total comments received)	Number of Comments Per Category	Percent of Comments Per Category
Scottsburg Bridge	11	48%
Other Nearby Locations	12	52%

Forty-eight percent of the comments in the Other Road Improvements Needed category requested that the Scottsburg Bridge be repaired or replaced (Scottsburg Bridge). The remaining fifty-two percent of responses varied greatly (Other Nearby Locations).

Many offered suggestions on how to increase safety, such as requesting a stop sign at Highway 38 and Cedar Street in Drain, requesting a walking path along old Highway 99 north in Drain and increasing the number of passing lanes between Elkton and Drain.

Figure A-6 illustrates the distribution of comments in this subcategory.

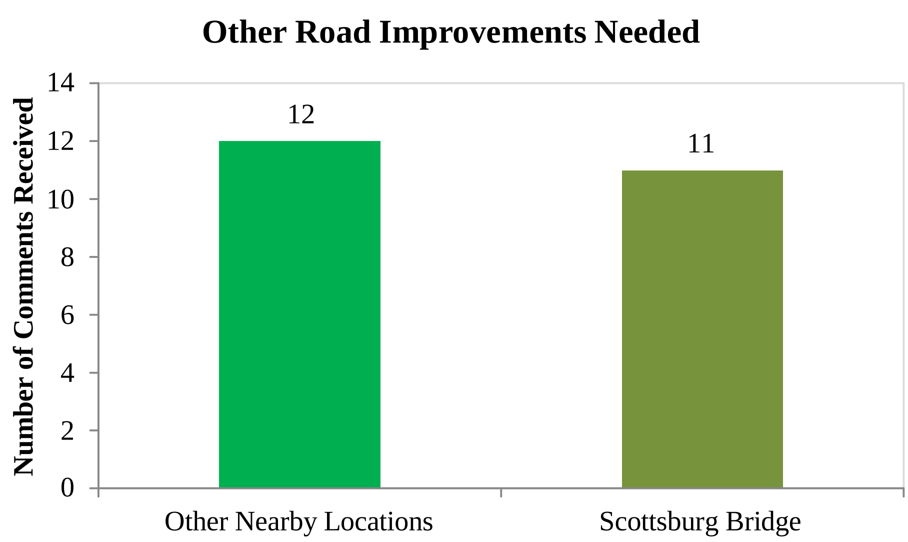

Figure A-6. Comments related to other needed road improvements.

Figure A-7 demonstrates the distribution of responses to Question 3 among the four categories of Accolades, Recommended Changes, Other Road Improvements Needed, and Other.

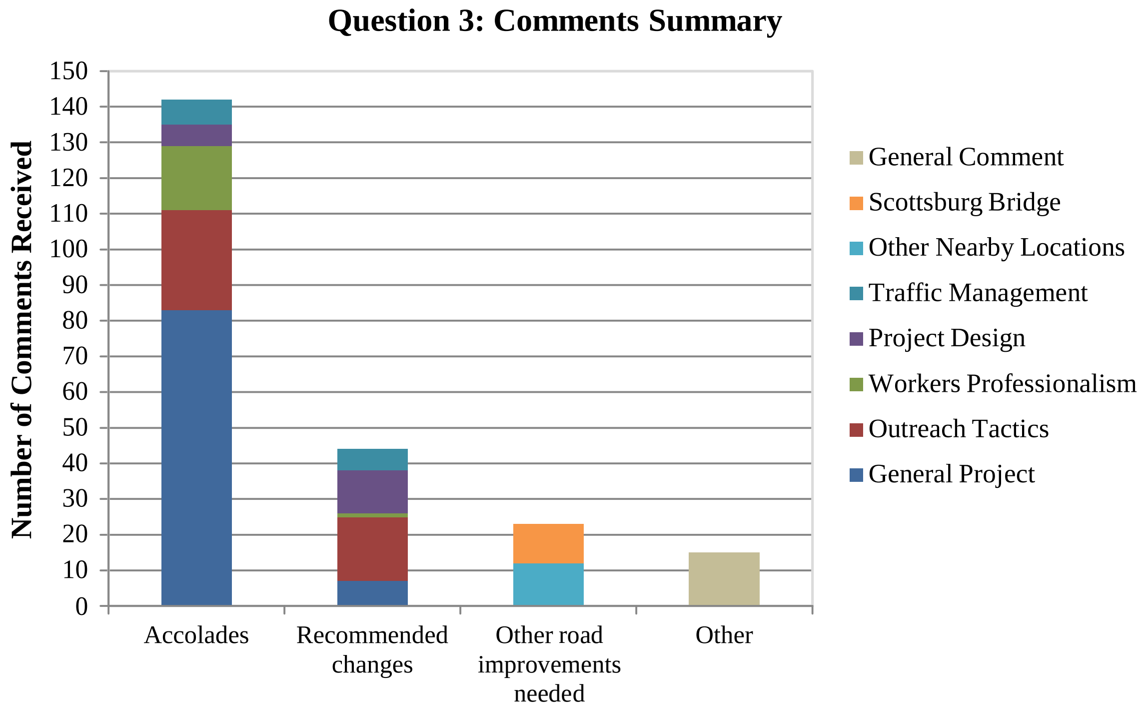

Figure A-7. Distribution of responses to question 3 for all categories.

REPORT SUMMARY

Beginning in 2007, ODOT's Highway 38 bridge project used unique outreach tactics to rally community interest, garner public support, and solicit critical public feedback. Stakeholder input helped influence the selection of the rapid replacement technique for the two bridges on either side of the Elk Creek Tunnel and also influenced the time of road closures.

Lois D. Cohen Associates used a survey to solicit stakeholder feedback regarding the success of ODOT's Highway 38 bridge project. LDC sent out approximately 2,000 surveys via mail and e-mail. As of Dec. 13, 2008, LDC collected 376 completed surveys, representing an 18.8 percent rate of return.

Results of the survey indicate that the public viewed the Highway 38 bridge project to be a success.

When asked to rate their level of satisfaction with the new bridges compared with the previous bridges and roadway alignments, ***more than 95 percent of respondents said that they consider the new bridges to be as good as or better than the previous infrastructure.***

The following comments reflect the general community consensus:

More than 96 percent of respondents said they were somewhat satisfied or very satisfied with the construction approach.

When given the opportunity to suggest preferred methods of public outreach, ***about 80 percent of those who commented complimented ODOT and the project team.*** *Twenty-five percent offered insight on how ODOT can improve future project implementation. Thirteen percent asked ODOT to make more improvements in their community.*

"This was a great project. We traveled this route several times, and took pictures each time. The construction crew did a quick and clean job. Many highway projects seem to take forever with a couple fellows working on it. This crew built some amazing bridges in a very short time. Thanks!!!!"

– Response 134

"This has been a wonderful experience for our community. Community and school involvement has been above and beyond. I have said the company doing the work has been so thoughtful, clean and positive. What a professional group of people. Bridge replacement video was awesome! Thinking of our walkers...you rock! Thank you!"

– Response 125

"You did fine. Not only did you gather opinions, you acted on the consensus rather than finding a reason not to. You got customer buy-in. That's the way it's supposed to work. Bravo."

– Response 96

APPENDIX B. WORKSHOP AGENDA

Cosponsored by:

Alternate Project Delivery and Accelerated Bridge Construction

Highways for LIFE Project Showcase

September 5-6, 2008
Village Green Resort
725 Row River Road
Cottage Grove, OR

This project is the replacement of five substandard major structures on Oregon's Umpqua River Highway, a major corridor between I-5 and US 101 near Elkton, Oregon. The bridges are being replaced for a variety of reasons:

- Load ratings indicating a lack of sufficient capacity to carry permit vehicles
- Substandard bridge widths
- Structural and functional deficiencies resulting in repair costs that exceed one-half of the replacement costs
- Avoid 50-mile detour for commercial vehicles

Focus Innovation: Accelerated Bridge Construction

Due to the extreme nature of the topography, all of the bridges present challenges, but two stand out for their exceptionally difficult site conditions. Slayden Construction's approach to replacing the 3rd and 4th crossings was to build the new bridge adjacent to the old structure and during a short-term closure demolish the old structure and slide the new structure onto the same alignment. Slayden elected to team with Mammoet USA, which specializes in the heavy lift and transport, to develop the plan to slide the old truss onto temporary supports and then slide the new bridge into place.

Other Innovations:

- Prefabricated bridge elements and systems
- Sliding rail bridge transporter
- Design-build contracting
- High-performance concrete
- Jointless deck design
- High-strength polyurethane bearing
- Context-sensitive and sustainable solutions

The benefits of this project are to essentially maintain two lanes of free-flowing traffic throughout construction, minimize queue lengths and increased trip times during construction, improve bridge quality and reduce future maintenance, improve worker safety, and improve user satisfaction.

Highways for LIFE Project Showcase
Village Green Resort and Gardens
Cottage Grove, OR
September 5-6, 2008

Alternate Project Delivery and Accelerated Bridge Construction Agenda

Time	*Session*	*Topic*	*Speakers*
	September 5, 2008		
12:30 p.m.	**Registration**		
1:00 p.m.	**Welcome and Introductions** History and Background of OTIA		ODOT
	Highways for LIFE Overview		FHWA
	National Perspective on ABC ABC philosophy and successes Resources available		Vasant Mistry, FHWA
	National Perspective on Design-Build State of the practice and lessons learned on design-build projects		Jerry Blanding, FHWA
	ODOT's Perspective Project description and approach		Bruce Johnson, ODOT
	Break		
	Design-Builder's Perspective Unique challenges of designing bridges and detour routes, particularly as they relate to ABC technologies Unique challenges of bridge construction and detour routes, particularly as they relate to ABC technologies Challenges faced in construction project management as it relates to D-B elements/goals, cost control (I/D clauses), quality control, and construction coordination		Slayden Construction Group
4:30 p.m.	**Adjourn**		
	September 6, 2008		
6:45 a.m.	**Board Buses**		
8:00–11:00 a.m.	**Site Visit to Witness Bridge Slide** **Bring safety vests and hardhats. Must have appropriate footwear. Reminder: This is an active work zone!**		
11:00 a.m.	**Return to Buses and Debriefing Aboard Buses**		Presenters
12:00 noon	**Evaluations and Adjourn**		All

Highways for LIFE Project Showcase
Village Green Resort and Gardens
September 5-6, 2008
Cotton Grove, OR PREREGISTRATION

FORM ** No Fee **

Please FAX form to: (435) 797-1582 or register online at: www.utahltap.org

<table>
<tr><td>Name:</td><td></td><td rowspan="5">Accommodations are available at:
The Hilton Eugene
66 E. 6th Ave.
Eugene, OR
(800) 937-6660

Ask for “Highways for LIFE” Rate
rooms based on availability</td></tr>
<tr><td>Agency:</td><td></td></tr>
<tr><td>City/State/Zip:</td><td></td></tr>
<tr><td>Phone/FAX:</td><td></td></tr>
<tr><td>Email:</td><td></td></tr>
<tr><td colspan="2">☐ Check here for Site Visit</td><td>Site Visit, September 6, 2008. You will need to bring your own vest, hardhat, and appropriate footwear for site visit.
REMINDER: This is an active work zone.</td></tr>
</table>

Figure B-1. Old and new superstructures side by side for crossing 4.