Arizona Demonstration Project:

Reconstruction of SR 179 in Sedona Using a Needs-Based Involvement Process

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.

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16. Abstract

As part of a national initiative sponsored by the Federal Highway Administration (FHWA) under the Highways for LIFE (HfL) program, the Arizona Department of Transportation (ADOT) applied for and was awarded a $1 million grant to showcase and demonstrate the use of innovative construction sequencing and a needs-based involvement plan (NBIP) for reconstruction of SR 179 from milepost 310.5 to 313.8, including a portion of SR 89A from milepost 374.0 to 374.2, in Sedona, AZ. Also included in this report are construction details of several roundabouts, retaining walls, a pedestrian overpass, water filtering devices, and the details of staged construction for the Oak Creek Bridge. Overall, the innovative construction features and management of ADOT's HfL project included the following:

- Innovative public outreach campaigns
- Innovative sequencing and staged construction techniques
- Performance contracting (lane rental)
- NBIP
- Reverse cantilever (L-shape) retaining walls
- Implementation of a new project management system
- Pilot program to train local law enforcement personnel
- Lightweight fill (foamed concrete)
- Innovative oil/sediment filtering system for storm drain system next to Oak Creek
- Prefabricated bridge components

Reconstruction of SR 179 was a great success, and ADOT was able to meet the HfL project performance goals on safety, construction congestion, quality, and user satisfaction.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
(none)	Mil	25.4	micrometers	μm
in	Inches	25.4	millimeters	mm
ft	Feet	0.305	meters	m
yd	Yards	0.914	meters	m
mi	Miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	Gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	Ounces	28.35	grams	g
lb	Pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela per square meter	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	Poundforce	4.45	Newtons	N
lbf/in^2 (psi)	poundforce per square inch	6.89	kiloPascals	kPa
k/in^2 (ksi)	kips per square inch	6.89	megaPascals	MPa
		DENSITY		
lb/ft^3 (pcf)	pounds per cubic foot	16.02	kilograms per cubic meter	kg/m^3
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
μm	Micrometers	0.039	mil	(none)
mm	Millimeters	0.039	inches	in
m	Meters	3.28	feet	ft
m	Meters	1.09	yards	yd
km	Kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	Hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	Milliliters	0.034	fluid ounces	fl oz
L	Liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	Grams	0.035	ounces	oz
kg	Kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	Lux	0.0929	foot-candles	fc
cd/m^2	candela per square meter	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	Newtons	0.225	poundforce	lbf
kPA	kiloPascals	0.145	poundforce per square inch	lbf/in^2 (psi)
MPa	megaPascals	0.145	kips per square inch	k/in^2 (ksi)

ACKNOWLEDGMENTS

The project team would like to acknowledge the invaluable insights and guidance of the 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 the approach and the technical matter for this document. The team is also indebted to Arizona Department of Transportation (ADOT) Project Manager Carl Burkhalter and Brandon DeCarlo, who were instrumental in making this project a success, and Karen King of the FHWA Arizona Division for her tireless effort in coordinating activities with HfL and ADOT.

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ABBREVIATIONS AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
dB(A)	A-weighted decibel
DOT	department of transportation
FHWA	Federal Highway Administration
HfL	Highways for LIFE
IRI	International Roughness Index
NBIP	needs-based involvement plan
OBSI	onboard sound intensity
OSHA	Occupational Safety and Health Administration
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SI	sound intensity
SRTT	standard reference test tire

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 has issued open solicitations for HfL project applications annually since fiscal year 2006. 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 1 year 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 Arizona Department of Transportation (ADOT) HfL demonstration project, which involved a needs-based involvement plan (NBIP) for reconstruction of SR 179 from milepost 310.5 to 313.8, including a portion of SR 89A from milepost 374.0 to 374.2, in Sedona, AZ. The report presents project details relevant to the HfL program, including use of innovative staged construction of roundabouts and the Oak Creek Bridge, prefabricated bridge components, innovative retaining walls, new Stormcepters, foamed concrete, performance-based contracting, and lane rental to keep traffic flowing during construction. The report also includes HfL performance metrics measurement and economic analysis. In addition, technology transfer activities that took place during the project and lessons learned are discussed.

PROJECT OVERVIEW AND LESSONS LEARNED

Project Overview

ADOT's HfL project consisted of reconstruction of a 3.5-mi segment of SR 179 from milepost 310.5 to 313.8 (junction with SR 89A), which included part of SR 89A from milepost 374.0 to 374.2, in Sedona. SR 179 passes through one of the most pristine and unique scenic areas in the world (figure 1). The project included the only bridge over Oak Creek, a designated unique and protected waterway. The economy of this incredibly beautiful area is driven primarily by tourism, with annual visitation in the 3 to 4 million range.

Figure 1. Scenic areas surrounding the SR 179 corridor.

In this tourist-oriented economy, services and trade provide 70 percent of the total employment in the area. SR 179 is the only route connecting the business and residential communities of the village of Oak Creek and the city of Sedona. In addition, SR 179 provides an important intercity link for residents, commuters, and commercial traffic in the Sedona–Verde Valley region.

After exploring many alternatives and evaluating the project and user costs, ADOT chose to consult with the residents and businesses in the community for the reconstruction of SR 179 through the NBIP process. ADOT initiated the NBIP to design and reconstruct SR 179 by using the context-sensitive design process to seek community input, thoughts, and ideas before the project began. Reconstruction of SR 179 in northern Arizona was a great success, and ADOT was able to complete the project while maintaining a steady flow of traffic and achieving user satisfaction.

Strategies that helped ADOT achieve its goal included the following:

- Implementation of a comprehensive public outreach campaign to keep residents and businesses informed of construction progress and traffic impacts. This process went beyond conventional public meetings, resulting in a more informed and cooperative public. This included an aggressive tourist education and notification effort that informed visitors how to get around in Sedona and Oak Creek during the construction period.

- Dramatically minimizing traffic disruptions and maintaining continuous traffic flow through careful construction sequencing of the roundabouts (by building half of the roundabouts at a time) and staged construction of Oak Creek Bridge. The project strived to continuously maintain business access throughout the construction period by constructing half of the driveways at a time instead of blocking the entire stretch with construction.

- Implementation of performance-based contracting through lane rental that discouraged lane closures and encouraged the contractor with financial incentives to keep one lane in each direction of traffic open at all times.

- Consultation with residents and businesses on the design and reconstruction of SR 179 through the NBIP process and the use of context-sensitive solutions to seek input and feedback before the project began.

- The use of L-shaped cantilever walls to minimize right-of-way impacts and total takes of residences.

- Implementation of a new project management system that enabled the same project team to work with the community during all phases of project development, design, and construction.

- Implementation of an innovative pilot program to train local law enforcement on enforcing the laws in and around the construction zone.

- Use of foamed concrete (lightweight fill) to reduce the dead load on an existing box culvert. This allowed extension of the existing box culvert at Morgan Wash rather than building of a new one. Building a new box culvert would have been expensive and time consuming and had a greater traffic impact on the traveling public.

- Installation of two innovative water filtering devices (Stormcepters®) at the Oak Creek Bridge. These devices help separate particles, free oils, and suspended solids from the storm water before it is outleted into Oak Creek.

- Incorporation of prefabricated bridge components to accelerate the construction of the Oak Creek pedestrian bridge and to lessen the impact of construction on the traveling public.

Data Collection

Safety, construction congestion, quality, and user satisfaction data were collected before, during, and after construction to demonstrate that an NBIP, innovative staged construction, and performance-based contracting with lane rental can be used to achieve the HfL performance goals in these areas.

For ADOT, safety of the workers and the traveling public was more than a performance goal; it was a requirement. ADOT's efforts to reduce the rates for work zone crashes and worker injuries and to improve the safety of the traveling public began before construction commenced. ADOT's extensive outreach and community involvement efforts through the NBIP process created a safer and quicker construction schedule with the least amount of disturbance to the surrounding roadway, right-of-way, and community economy, which is heavily based on tourism.

Through the NBIP process, ADOT was able to establish an extensive and continuous dialogue with the community. The community's participation in the project was solicited through interactive activities and events, educational forums, surveys, booths, newsletters, an extensive Web site, and a variety of other media efforts. The need for safety was a major community focus, which resulted in the development of many safety features for the project. During construction, ADOT project management collaborated with the contractors on extraordinary steps to assure that crashes were kept to a minimum, traffic flowed continuously, and businesses and residents were satisfied.

The many safeguards put in place to prevent crashes during construction were effective and paid huge dividends. These included procuring and training additional local law enforcement during the construction period. The number of officers in the work zone was doubled to calm and slow travelers approaching the work zone and throughout the project. Other effective measures included a monthly report by the contractor on the number of crashes and measures taken to eliminate future incidents. A review of individual incidents showed that only a few minor rear-end crashes occurred in the vicinity of the project corridor. ADOT reported, however, that none of the crashes could be attributed to the construction activities. The post construction crash statistics indicate that the safety performance of the facility greatly improved after construction with significant reduction in injury rates.

The performance goal ADOT established on motorist delay was monitored through a performance-based contracting method known as lane rental. To encourage the contractor to maintain two-way traffic during construction, ADOT set aside $400,000 as a lane rental fee for the duration of the project. For every minute that the contractor did not maintain two-way traffic, it was charged a rate between $20 and $100 a minute. This created a disincentive to not maintain two-way traffic. At the end of the project, the total disincentive charges were subtracted from the $400,000 and the remaining amount was given to the contractor, creating the incentive to minimize the amount of closures.

During the project planning stages, ADOT began an aggressive and comprehensive effort to communicate with affected residents and businesses along the project corridor to keep them abreast of all activities during pre- and postconstruction of SR 179. User satisfaction surveys distributed by ADOT clearly demonstrated a high level of public satisfaction with the construction approach and the final product. ADOT greatly exceeded the HfL customer satisfaction expectation by a large margin.

Lessons Learned

The reconstruction of the 3.5-mi stretch of the SR 179, including the construction of six roundabouts and the removal and replacement of the Oak Creek Bridge, was a great success. It resulted in a quality project that was completed while maintaining mobility and reducing impact on tourists, residents, and businesses. Through this project, ADOT gained insight on using innovative construction features and public outreach practices and learned many valuable lessons that can be incorporated into similar projects in the future.

Conclusions

From the standpoint of the final product, community satisfaction, quality, and safety of workers and motorists during construction, the ADOT project was a great success and exemplified the principles of the HfL program. ADOT learned that the implementation of a comprehensive public outreach campaign, the use of proven innovative construction techniques, maintenance of a cohesive management team from design through construction , and a commitment to continuously maintain traffic resulted in an award-winning project that the community and local stakeholders could be proud of. The as-built alternative took longer to develop through the NBIP process and had higher construction costs and more challenging phased construction, while the baseline case could have been cheaper. However, intangible benefits were realized through project development with the NBIP process with a higher quality project that fits in the context of the community and environment. A post construction stakeholder survey conducted by ADOT clearly demonstrated the satisfaction of the local residents and businesses with the construction approach and the final product.

PROJECT DETAILS

BACKGROUND

The North Forest Boundary project is located on existing SR 179 from milepost 310.5 to 313.8 (junction with SR 89A), which includes a portion of SR 89A from milepost 374.0 to 374.2, in Sedona (figure 2).

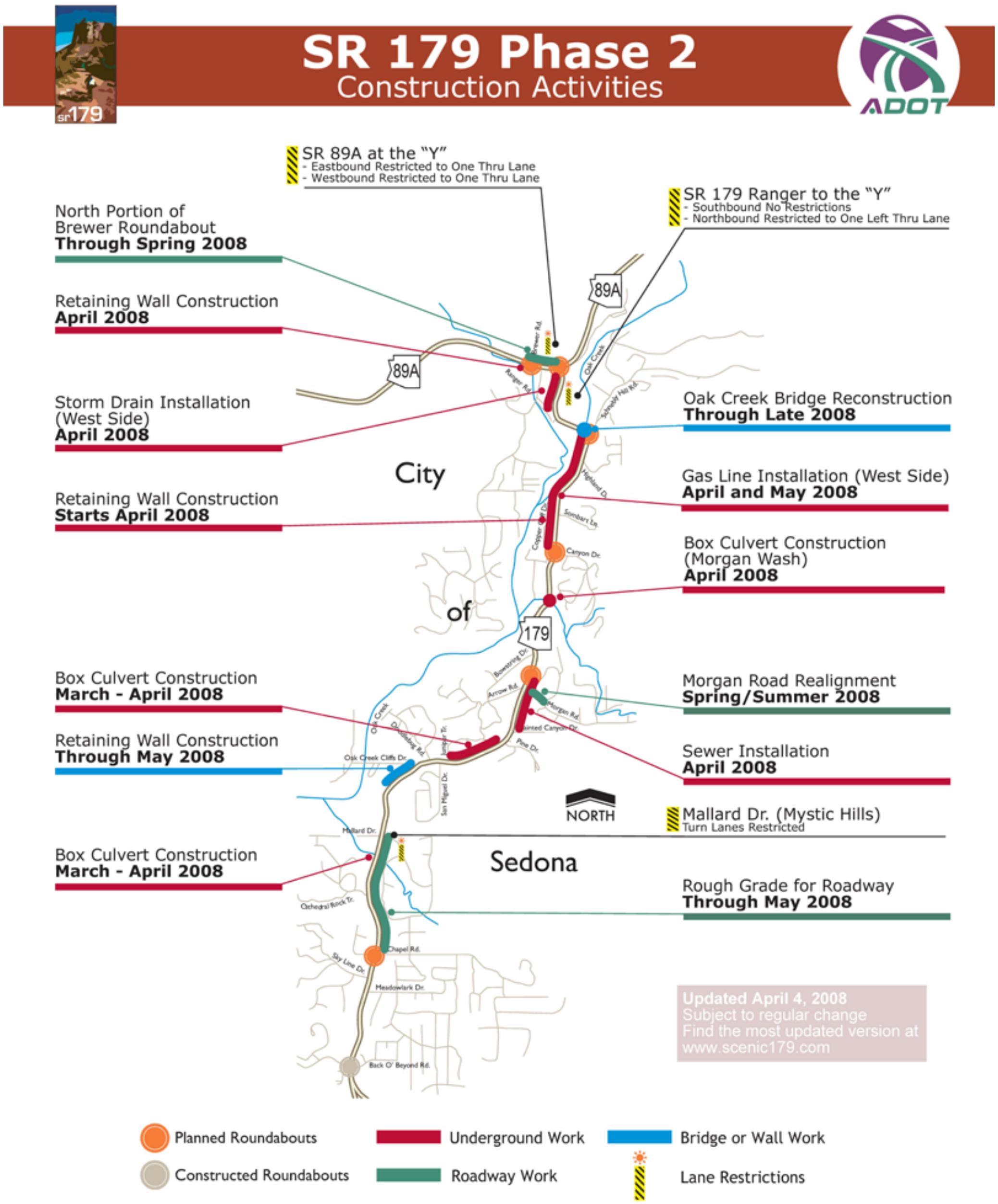


Figure 2. SR 179 project boundary.

The existing SR 179 is functionally classified as an urban principal arterial and is a two-lane undivided highway with no shoulders or dirt shoulders at some locations. Figure 3 shows the existing SR 179 looking north at Meadowlark Drive. Safety concerns coupled with the lack of roadway capacity to accommodate multimodal use by motorists, pedestrians, bicyclists, and an overwhelming amount of visitor traffic prompted ADOT to address the deficiencies of the entire 9-mile corridor. In response to the community's need and to conserve the unique scenic nature of the area, ADOT initiated a comprehensive, two-phase project between the village of Oak Creek and the junction of SR 89A.

The North Forest Boundary–Sedona project is the second phase of the overall project, which covers SR 179 from milepost 310.5 to 313.8 (junction of SR 89A) and includes a portion of SR 89A from milepost 374.0 to 374.2.

Figure 3. Existing SR 179 looking north at Meadowlark Drive.

PROJECT DESCRIPTION

The second phase of the Sedona project consisted of widening the existing undivided two-lane highway to a two-lane divided highway with raised median. The northbound and southbound lanes were constructed with an 8-foot (ft) paved shoulder along with several dedicated right and left turn lanes to keep the through-lane traffic moving. Six roundabouts were constructed at the major intersections (two two-lane and four single-lane). Two local crossroads were realigned to consolidate access points at the Arrow and Morgan roundabouts. Curbs and gutters were established along the entire project.

A designated, signed, and striped 5-ft-wide bike lane was installed in the 8-ft shoulders. Sidewalks and/or pedestrian pathways with dedicated transit stops were established along the entire corridor. Many parts of the old alignment were graded to create a more level highway at this mountainous 4,200-ft elevation. The new roadway was surfaced with rubberized asphalt. The 2003 average daily traffic (ADT) for the SR 179 ranged from 14,000 at the village of Oak Creek to 21,000 at the junction of SR 89A. Truck traffic is estimated at 4.5 percent of the total daily traffic during the weekdays and about 2 percent during the weekends.

ADOT included many innovative but proven technologies and techniques to accelerate reconstruction of SR 179, six roundabouts, and the Oak Creek Bridge while addressing the many environmental issues associated with the project and minimizing the inconveniences to the neighboring residents, businesses, and tourists. ADOT's goals were to maintain one lane of free-flowing traffic in each direction of SR 179 throughout the construction zone, minimize traffic interruptions and queue lengths and, most important, improve safety, quality, and user satisfaction. The innovative features and accelerated construction elements of the ADOT HfL project included the following:

- Innovative public outreach campaigns
- Innovative sequencing and staged construction techniques
- Implementation of an innovative pilot program to train local law enforcement
- Implementation of a new form of project management
- Lane rental incentive/disincentive clauses
- Foamed concrete
- Innovative water filtering devices
- Reverse cantilever L-wall style retaining wall
- Use of prefabricated bridge components

These innovative elements are described in the following subsections.

Innovative Public Outreach Campaigns

One of the key elements of the success of the SR 179 project was an unprecedented degree of public involvement at the community level. During the planning and construction phases of the project, ADOT proactively engaged in an outreach program that effectively kept the residents, businesses, and commuters along SR 179 corridor abreast of all construction activities.

Long before any heavy equipment or construction crews arrived on the jobsite, ADOT, through the NBIP process and the use of context-sensitive solutions, consulted with the residents and businesses on the design and reconstruction of SR 179 and obtained their input and feedback. For the most part, this process eliminated reworks, redesigns, and change orders. This effort allowed the community to choose alternate travel times to avoid peak traffic congestion because they were kept well informed of construction activities at all times.

An interactive Web site (www.scenic179.com) played a major role in keeping residents, businesses, and tourists informed of weekly activities. Figure 4 shows the Web site for the week of January 18, 2010, allowing viewers a glance at all the activities scheduled for the week and access to other information.

Construction updates

Weekly Construction Alert
January 18, 2010

- The contractor will be working on Martin Luther King day, this Monday. No traffic restrictions are expected.
- Night work continues this week between Canyon Drive and Morgan Wash to install a 42" storm drain. Work will be from 8 p.m. to 5 a.m. There will be one lane of traffic directed by flaggers in this area.
- During the day, short duration traffic restrictions to one lane may be necessary for up to 10-minutes during wall form setting, and for equipment and truck access to the work area between Canyon Drive and Morgan Wash. Please plan your travels accordingly.
- Excavation will continue over night at the uphill and downhill retaining wall locations.

View Site Map | Contact Us

Figure 4. View of SR 179 Web site for the week of January 18, 2010.

In addition to the Web site, e-mails were sent weekly to residents and businesses to provide project updates and keep them abreast of upcoming project schedules and activities. An 800 number (hotline) was put in place to address community concerns. Once a month, a construction chat was held to allow the public to provide feedback and express likes and dislikes. ADOT's resident engineer had a monthly interview with a local radio station (figure 5) to keep citizens of

Sedona informed about the major construction activities affecting them. Figures 6 and 7 show camera crews interviewing a local policeman and a business owner about the impact of the project on the traveling public and businesses.

Figure 5. Resident engineer's interview with Sedona radio station.

Figure 6. Sedona policeman on camera.

Figure 7. A local businessman on camera.

Innovative Sequencing and Staged Construction Techniques

ADOT took a corridor-based approach and bundled the construction of the six roundabouts, retaining walls, and Oak Creek Bridge and the installation of the Stormcepters into a seamless operation that minimized inconvenience to residents, tourists, and businesses and kept continuous traffic flow in each direction.

Innovative construction sequencing of the six roundabouts (building half of the roundabout at a time) and the carefully staged construction of the Oak Creek Bridge (the only access over Oak Creek) played a major role in the overall success of the SR 179 project. Figures 8 and 9 demonstrate construction of the biggest roundabout at SR 89A and SR 179.

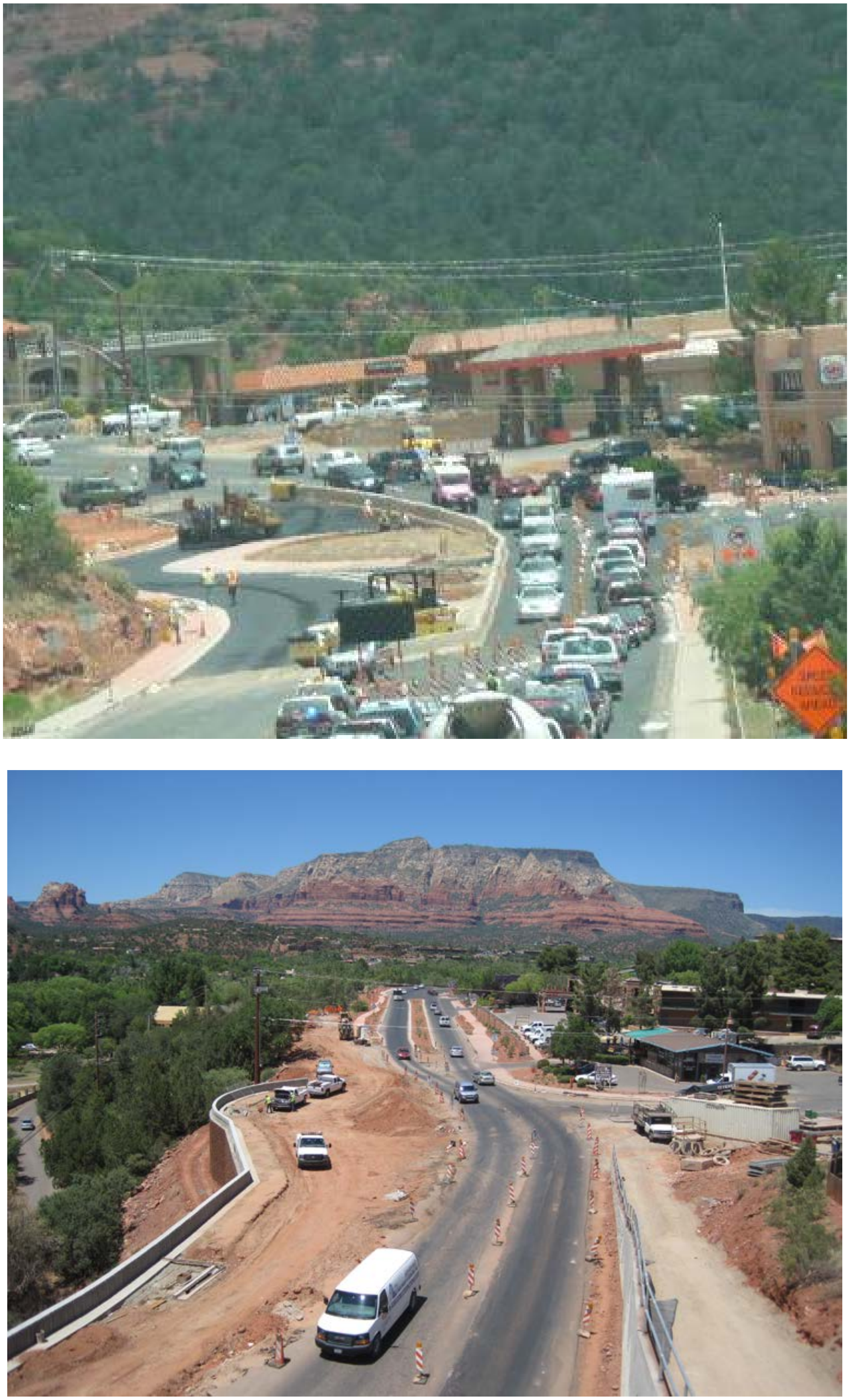


Figure 8. Half-and-half construction of roundabouts.

During Construction

After Construction

Figure 9. SR 179 and SR 89A intersection before and after construction with fully functional two-lane roundabout.

Figure 10 shows the new divided SR 179 with the completed pedestrian walkway. The median and the space next to the pedestrian walkway were landscaped with native plants in spring 2010.

Figure 10. View of reconstructed SR 179 looking north.

Lane Rental Incentive/Disincentive Clauses

ADOT learned that incorporating performance-based incentive/disincentive clauses for lane rental could encourage the contractor to minimize road user impacts during construction. Under the lane rental concept, a provision for a rental fee assessment is included in the contract. The lane rental fee is based on an estimated cost of delay or inconvenience to the road user during the rental period.

The primary objective was to award the contractor as much as of the allotted lane rental funds as possible (i.e., incentive versus disincentive). The lane rental concept was a great success, even though the contractor was not awarded any incentive from the set-aside lane rental fee of $400,000. Because of the success of lane rental, the impact on the traveling public was significantly minimized. For the most part, as ADOT mandated, one lane in each direction of traffic remained opened for the duration of the construction.

Needs-Based Implementation Plan

Working through the NBIP process with ADOT and the community were agency stakeholders, including the Big Park Regional Coordinating Council, village of Oak Creek, Yavapai County, Coconino National Forest, Federal Highway Administration (FHWA), city of Sedona, and Coconino County.

Innovation
ADOT followed an innovative approach to improving SR 179 known as a Needs-Based Implementation Plan process. The NBIP was the result of a collaborative process that evaluated existing corridor conditions and used community values and technical analysis of present and future user needs as the foundation for solutions. The process included a broad and continuous dialogue with the community and stakeholders, as well as indepth technical analysis of alternative improvement strategies. Throughout the process, ADOT solicited unprecedented input and involvement from the relevant jurisdictional agencies and community using a variety of methods to encourage participation, including interactive activities and events, educational forums, surveys, booths, newsletters, and a variety of media outreach. Public input opportunities were provided for people who had only enough time to check a Web site or complete a questionnaire as well as for those who could commit to intense participation in one of a series of three week-long charrettes. A major communications program was an integral part of the NBIP process, including innovative use of a comprehensive project Web site, an e-newsletter, and intense media outreach in addition to direct mail. Communication materials served a multitude of purposes, providing public education on basic transportation concepts and tradeoffs between alternative solutions, encouraging participation, and ensuring an informed community.

“We learned from our experiences. Solutions brought forward by previous efforts were not supported by the community,” said Jennifer Livingston, then senior project manager for ADOT. “As a result we were at a stalemate. This is a positive step forward and now we are working together to incorporate community values into improvements for SR 179 through the village of Oak Creek to the 'Y' in Sedona.” Beginning in August 2003, thousands of community comments were received and thousands participated in events and surveys, a very positive response and enthusiastic turnout.

In addition to community interviews, focus groups, educational forums, open exhibits, and workshops, a series of three multiday, collaborative charrettes was conducted to identify the complete range of planning concepts, fine tune the concepts, and select the preferred concept. Each charrette represented a major decision point for the project and provided specific direction for all subsequent work by the project team. The charrettes used a variety of techniques, including small group discussions, visual corridor characteristics surveys, comment cards, trolley talks, gaming, and prioritization exercises. One participant commented, “It is the first time in a long time in Sedona that we were able to stand shoulder-to-shoulder with people that have very different viewpoints regarding SR 179 and it didn’t end in a shouting match.”

Quality
For 2 years, two teams guided the NBIP process. The main role of the Executive Team, which included two representatives from each agency stakeholder, was to monitor the process and provide decisions at key project milestones. A Public Outreach Team, which included one representative from each agency stakeholder, served as advisors for the public outreach program, working closely with ADOT and the consultants.

All communication materials (meeting handouts, questionnaires, postcards, newsletters, e-newsletters, PowerPoint presentations, maps, exhibits, graphics, etc.) were reviewed and approved by the Public Outreach Team (citizen- and agency stakeholder-based) and Project Management Team (ADOT and consulting teams) before public use.

Aerial photographs were used for a gaming workshop during Charrette #2, during which citizens placed a wide range of "game pieces" (sidewalks, lanes, medians, pullouts, signals, roundabouts, etc.) to show their preferences. Visual simulations showed how intersections would look with roundabouts versus signals, meandering paths, lanes with medians, and bifurcation, among other techniques. Video was played at Charrette #3 to show traffic simulations of project traffic flow through the Oak Creek and at the "Y" intersection in Sedona. Artist renderings displayed the potential character of the roadway, business access, landscaping, and pedestrian crossings, depending on the alternative.

Participants in every event were asked to complete an evaluation sheet to rate the event from 1 (lowest) to 5 (highest) based on meeting location, quality of presenters, information presented, interest in the topics, and how well the event was planned and organized. Evaluations were analyzed and comments summarized, and subsequent events were planned to continuously improve on the events and the public outreach approach. On the 30-some events held over 9 months, the team received an average score of 4.6 out of a possible 5.

A complete report from each event and survey was posted on the project Web site (www.scenic179.com) for the public to access and review. Twenty-seven event reports are available online for Charrette #1. Community comments were extremely complimentary, especially on the quality of the process, events, and materials.

Implementation

The NBIP process consisted of three phases: the process definition phase, during which the project team and agency stakeholders agreed on the process flow and supporting public outreach process for the ensuing 18 months; the corridorwide framework phase; and the segment concept design phase. The corridorwide framework represented impressive community consensus on main transportation elements of the corridor, such as lane configurations, intersections types, and multimodal accommodations. The end of the segment concept design phase marked the completion of the NBIP, about a 30 percent design. Other NBIP implementation milestones included the following:

- Creation and approval of the NBIP process by all agency stakeholders and formal commitment by signature on a memorandum of understanding
- Decisionmaking process developed openly and approved before NBIP initiation
- Total team approach to the project, including internal and external partnering
- Success of community participation in terms of actual numbers and quality of the input
- Formal approval and overwhelming community acceptance of the vision and core values that set the framework for the corridor improvements
- Community creation and approval of evaluation criteria and performance measures
- Universe of planning concepts developed by the community with project team assistance

Before initiation of the NBIP process, community and agency trust of ADOT was at an all-time low. Trust has been restored between the government agencies and the community, as well as among the agencies. The potential consequences of not implementing a collaborative process were staggering. The process proved that open communication and committed leadership are keys to successful working relationships, which save time and money on projects.

Maintaining a comprehensive and ongoing public outreach program ensured that transportation planning initiatives were implemented in an equitable manner. Also, the Executive Team structure ensured that impacts on any one community or area would not be disproportionate with impacts elsewhere. One of the critical roles the Public Outreach Team served was to ensure that all community members were involved and, more important, that all viewpoints were recognized. After every public event, the Public Outreach Team discussed the participation and input received . It constantly reviewed and improved strategies for public outreach efforts to ensure maximum participation.

The Executive Team was involved at every step in the process, providing approval of the NBIP process, the vision and core values, the evaluation criteria and process, the preferred planning concept, and the final corridorwide design framework. At the completion of the NBIP in November 2004, it approved the segment concept design plans, the NBIP, and the access management and corridor management plans.

Comprehensiveness

Public and stakeholder involvement was not an afterthought in the SR 179 project as it is in many public agency planning studies. The government agencies with jurisdictional responsibility along the corridor were involved from the genesis of the project. The scope of work for the corridor development and public outreach consultants was prepared in an intense collaborative effort with the agencies. In addition, representatives of the various agencies sat on the selection panels for both consultant contracts. The coordination of the multiple agencies was comprehensive and remained strong throughout the NBIP process.

Community involvement led the technical development of the NBIP, and the public had primary responsibility for the creation of the preferred planning concept. Instead of reacting to an alternative, the public created the alternative. To ensure that the public and stakeholders had the tools to develop a buildable plan, ADOT, agency stakeholders, and the consulting teams implemented a comprehensive education and public involvement program. Success of this involvement process required the ability to communicate complex technical terms and concepts in ways the general public would understand. Also, careful attention was given to creating events and techniques that would result in the appropriate type of input at the appropriate time in the process. Being committed to a comprehensive and open process and ensuring milestone decisions were made resulted in minimal backtracking on ideas, concepts, and solutions as the project evolved and new participants entered the process.

Project communications were regularly distributed to every household in the community (about 15,000) as well as to individuals outside the community who expressed interest via mail, the project Web site, and newspaper inserts. A comprehensive database of about 3,000 names evolved throughout the process as participants signed up.

Significance
The SR 179 NBIP process was coordinated with several local and regional transportation studies. The Uptown Sedona Enhancement Project, which included a traffic circulation study that directly connects to SR 179; the Sedona Transit Study; and the Yavapai County Regional Transportation Study were conducted simultaneously. The NBIP process was also coordinated with a gasline siting project in the corridor and the development of a Forest Service Information Center. The SR 179 NBIP process was also coordinated with access management and corridor management plans for the SR 179 corridor. The processes were woven together, but resulted in separate documents. Coordination of these studies maximized resources, staffing, and public involvement while not confusing the public about the various processes.

As a result of the successful collaborative effort, the NBIP process held up as a model for future local and regional planning processes by ADOT, the counties, FHWA, and the Forest Service. The NBIP public dialogue also renewed community discussions on innovative and sometimes controversial issues and fostered a belief that if consensus could be reached on a solution for SR 179, the area could tackle any community issue in a positive, collaborative manner.

Reverse Cantilever L-Wall Style Retaining Wall

Figure 11 shows a section view of a reverse cantilever L-wall style retaining wall.

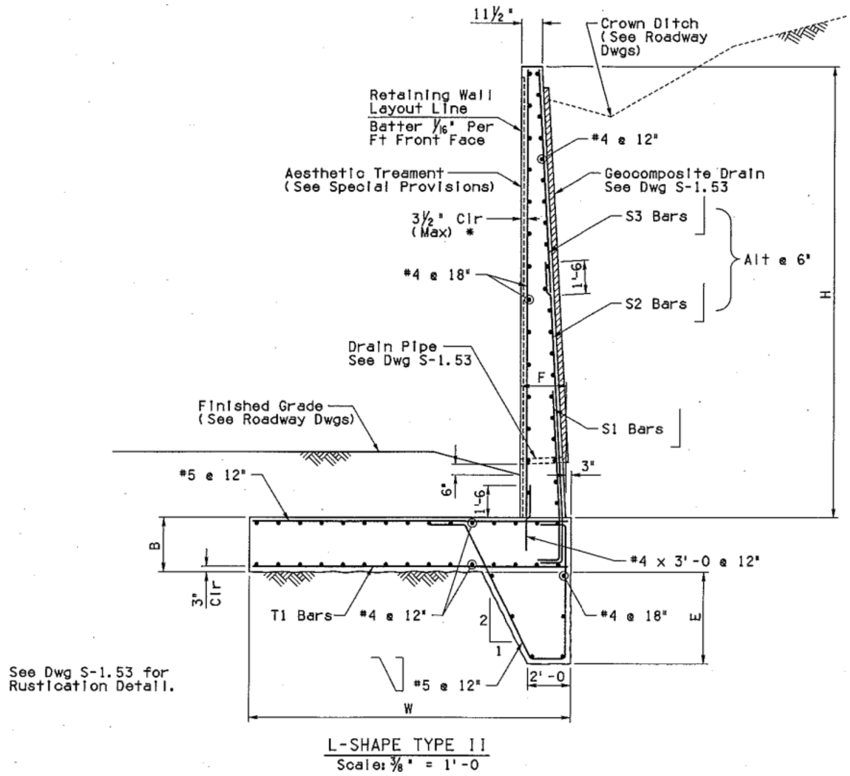


Figure 11. Typical reverse L-wall style retaining wall.

A reverse cantilever L-wall style retaining wall was installed at select locations to minimize right-of-way impacts and excavation limits while providing a durable, functional, and aesthetically pleasing retaining wall (see figure 12). This type of wall design reduced right-of-way impacts and eliminated the total taking of multiple residences in the corridor.

Figure 12. L-walls minimized right-of-way impacts.

Implementation of a New Form of Project Management

One of the key success factors in the SR 179 project was the fact that ADOT kept the same project team for the duration of the project to work with the community during all phases of design, development, and construction. Typically, a project is handed off to different teams for planning, design, and construction. Having the same team for the duration of the project minimized questions that can arise during construction on the intent of the design and resulted in the project being constructed more efficiently and cost-effectively, lessening the impact on the neighboring community, businesses, and traveling public.

Implementation of Innovative Pilot Program to Train Local Law Enforcement

ADOT implemented an innovative pilot program to train local law enforcement personnel on enforcing laws in and around the project construction zone. The 1-day training class educated officers the on hazards of working in a construction zone, traffic calming techniques, public awareness, and ADOT's expectations. In addition, ADOT hired additional law enforcement officers to provide a visible presence throughout the project. In fact, the typical number of officers was doubled, and they were positioned at strategic locations throughout the work zone, not just at the beginning, which is normally the case. This drew the attention of the traveling public, promoted slower speeds, and improved work zone safety for everyone.

Foamed Concrete (Lightweight Fill)

Foamed concrete was used to raise the vertical profile of the existing box culvert at Morgan Wash. The use of this innovative material was necessary to reduce the dead load on the existing culvert. The structural capacity of existing culvert was not adequate to support the weight of the additional concrete necessary to raise the roadway.

The foam concrete weighs 33 pounds per cubic foot (lb/ft^3), much less than conventional concrete at about 150 lb/ft^3. Figure 13 demonstrates the lightness of the foamed concrete.

By using foamed concrete, ADOT was able to eliminate the need for and expense and time-consuming effort normally associated with subexcavation, removal, and replacement of the existing culverts. In addition to saving money and time, ADOT was able to build a long-lasting infrastructure, substantially accelerate the construction, and reduce the impact on the traveling public.

Figure 13. Demonstrating the lightness of a 4x8-in foamed concrete cylinder.

Innovative Oil/Sediment Filtering Devices

Oak Creek is a waterway that runs alongside SR 179 in Sedona. Because Oak Creek is designated as a "unique waterway," ADOT took extraordinary measures to maintain the water quality during and after construction. During the construction of the new bridge and demolition of the old one, the creek was temporarily diverted and the quality of the water monitored at key locations. During construction, ADOT installed four innovative oil/sediment filtering devices as a pilot on this project. To the project team's knowledge, these were the first oil/sediment filtering devices installed on an ADOT facility.

Sets of two oil/sediment filtering devices were installed at two different locations (figures 14 and 15) to filter the water from Oak Creek runoff and roadway runoff. The oil/sediment filtering device (trade name Stormcepter) is a precast concrete system designed to capture and remove a wide range of particle sizes as well as well as free oils and suspended solids from storm water.

Figure 14. Stormcepters before installation.

The system is a patented scour-prevention technology that ensures pollutants are captured and contained. Although this is a new application for ADOT, the Stormcepter equipment has undergone a vigorous field and laboratory investigation in the industry.

Figure 15. Stormcepters after installation at Morgan Wash.

Prefabricated Bridge Components

The entire pedestrian/utility bridge was prefabricated in Phoenix using a clear span weathering steel truss so that all utilities (wet and dry) can be relocated to it. The bridge was delivered to the jobsite and was secured at either end to abutments.

The abutments for the bridge were constructed before the prefabricated bridge was moved to its final position. These abutments were supported at one end by a drilled shaft and at the other end by a spread footing. Figure 16 shows the front of the west abutment wall, and figure 17 shows the new pedestrian bridge and the relocated utilities from the existing Oak Creek Bridge.

Figure 16. Front view of the pedestrian bridge abutment.

Figure 17. The utilities and the prefabricated pedestrian bridge.

Figure 18 shows the existing Oak Creek Bridge during construction. All utilities (wet and dry), including water, gas, electrical, cable, telephone, and sewer, were relocated to the new pedestrian bridge. This allowed the demolition of the existing vehicular bridge without any conflicts with utility relocation or lengthy impact on traffic flow.

Figure 18. Existing Oak Creek Bridge during construction.

Figures 19 and 20 show the plan and elevation view of the pedestrian bridge. As shown, the east abutment is supported by a spread footing and the west abutment is supported on a drilled shaft.

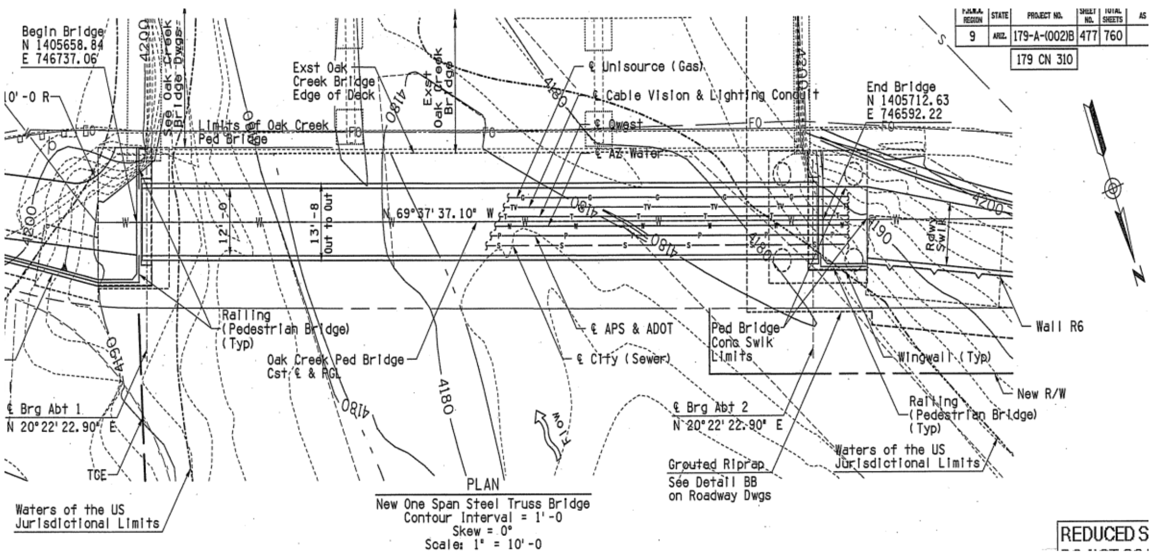


Figure 19. Plan view of the prefabricated pedestrian bridge.

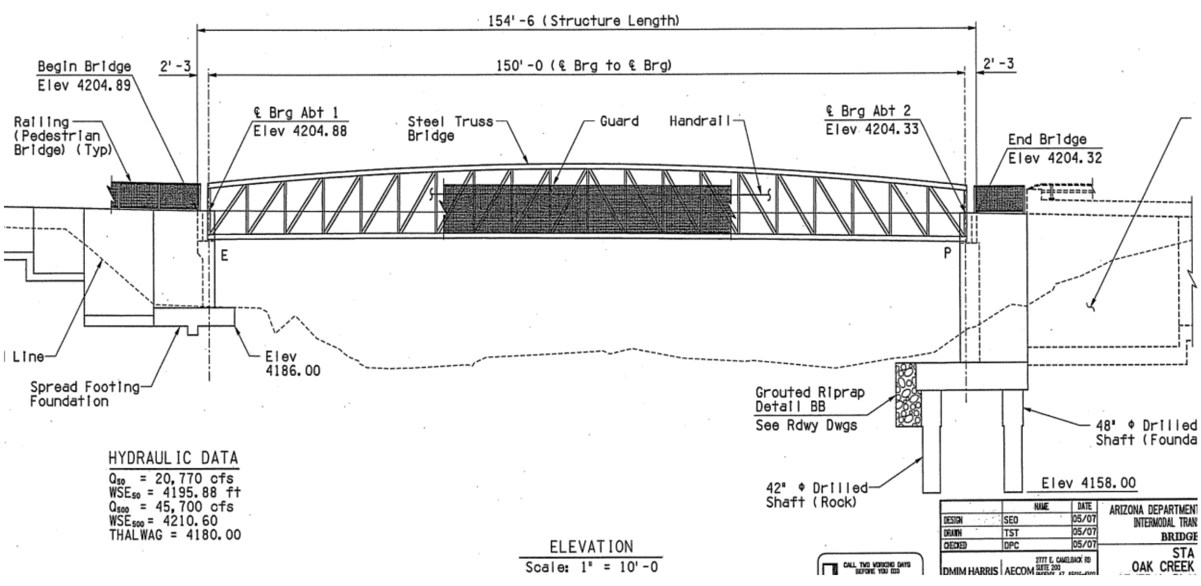


Figure 20. Elevation profile of the prefabricated pedestrian bridge.

Other utility relocation options that were proposed and investigated included boring under Oak Creek, which would have been extremely expensive for the six affected utilities as well as environmentally disruptive. This was ADOT's first attempt to build a joint pedestrian/utility bridge in Arizona. The new Oak Creek Bridge was realigned to a 135-degree curve to smooth out the 90-degree bend at the Schnebly Hill Road intersection. Figures 21 through 23 show the typical sections (spans 1 through 3) and plan view of the new Oak Creek Bridge.

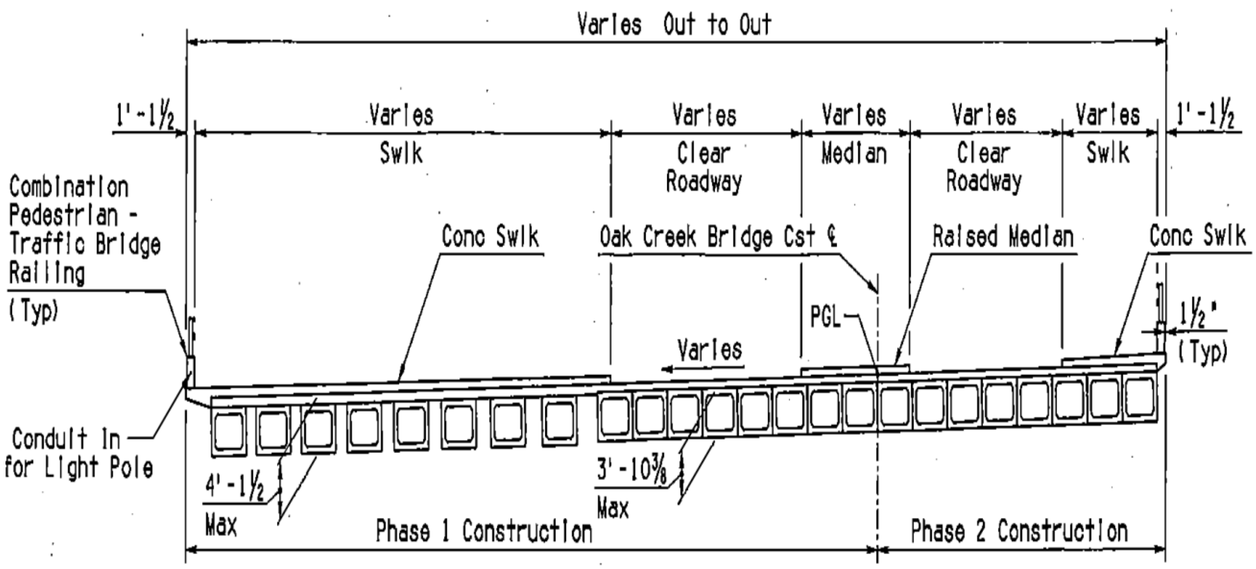


Figure 21. New Oak Creek Bridge typical section (span 1.)

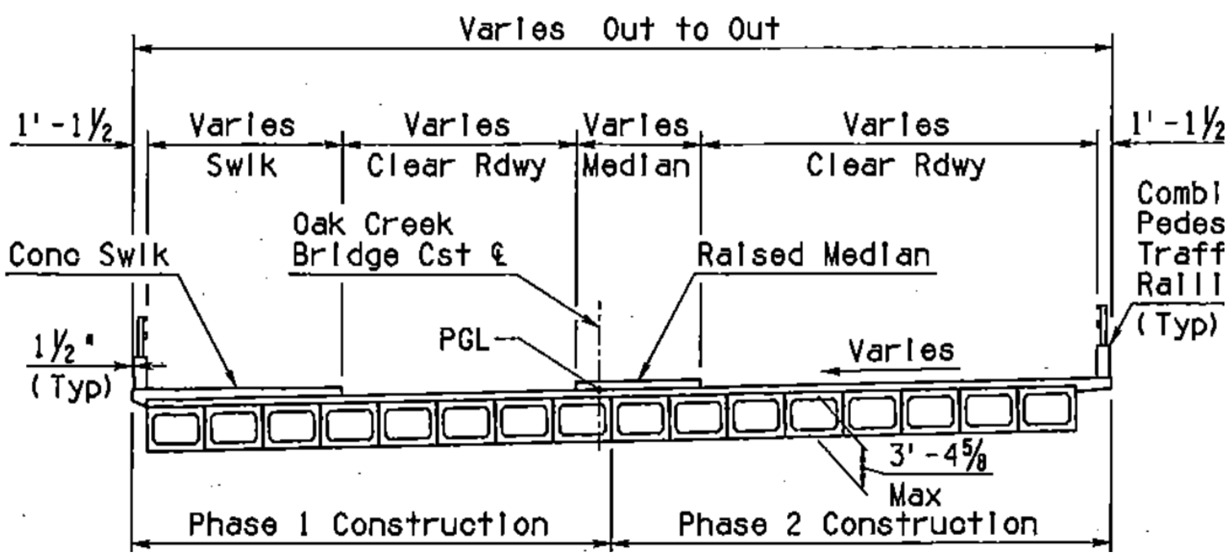


Figure 22. New Oak Creek Bridge typical sections (spans 2 and 3).

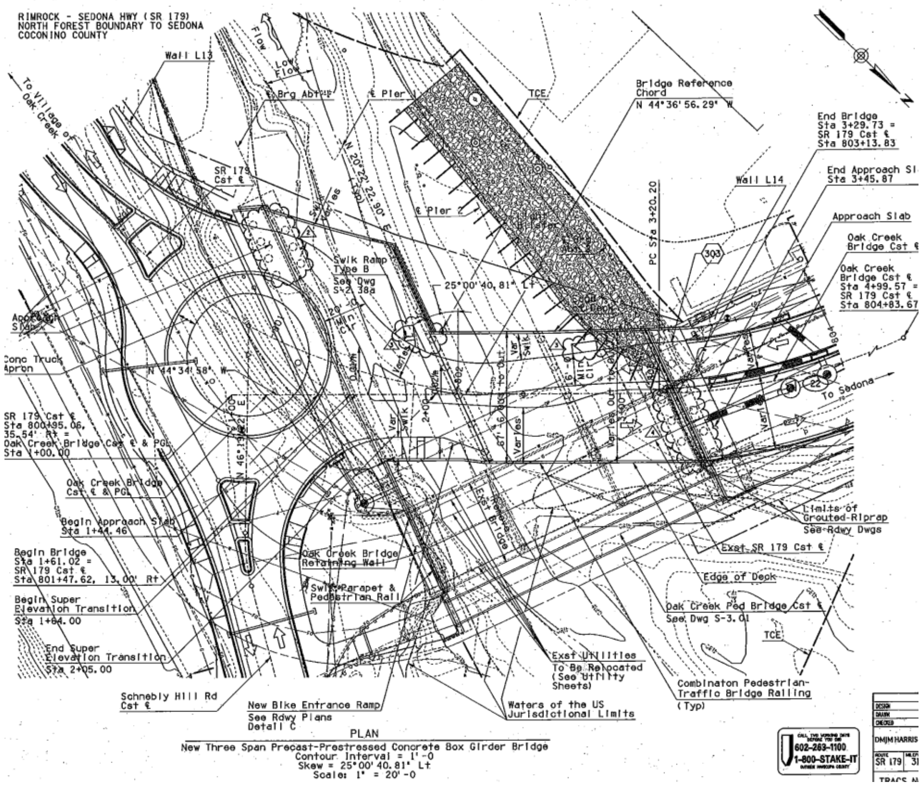


Figure 23. Plan view of the new roundabout and Oak Creek Bridge.

Construction of the first and second phases of the new Oak Creek Bridge is shown in figures 24 and 25.

Figure 24. Construction of the first phase of the new Oak Creek Bridge (prefabricated pedestrian bridge already constructed in the background).

Figure 25. Construction of the first phase of the new Oak Creek Bridge with the already-built pedestrian/utility bridge in the background.

The pedestrian experience was also enhanced with an underpass. Saving the native trees was one of ADOT's main concerns. As figure 26 shows, during the construction of the pedestrian underpass, ADOT saved the trees by laying the sidewalk around them.

Figure 26. The pedestrian underpass and the saved trees.

DATA ACQUISITION AND ANALYSIS

Data collection on the ADOT 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. It was also done to demonstrate that an innovative sequencing process and carefully staged construction coupled with the use of prefabricated bridge components and performance-based incentive/disincentive clauses (lane rental) 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 flexibility offered to the contractor.
- Produce greater user satisfaction.

This section discusses how well the ADOT 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 ADOT, safety of the workers and the traveling public was job number one and began before the construction commenced. All site personnel, field crews, designers, inspectors, and owner's representatives received site-specific orientation and safety training before working on this project. ADOT's outreach through the NBIP process created a safer and quicker construction schedule with the least amount of interference with traffic flow and the least amount of disturbance to the businesses, surrounding roadway, and right-of-way.

During the reconstruction of the SR 179 roadway, a few worker injuries were reported, but they were minor. Six incidents were reported over a 2-year period (i.e., 0.25 incidents per month). 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).

The safety of the traveling public was of concern. ADOT's foremost solution was to minimize traffic disruption and interaction with construction activities and workers. The crash history for the 5-year period between May 1, 1998, and April 30, 2003, showed a total of 245 crashes, 134 of which were rear-end crashes. The crash breakdown was as follows: 77 percent noninjury, 11 percent possible injury, 9 percent nonincapacitating, 1 percent incapacitating, zero fatal, and 2 percent unknown.

During construction, the contractors took extraordinary steps to assure that crashes were kept to a minimum. The many safeguards ADOT put in place to prevent incidents during construction were effective. These included implementation of an innovative pilot program to train local law enforcement personnel on enforcing laws in and around the project construction zone. ADOT also hired additional law enforcement officers (doubling the number of officers) for their visible presence throughout the project. Other effective measures included open houses, regular news releases, a dedicated phone line, and a Web site.

ADOT Traffic Records Group gathered crash data for pre, during and post construction periods. The crash data was collected for a total of 3.5 miles (SR 179 from milepost 310.5 to 313.8 and SR 89A from milepost 374.0 to 374.2 (intersection with SR 179). Table 1 presents the crash statistics by KABCO scale (a measure of the functional injury level of the victim at the crash scene) collected for pre and during construction periods. As indicated in table 1, the number of crashes during construction for all severity types except injury possible (C) type were almost the same as preconstruction statistics. Table 2 presents the crash data (by severity type) for the facility after construction.

Table 1. Crash statistics for preconstruction and during construction periods.

Crash Type	Preconstruction	During construction
Fatal (K)	0	0
Incapacitating (A)	2	0
Injury evident (B)	22	12
Injury possible (C)	27	4
Property damage only (O)	189	101
Date (Days) of coverage	5/1/1998 to 4/30/2003 (1,826)	2/11/2008 to 9/27/2010 (960)

Table 2. Post construction crash statistics.

Crash Type	Post construction			
Year of coverage	2010	2011	2012	Total
Days of coverage	365	365	365	1095
Fatal (K)		1		1
Incapacitating (A)	1	0	1	2
Injury evident (B)	5	0	2	7
Injury possible (C)	1	3	6	10
Property damage only (O)	37	31	51	119

The safety performance of the facility after construction was evaluated using pre and post construction crash rates. Table 3 shows the crash rates by severity type for both pre and post construction periods. As indicated in table 3, the total crashes decreased marginally by 4 percent after construction; the injury rates significantly decreased by 62 percent, while the property damage rates increased marginally by 4 percent. There was only a single fatal event after construction. The safety of the facility has improved after construction, while the HfL goal of twenty percent reduction in fatalities and injuries was fully achieved.

Table 3. Crash rates for pre and post construction periods.

	Preconstruction	Post construction	Difference
Days of coverage	1826	1095	
Section length (mi)	3.5	3.5	
Average ADT	14000	14086	
Million vehicle miles travelled	89.47	53.98	
Total crashes	2.68	2.57	-4%
Fatalities	0.00	0.02	100%
Injuries	0.57	0.35	-62%
Property damage only	2.11	2.20	4%

CONSTRUCTION CONGESTION

Expedited construction is a key HfL performance goal that specifies a 50 percent reduction in the time highway users are impacted during construction compared to traditional practices. ADOT believes that through innovative construction sequencing of the six roundabouts (building half of the roundabout at a time), carefully staged construction of the Oak Creek Bridge, and the use incentive/disincentive contract clauses (lane rental), it was able to dramatically reduce the impact of construction activities on neighboring residents, businesses, tourists, and roadway users.

TRAFFIC STUDY

To assess the impact of the construction project on motorists, researchers used the floating vehicle methodology to collect travel times, attempting to mimic the typical driving speed of other vehicles along the various roadway segments of the detour route. Data were collected in April 2008 during daytime hours because traffic demands were lower at night and any effects of the total roadway closure would be smaller. Specifically, data were collected in the a.m. peak (7 to 9 a.m.), noon (11 a.m. to 1 p.m.), and p.m. peak (4 to 6 p.m.) periods. Because of significant tourist traffic on this facility, data were collected on weekdays (Thursday and Friday) and on weekends (Saturday and Sunday). The project was already underway when data were first collected, so no preconstruction data could be obtained. However, researchers used a previously-prepared traffic report to estimate preconstruction travel times.

Figure 27 illustrates the limits of the project. Travel times were obtained between Back O' Beyond Road to the south and the SR 179/SR 89A intersection to the north.

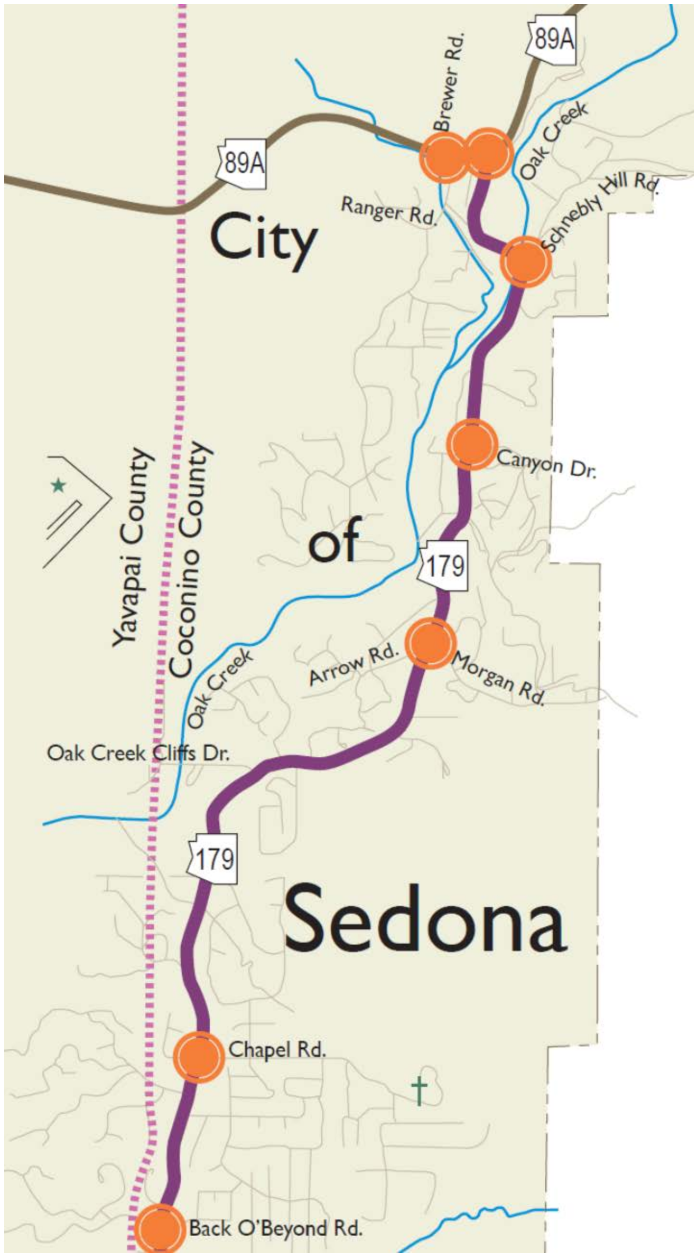


Figure 27. Limits of travel time study.

Travel times in each direction were averaged across four to six runs in each of the six time periods (weekday a.m., noon, and p.m. and weekend a.m., noon, and p.m.). These average travel times are shown in table 4.

Table 4. Travel times, April 2008.

Time Period	Northbound Travel Time (minutes)	Southbound Travel Time (minutes)
Weekday:		
a.m.	8.8	8.2
noon	15.0	9.1
p.m.	16.4	9.5
Weekend:		
a.m.	7.4	7.0
noon	9.7	8.1
p.m.	9.4	7.5

Average travel times ranged from 7.4 to 16.4 minutes northbound and from 7.0 to 9.5 minutes southbound. These correspond to average speeds between 30 miles per hour (mi/h), the approximate posted speed limit on the roadway, and 13 mi/h. Weekday travel times tended to be greater than those on the weekend, despite expectations that weekend traffic conditions would be worse because of higher tourist traffic volumes on Saturday and Sunday. Data collection staff noted indicate that weekday noon and p.m. travel times were occasionally delayed by flagging operations. However, a review of the travel time data indicated that such delays were limited to 30 seconds or less.

The biggest influence on northbound travel times did appear to be the traffic signal at the SR 179/SR 89A intersection. The northbound direction at the signal gradually became oversaturated and resulted in lengthy queues in the weekday noon and p.m. time periods. However, this type of backup did not occur on the weekends, so it is possible that weekday construction activities at the north end of the project had some confounding effects on the signal.

Delay Analysis Results

The lack of preconstruction data created a challenge in determining what impacts the project had on motorist delays. A 2004 traffic study suggested that the intersection signal at SR 179/SR 89A generated an average of 20 seconds of additional delay per vehicle during the Saturday p.m. peak period. However, the report did not provide additional insights on total corridor travel times that existed before construction. The report's age also made it difficult to draw solid inferences on travel time impacts of the project.

The general traffic-handling scheme used for the project would be expected to cause only minimal additional traffic delays because the number of lanes that existed before construction was maintained during construction. However, interactions between work activities at the north end of the project and the operation of the traffic signal may have caused some additional delay during weekdays (based on the extent of low-speed operations observed on weekdays at the north end of the project). As a conservative estimate, it is suggested that the average weekend travel times be used as a baseline of conditions that existed before construction and that the difference between weekday and weekend travel times be attributed to work activities occurring throughout the project. Table 5 summarizes those delay numbers.

Table 5. Construction-related per-vehicle delays, weekdays April 2008.

Time Period	Northbound Delays (minutes per vehicle)	Southbound Delays (minutes per vehicle)
a.m.	1.2	1.2
noon	5.3	1.0
p.m.	7.0	2.0

QUALITY

Pavement Test Site

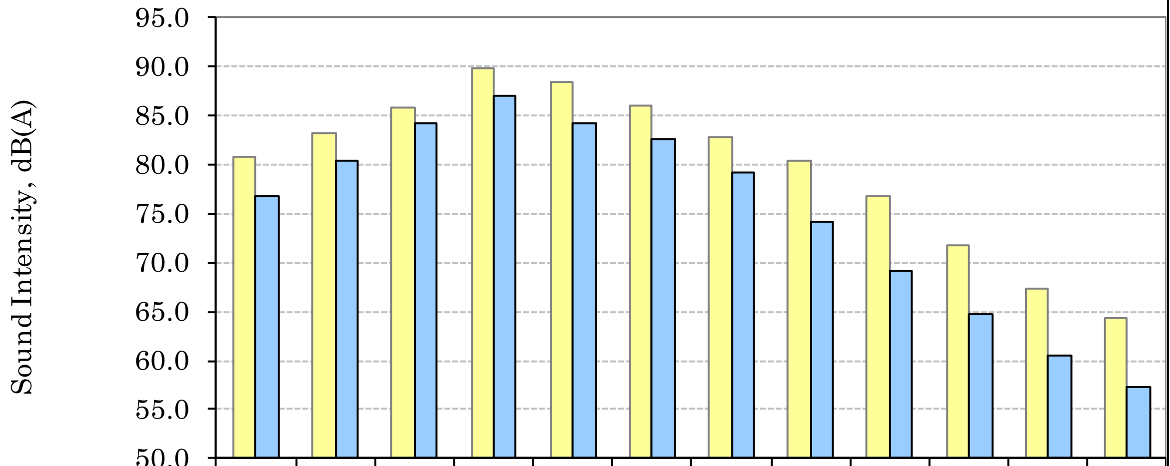
Sound intensity (SI) and smoothness test data were collected from three 525-ft tangent sections avoiding roundabouts, curves, and hills on SR 179 through Sedona. These three test sections serve as a representative sample of the highway. Comparing these data before and after construction provides a measure of the quality of the finished pavement.

Sound Intensity Testing

SI measurements were made using the current accepted OBSI technique AASHTO TP 76-10, which includes dual vertical SI probes and an ASTM-recommended standard reference test tire (SRTT). Data was collected before construction and on the new pavement surface after the road was opened to traffic. SI measurements were recorded and analyzed using an onboard computer and data collection system. Multiple runs were made in the right wheel path with the two microphone probes simultaneously capturing noise data from the leading and trailing tire-pavement contact areas. Figure 28 shows the dual probe instrumentation and the tread pattern of the SRTT.

Figure 28. OBSI dual probe system and the SRTT.

The average of the front and rear SI values was computed to produce a global SI value from the three test sections. Raw noise data were normalized for the ambient air temperature and barometric pressure at the time of testing. The resulting mean SI levels were A-weighted to produce the frequency spectra in one-third octave bands, as shown in figure 29.



	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
Preconstruction	80.7	83.1	85.8	89.8	88.4	85.9	82.9	80.3	76.7	71.7	67.4	64.2
Postconstruction	76.7	80.4	84.3	87.0	84.3	82.6	79.2	74.1	69.1	64.6	60.6	57.3

Figure 29. Mean A-weighted SI frequency spectra from before and after construction.

SI levels were calculated using logarithmic addition of the one-third octave band frequencies across the spectra. The global SI value was 94.9 dB(A) for the existing pavement and 91.8 dB(A) for the new pavement. The SI levels from the new construction meets the HfL goal of less than 96.0 dB(A) and is a noticeable 3.1 dB(A) quieter than the old pavement.

Smoothness Measurement

Smoothness testing was done in conjunction with SI testing using a high-speed inertial profiler integrated with the test vehicle. The smoothness or profile data were collected from both wheel paths and averaged to produce an IRI value. Low values are an indication of higher ride quality (i.e., smoother road). Figure 30 shows the test vehicle with the profiler positioned in line with the right rear wheel. Figure 31 graphically presents the IRI values for the preconstruction and newly constructed pavement. Shaded areas on the plot indicate the test sections (IRI values are plotted continuously for the new pavement as a reference). The existing distressed pavement had a 209 in/mi value and the new pavement had a 135 in/mi value. While not meeting the HfL goal of less than 48 in/mi, the 135 in/mi is much smoother than the existing pavement.

Figure 30. High-speed inertial profiler mounted behind the test vehicle.

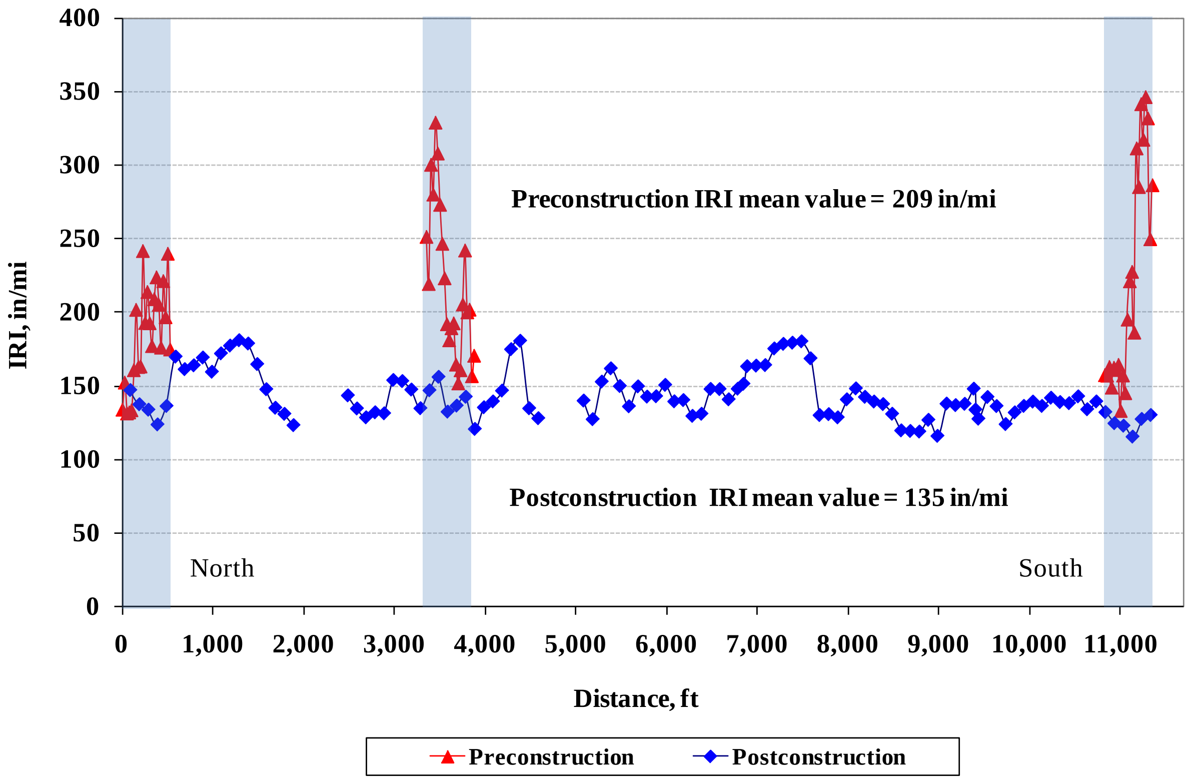


Figure 31. Mean IRI values for the bridges and roadway before construction.

USER SATISFACTION

As indicated earlier, during the planning stages of the project ADOT began an aggressive and comprehensive effort to communicate with affected residents and businesses along the SR 179 corridor and keep them abreast of all pre- and post construction activities. The HfL requirement for user satisfaction included a performance goal of 4-plus on the Likert scale of 1-7 for the six questions listed in Appendix.

Although the project went over the expected construction contract duration by 8 to 9 months, the result was well received by the community. ADOT's post construction stakeholder survey clearly indicated that neighboring residents and businesses were satisfied with the construction approach and the final product. ADOT exceeded the HfL expectation by a large margin.

TECHNOLOGY TRANSFER

To promote and accelerate the nationwide adoption of the many innovative techniques and materials used on the Sedona project, ADOT held numerous workshops and meetings that attracted professionals from FHWA, design consultants, contractors, and other transportation agencies. However, there was no technology transfer workshop sponsored by the HfL program.

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 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.

CONSTRUCTION TIME

ADOT believes that overlapping design and construction and using alternate project delivery, incentive/disincentive contract clauses, and innovative accelerated construction technologies enabled it to dramatically reduce the duration and impact of construction activities on residents, businesses, and roadway users. Although it took several months to complete the construction of the substructure and superstructure for the pedestrian overpass and the new Oak Creek Bridge, the as-built construction impact on users was minimal.

COST SUMMARY

Table 6 presents the summary of the planned and actual costs for the as-built alternative. Table 7 provides the detailed breakdown of the actual costs. As noted in table 6, the as-built construction cost was about four times the budgeted cost of the project.

Assuming that the baseline alternative is to construct a standard, four-lane divided highway, a reasonable comparison of cost estimates for the as-built and baseline alternatives could not be made. The as-built alternative took longer to develop through the NBIP process, incurred higher construction costs, and provided more challenges in phasing construction, while the baseline case could have been cheaper. However, intangible benefits were realized through project development with the NBIP process with a higher quality project that fits within the context of the community and environment.

Table 6. Original versus current budget.

Original Budget	$14,680,000.00
Current Budget	$54,989,036.35
Total Charges	$53,875,389.22

Table 7. Detailed breakdown of the actual projects.

Contractor Pay	$44,262,350.62
Other Construction	$225,300.21
Public Relations	$11,545.43
Direct Construction Engineering	$1,549,771.63
Other Construction Engineering	$758,865.96

Table 7. Detailed breakdown of the actual projects.

Construction Administration	$0.00
Rent-A-Tech	$4,094,368.23
Total Construction Estimate	$6,403,005.83
Postdesign	$2,609,720.30
Department of Public Safety	$350,347.36
Joint Project Agreements	$13,119.47
Utilities	$0.00

USER COSTS

Several major innovations were implemented in this project to mitigate the construction impacts and improve mobility and safety during construction. The major innovations included roundabout phasing, increased use of law enforcement, use of prefabricated bridge elements, use of a lane rental contract provision, and enhanced public outreach.

As noted earlier, the crash frequencies during construction were generally lower than the preconstruction frequencies. Considering that the same number of lanes that existed before construction was maintained during construction, no major impacts were observed except for some delays observed at the north end of the project. Also, the observed work zone speeds ranged between 13 and 30 mi/h.

Because construction costs of the as-built and the baseline scenarios were not compared, user costs also were not computed. Furthermore, the intangible road user and community benefits realized with the NBIP process cannot be readily monetized with available methods.

APPENDIX - USER SATISFACTION SURVEY

On a scale of 1-7, please rate the Arizona Department of Transportation's (ADOT) and the construction contractor's performance in the following areas during the recent roadway reconstruction on SR 179.

Performance Areas	1	2	3	4	5	6	7
Length of time the project was under construction	**91**	21	28	33	44	26	24
Safety during construction	11	6	17	22	49	79	**85**
Detours during construction	17	21	16	42	**68**	64	47
Noise during construction	24	18	22	44	52	**65**	37
Property/business access during construction	25	26	27	41	**62**	56	36
Traffic movement along the roadway during construction	30	25	30	34	48	**53**	51

On a scale of 1-7, please rate your satisfaction level with the following.

Performance Areas	1	2	3	4	5	6	7
Our information efforts, or the ways we provided you information about the recent roadwork activities on SR 179	14	15	8	21	36	66	**110**
Your overall satisfaction level with the results of the recent roadwork on SR 179	35	15	17	17	23	51	**105**
Your information level, or how well informed you were during the recent roadwork activities on SR 179	15	10	14	24	36	70	**99**
ADOT's overall performance during construction	29	20	18	21	37	**74**	72
The construction contractor's performance during this project	30	19	14	24	45	63	**69**

For this project, traffic was maintained by alternating traffic, using single-lane closures along with flag control, and providing very limited lane closures. On a scale of 1-7, how satisfied were you with the maintenance of traffic during construction in terms of alleviating congestion?

1	2	3	4	5	6	7
22	18	27	31	51	**63**	49

On a scale of 1-7, how satisfied were you with the delay time experienced by motorists traveling through this construction zone?

1	2	3	4	5	6	7
31	26	24	22	64	**66**	32

On a scale of 1-7, please rank the materials or methods we used to keep you informed about the activities and schedules during the recent roadwork on SR 179?

Performance Areas	1	2	3	4	5	6	7
Direct mail/newsletters	17	7	13	26	31	60	**71**
Flyers delivered to your home or business	17	8	13	21	26	53	**60**
Weekly e-mail updates	16	6	11	23	10	33	**54**
Local meetings	19	14	12	18	24	33	**41**
Project Web site	18	3	9	20	14	26	**35**
Local radio/TV spots	22	8	14	22	13	19	**31**
Highway advisory radio	20	9	10	17	13	20	**26**
Project Hotline (800-529-2876)	17	8	10	16	17	22	**29**

On a scale of 1-7, how satisfied are you with the results of the new two-lane roadway between the village of Oak Creek and the city of Sedona compared to the previous roadway?

1	2	3	4	5	6	7
32	14	14	17	23	44	**116**