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Summer 2022



## Resources for Applying Resilience Concepts to Projects in River Environments

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**NEW LOOK!** Guest Editorial Explores Advancing Research through TPF Program

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Using Online Tools to Protect the Environment



U.S. Department  
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COVERS and ABOVE—Transportation professionals benefit from understanding natural river functions when planning, designing, building, and maintaining infrastructure projects in river environments. Although studies of natural systems may seem daunting to some, even casual students of river science may readily learn some fundamental concepts to aid them in developing resilient projects.

Source: FHWA.



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*Public Roads* (ISSN 0033-3735; USPS 516-690)  
is published quarterly by the Office of Research,  
Development, and Technology, Federal Highway  
Administration (FHWA), 6300 Georgetown Pike, McLean,  
VA 22101-2296. The business and editorial office of  
*Public Roads* is located at the McLean address above.  
Phone: 202-493-3375. Fax: 202-493-3475. Email:  
lisa.a.shuler@dot.gov. Periodicals postage paid at McLean,  
VA, and additional mailing offices (if applicable).

POSTMASTER: Send address changes to  
*Public Roads*, HRTM-20, FHWA,  
6300 Georgetown Pike, McLean, VA 22101-2296.

*Public Roads* is sold by the Superintendent of Documents,  
U.S. Government Printing Office, Washington, DC 20402.  
Requests for subscriptions should be sent directly to New  
Orders, Superintendent of Documents, P.O. Box 979050,  
St. Louis, MO 63197-9000. Subscriptions are available  
for 1-year periods. Paid subscribers should send change  
of address notices to the U.S. Government Printing Office,  
Claims Office, Washington, DC 20402.

The electronic version of *Public Roads* can be accessed  
through the Turner-Fairbank Highway Research Center  
home page (<https://highways.dot.gov/research>).

The Secretary of Transportation has determined that  
the publication of this periodical is necessary in the  
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The Transportation Pooled Fund Program helps partners advance research while reducing costs and increasing benefits and impacts.

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Source: FHWA.

## Transportation Pooled Fund (TPF) Program: Moving Research Forward Through Partnerships

With the passage of the Bipartisan Infrastructure Law, this is a historic time in transportation. It is now even more important to provide opportunities to collaborate and foster partnerships to move research and innovation forward to meet the Nation’s diverse transportation needs. For more than 45 years, the Transportation Pooled Fund (TPF) Program has enabled public and private entities to combine resources to conduct high-priority research on a variety of shared, highway-related problems.

In this issue of *Public Roads*, one of the feature articles, “Transportation Pooled Fund Program: Advancing Research through Innovation,” showcases how the TPF Program helps produce research and innovation on a variety of important transportation topics.

The TPF Program provides a mechanism to allow agencies to partner together to invest in multiple research efforts at a fraction of the cost of conducting the research alone. A unique benefit of the TPF Program is that it encourages and allows for a variety of partners, including State departments of transportation (DOTs), the Federal Highway Administration, other Federal agencies, regional and local agencies, academic institutions, industry trade associations, private industry, and foreign entities. The TPF Program allows those with limited research or innovation funding to participate in large-scale efforts. By pooling funds and expertise, participants maximize their return on investment.

FHWA’s Turner-Fairbank Highway Research Center Office of Corporate Research, Technology, and Innovation

Management manages the TPF Program. Since 2003, the TPF Program has processed over \$600 million in collaborative funding between partnering agencies. As of February 2022, there were 172 active projects and 10 open solicitations. Of these projects, 116 were State DOT led, and 56 were FHWA led. TPF research topics span safety, pavements, bridges, design, equity, climate, sustainability and much more!

The TPF Program also allows for knowledge transfer across partners. In addition to an assigned FHWA technical liaison, each study forms a Technical Advisory Committee, which includes agency representatives and subject matter experts from all participating agencies. Participants learn from others’ experience and form connections that not only assist with that specific research but can benefit their work in other areas as well.

Many of the research or innovations produced by TPF studies have been used to advance the state of practice in their respective fields. For example, TPF-5(317), Evaluation of Low-Cost Safety Improvements (ELCSI), works with more than 40 participating agencies to help improve safety and reduce traffic-related fatalities. In this study, rigorous before and after testing is used to evaluate how low-cost, implementable countermeasure approaches reduce safety risks. One example of a low-cost safety improvement is the use of high friction surface treatments. With one-quarter of highway fatalities in the United States occurring at or near horizontal curves, high friction surface treatments studied under ELSCI have shown significant reduction in wet pavement crashes after treatments. The

low-cost safety improvement approaches have been documented in more than 60 publications and 800 crash modification factors.

There have been several other TPF studies that have helped to transform the transportation industry. TPF-5(165), TPF-5(217), TPF-5(366), and TPF-5(468) have all researched different topics related to the performance of Ultra High-Performance Concrete (UHPC). UHPC is the most technologically advanced concrete available today. It is five times stronger and 10 times more durable and longer lasting than bridges built using conventional concrete. There are over 200 bridges in the US built with UHPC. These studies have helped to provide further research to bring this technology to the forefront of US bridge engineering design and construction.

The TPF Program has produced high value research and innovations that have been adopted and institutionalized by partners and agencies around the world. It is a great resource to leverage limited funds to address important issues. For more information on how to participate in this exciting, high value research program see “Transportation Pooled Fund Program: Advancing Research through Innovation,” on page 24.

**Dr. Kelly Regal**  
Associate Administrator for Research, Development, and Technology Director, Turner-Fairbank Highway Research Center  
Federal Highway Administration

## Computer Vision Research Drives Real-World Innovation

Intelligent algorithms designed to support FHWA research are driving development of new and useful applications in diverse disciplines.

by **MARY HUIE** and **ADIL ANIS**

Researchers at the Federal Highway Administration are using extremely large datasets to identify and understand complex transportation issues that can impact efficiency, cost, and safety. New automated tools for data extraction and analysis are needed to help make these massive datasets accessible to the widest possible range of researchers, academia, and industry.

The second Strategic Highway Research Program's (SHRP2) naturalistic driving study (NDS) demonstrates the immense scale of data gathered in recent years. The study focused on driver behavior and addressed the notion that it is possible to obtain information on what people do when they drive on a day-to-day basis. The study involved more than 3,000 volunteer drivers and their vehicles, each of which was equipped with four cameras, GPS, and various sensors. Over a two-year period, NDS researchers gathered more than 1.2 million hours and more than two petabytes of data, the majority of which came from video captured by onboard cameras.

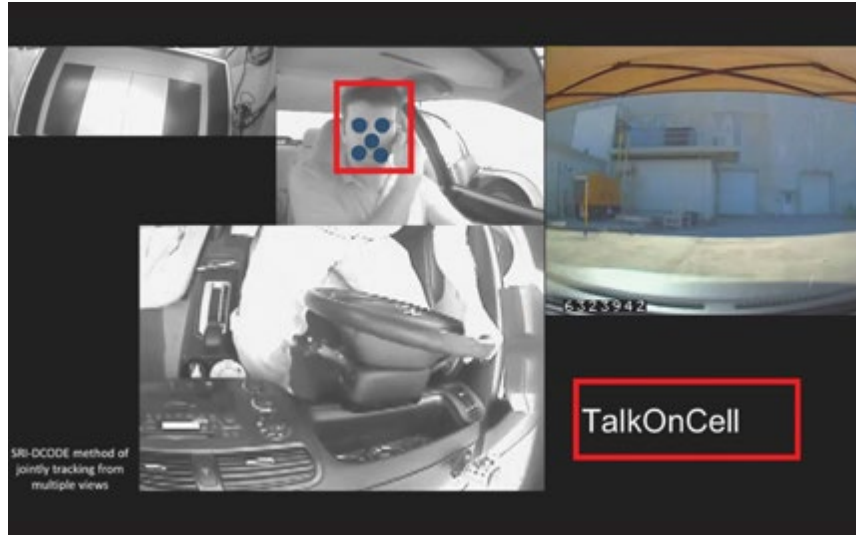
The massive size of the NDS video data resulted in a bottleneck that made traditional methods for identifying and extracting features of interest in video inadequate. Traditionally, researchers manually logged the location in the video where each feature of interest was found; however, it is estimated that it would take almost 600 technicians a full year to manually analyze all the video in the NDS.

### EAR Investment in Computer Vision

Computer vision, which uses artificial intelligence algorithms to perform visual perception tasks, offers a more efficient method for analyzing video data. The Exploratory Advanced Research (EAR) Program has funded computer vision research on SHRP2 safety data at the Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL) via an interagency agreement. One of the most successful ORNL efforts focused on continuing development of a highly flexible data processing framework for ingesting image data and coordinating the application of multiple facial recognition models to process that data. This framework includes a variety of machine learning tools, ranging from face detection and characterization to body pose attributes. These tools can be used to detect facial attributes, such as looking forward and checking mirrors, and expressions or body movements, such as turning or reaching. ORNL calls this data processing framework "Face Recognition from Oak Ridge," or FaRO.

### Innovations Using FaRO Computer Vision Algorithm

There have been several collateral innovations that have resulted from the development of FaRO. ORNL has used FaRO internally



FaRO used for privacy analysis and attribute extraction of a user talking on a cell phone while simultaneously tracking from multiple views in the vehicle.

Source: U.S. Department of Energy/Oak Ridge National Laboratory.

for enhancing unmanned aerial system capability modeling via a portable system that performs on-device object detection and avoidance. FaRO is also used by the DOE's Office of Energy Efficiency and Renewable Energy for controlling access to the network—an application that uses industrial cameras to perform real-time video analytics of biometrics data. Other organizations, including a university, a commercial entity, and Federal intelligence agencies are now interested in using FaRO. The software is available through an open-source license and is freely distributed. Resultantly, the return on investment of these spinoff uses will continue to increase the value of the public funds invested.

### EAR Supports Cutting-Edge Research/Looking Ahead

FHWA's goals are both short and long term. In the short term, FHWA wants to extract value from the NDS data. In the long term, FHWA wants to ensure that the data being collected will improve transportation safety. The EAR Program seeks to leverage advances in science and engineering that could lead to breakthroughs for critical current and emerging issues in highway transportation by supporting a community of experts from different disciplines who have the talent and interest to research solutions but who likely would not do so without EAR Program funding.

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**ADIL ANIS** is a program manager working as a contractor with FHWA's Technology Transfer Program. He holds a B.S. in computer engineering from George Mason University in Fairfax, VA.

For more information, see <https://highways.dot.gov/research/research-programs/exploratory-advanced-research/exploratory-advanced-research-overview> or contact Mary Huie, 202-493-3460, [mary.huie@dot.gov](mailto:mary.huie@dot.gov)



## Every Day Counts: Innovations With Impact!

Warm mix asphalt saves time and money, improves pavement quality, and benefits workers and the environment.

Source: FHWA.

by **JEFFREY ZAHAREWICZ**

The Federal Highway Administration's Office of Transportation Workforce Development and Technology Deployment is deep in the planning process for Every Day Counts (EDC), the agency's flagship technology deployment program. The seventh round of EDC (EDC-7) is scheduled for 2023 and 2024 and will highlight the next portfolio of market ready and proven, yet underutilized, practices and technologies. The process of identifying these innovations brings with it a sense of reflection on the many past initiatives EDC has helped advance into more widespread and mainstream use.

### Warm Mix Asphalt a Game Changer

One of the earliest EDC initiatives may also be one of the most impactful to the transportation industry. Warm mix asphalt (WMA) is the generic term for a variety of technologies that allow producers of hot mix asphalt pavement material to lower the temperatures at which the material is mixed and placed on the road. Using WMA can reduce paving costs; extend the paving season; improve asphalt compaction; allow asphalt mix to be hauled longer distances; and improve working conditions by reducing exposure to fuel emissions, fumes, and odors. This technology saves time, promotes good stewardship of human and environmental resources, and enhances project quality—all hallmarks of EDC innovations.

As adoption increased, WMA was considered a "disruptive" technology and a "game changer," as it required physical modifications to asphalt mixture plants and significant adaptation of existing specifications. By the December 2012 conclusion of the first EDC cycle, the WMA deployment team celebrated the achievement of their implementation goal—40 State departments of transportation and all Federal Lands Highway Divisions had either a specification or contractual language allowing WMA on projects. The impact of using WMA has only continued to grow since: utilization of WMA technologies in 2019 was 879 percent more than the estimated 16.8 million tons in the 2009 construction season, and asphalt produced with WMA technology made up 38.9 percent of the total estimated asphalt mixture market as of 2019.

### Significant STEPs FoRRRWD in Safety

Safety has been a cornerstone topic throughout the history of EDC—so much so that FHWA hosted the virtual September 2021 Safety Summit Series to highlight seven EDC safety initiatives. This peer exchange included professionals just beginning to learn about those safety innovations, as well as those further along in their deployment journey. Among the initiatives highlighted at

the 2021 summit were the Focus on Reducing Rural Roadway Departures (FoRRRWD), which aims to address the nearly 12,000 people who die every year in crashes when their cars leave their travel lane on a rural road, and Safe Transportation for Every Pedestrian (STEP), which is advancing the systemic application of proven, cost-effective countermeasures to help reduce pedestrian fatalities at both uncontrolled and signalized crossing locations.

As many other EDC initiatives have done, both FoRRRWD and STEP promoted a toolkit of resources and countermeasures that are adoptable by a wide range of transportation agencies. Both deployment teams also employed highly creative and innovative marketing tools, including printable trading cards to explain rural roadway departure crash types and countermeasures, and the STEP UP Campaign, which provided downloadable information for agencies to use in customized news articles, social media posts, and print items. The teams used these tools, in concert with other targeted training and technical assistance activities, to help 42 and 51 States, respectively, achieve their deployment goals.

These examples are merely a snapshot of the significant positive impact the EDC program has made in accelerating the deployment of innovations and in building a culture of innovation within the transportation community. FHWA is excited to continue the track record of positive impacts with EDC-7. Look for more information in upcoming Innovation Corner features!

### Useful Links:

- EDC 2021 Virtual Summit (available through September 2022) <https://www.labroots.com/ms/virtual-event/2021-edc-virtual-safety-summit-series>.
- FoRRRWD: <https://highways.dot.gov/public-roads/winter-2021/reducing-rural-roadway-departures-moving-forrrwd-part-ii>.
- FoRRRWD trading cards: <https://safety.fhwa.dot.gov/forrrwd/TradingCards/>.
- STEP: [https://www.fhwa.dot.gov/innovation/everydaycounts/edc\\_5/step2.cfm](https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/step2.cfm).
- STEP UP toolkit: [https://safety.fhwa.dot.gov/ped\\_bike/step/step\\_up\\_campaign/](https://safety.fhwa.dot.gov/ped_bike/step/step_up_campaign/).

**JEFFREY ZAHAREWICZ** is the acting director for the Accelerating Innovation program team in the FHWA Office of Transportation Workforce Development and Technology Deployment.

For more information, see <https://www.fhwa.dot.gov/innovation/everydaycounts/> or contact Jeffrey Zaharewicz at [jeffrey.zaharewicz@dot.gov](mailto:jeffrey.zaharewicz@dot.gov).



## Improving Efficiency and Safety Through Digital Infrastructure and Cooperative Driving Automation Research

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### *The Federal Highway Administration is driving the future of transportation through its national CDA Program.*

To prepare for the deployment of automated vehicles on the Nation's highways, the CDA Program is leading research on the digital infrastructure necessary to support CDA.

The CDA Program testing activities consider the future impact of CDA concepts on the transportation system, including the effect of CDA in traffic, reliability, and freight operations scenarios. CDA testing videos for basic travel, traffic incident management, weather, and work zone scenarios are available at <https://bit.ly/CARMAVideoSeries>.

The CARMA<sup>SM</sup> Ecosystem of open-source tools and products enables collaborative research and development of CDA features and capabilities across the transportation network, setting the foundation for the safe introduction of CDA technology on our Nation's roads.

YOU can help shape the future of transportation  
by contributing to this critical research.  
Learn more at <https://bit.ly/CDAProgram>,  
or email [CARMA@dot.gov](mailto:CARMA@dot.gov).



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# Information for Planning and Consultation (IPaC) Streamlines Endangered Species Act Reviews

IPaC's online resources, including the new Consultation Package Builder for creating biological assessments, help agencies understand and document how their proposed projects will affect listed species and critical habitats.



by **CHELLBY KILHEFFER** and **VICTORIA FOSTER**

Road and bridge projects often cross forests, streams, and other sensitive plant and animal habitats. Under section 7(a)(2) of the Endangered Species Act (ESA), Federal agencies (i.e., action agencies) are required to consult with U.S. Fish and Wildlife Service (USFWS)<sup>1</sup> to ensure that actions they fund, authorize, or carry out are not likely to jeopardize the continued existence of any listed species or destroy or adversely modify designated critical habitats.

Along with meeting the requirements of section 7(a)(2), interagency consultations with the USFWS help minimize the negative effects of infrastructure projects on species and habitats protected under the ESA. But for many agencies, especially

smaller ones without dedicated environmental staff, the process was often complicated and time consuming.

To help streamline the consultation process, USFWS created the Information for Planning and Consultation (IPaC) system—a free, web-based application that provides up-to-date information on ESA protected species, helpful templates, and other useful resources for transportation agencies and their partners. Since its inception, IPaC's resources have assisted agencies across the United States with completing consultation on thousands of projects. The latest IPaC tool—Consultation Package Builder (CPB)—provides agencies with even more support during the early stages of infrastructure projects.

## Early Design Consultation for ESA Compliance

Designing projects while considering potential effects to ESA-listed species and ESA-designated critical habitats is one of the most effective ways to ensure efficient section 7 consultation and overall environmental protection. Early coordination between action agencies and USFWS saves agencies time and money—project designs consider environmental resources from the start, the consultation is more efficient and predictable, and agencies avoid costly modifications and delays during the planning and permitting stages.

USFWS uses tools, like those in IPaC, to collaboratively solve conservation challenges and create opportunities for action agencies

<sup>1</sup> Some cases require consultation with the National Oceanic and Atmospheric Administration, but those cases are not covered by IPaC or in this article.





The candy darter is a small, freshwater fish endemic to portions of the upper Kanawha River basin in Virginia and West Virginia.

Source: Ryan Hagerty, USFWS.

to reduce impacts to the ecosystems of listed species through project design.

### IPaC's Three Tools: Streamlining Consultation

IPaC helps agencies, their applicants, and other project proponents prepare for their ESA section 7 consultations during the critical early stages of a transportation project. IPaC facilitates early coordination by providing automated project planning and analysis tools based on the proposed action's location, possible trust resources in that location (e.g., ESA listed species, migratory birds, wetlands, marine mammals, and USFWS-managed lands like refuges and fish hatcheries), and listed species' conservation needs. IPaC also facilitates communication among action agencies, project proponents,

The first step in IPaC is to draw the project location on an interactive mapping tool.

Source: USFWS.

and the USFWS field office. Creating consultation documents through IPaC improves consistency, transparency, and efficiency for both the action agencies and the USFWS.

In IPaC, users begin by drawing their project location on an interactive mapping tool. IPaC uses the project location to gather the relevant information needed to use IPaC's tools. The three tools available in IPaC are the official species lists (OSLs), determination keys (DKeys), and the new Consultation Package Builder (CPB). These tools can be used sequentially or independently, depending on the action agency's needs.

#### OSLs

An OSL is a letter from the local USFWS field office that helps agencies evaluate potential impacts of their projects. Along with providing a project tracking number, the OSL includes a list of candidate, proposed, threatened, and endangered species, and proposed and designated critical habitats that should be considered under section 7 of the ESA.

Depending on field office preferences, OSLs may also include attached lists of migratory birds of conservation concern, USFWS-managed refuges and fish hatcheries, marine mammals, and wetlands and other aquatic areas of concern under section 404 of the Clean Water Act. The ESA requires an OSL be requested for projects conducted, permitted, funded, or licensed by a Federal agency.

The Virginia Department of Transportation (VDOT) reviews projects for ESA

section 7 compliance every six months or at project development milestones—a process that requires the agency to obtain an up-to-date OSL. Amy Golden, biological resources program manager for VDOT, says “One benefit to IPaC is having a central location to obtain a project OSL. Prior to IPaC, some States would email or write a letter to the field office requesting an OSL, which was time consuming. IPaC makes it easy to obtain an updated OSL for projects.”

### Why Use IPaC?

Using IPaC provides several benefits to transportation agencies:

- Available online 24 hours a day, 7 days a week.
- Offers georeferenced analyses.
- Updated frequently so tools, including OSLs, DKeys, and CPB use the latest data.
- Provides resource lists updated in real time.
- Allows project proponents to store documents and collaborate on project files.
- Results in more complete, better formatted consultation packages.
- Reduces number of follow-up questions during the consultation process.

## DKeys

A DKey is a screening tool provided through IPaC that can streamline the consultation process for common project types. DKeys are based on programmatic biological opinions or standing USFWS analyses which are designed to assist action agencies in reaching predetermined consultation outcomes based on an assessment of their project. To use a DKey, an IPaC user answers a series of questions to determine whether a proposed project qualifies for an existing programmatic consultation or analysis. DKeys can be restricted to certain project types, geographic locations, agencies, or species. If a project qualifies for a DKey, the action agency may receive a consistency or concurrence letter, depending on which predetermined consultation outcome they reach.

Lane Masoud of the Michigan Department of Transportation recommends DKeys to local partners, saying “Many of the agencies I work with are small, rural road commissions who lack their own environmental staff. Utilizing IPaC has been extremely helpful. The Michigan DKey, in particular, has reduced how frequently I follow up with an agency to get more information. I really appreciate that the DKeys not only ask questions, but also provide guidance.”

## CPB

When there are listed species in the project location that have not been addressed by a DKey, IPaC’s new project analysis tool, CPB, can be used to further analyze the project. CPB, which replaces IPaC’s formerly available “impact analysis” tool, walks users step by step through analyzing the potential effects of their project and assists them in making well-informed effect determinations. The end result is a document, typically called a biological assessment (BA) or biological evaluation (BE), that can be submitted to USFWS for consultation. Currently, the user must download this document and submit it by email or mail to the appropriate USFWS field office.

CPB is an optional tool that is helpful for many projects in which some species in the project area have not been covered by a DKey as it assists with writing a BA or BE. CPB both prompts users to populate all of the information needed to conduct the consultation and provides pertinent information regarding potential effects on species and conservation measures based on the specific work proposed and species in the area.

## IPaC Usage Data and Case Studies

In fiscal year 2021, IPaC assisted Federal agencies in carrying out their ESA section 7

responsibilities on more than 123,000 occasions (including OSLs and DKey letters). Based on the helpful information in the DKeys, and—in some cases—through additional consultation with the USFWS field office, action agencies were able to revise their project designs to avoid previously expected adverse impacts to listed species and critical habitats. In many of these instances, after project design revision, the action agency was able to finalize their consultation via a DKey.

### Case Study 1: FHWA Bats DKey

FHWA worked with USFWS to develop a DKey based on a programmatic biological opinion specifically for transportation projects that may affect two wide-ranging species of listed bats—the endangered Indiana bat and the threatened Northern long-eared bat (NLEB). This DKey—called “FHWA, FRA, FTA Programmatic Consultation for Transportation Projects Affecting NLEB or Indiana Bat”—is intended for projects and activities funded or authorized by FHWA, Federal Railroad Administration (FRA), and/or Federal Transit Administration (FTA) that may require consultation with USFWS under section 7 of the ESA. Since the FHWA Bats DKey was published in 2018, use of this DKey accounts for about 40 percent of all projects assessed by DKeys.

For projects within the range of these two bat species, FHWA, FRA, FTA, and their designated representatives begin the consultation process by using IPaC to determine whether their project is covered by this DKey. In FY2021, the DKey assisted users with making the determination that 1,568 projects would have no effect on these two bat species, and it allowed them to complete consultation on an additional 1,688 transportation projects that may affect these two bat species through IPaC. Screening a project in IPaC often takes about an hour, and projects are easy to update. For projects where no other listed species or critical habitats were identified, the Federal agency needed no further coordination with the USFWS. For more information about this DKey, see <https://www.fws.gov/node/266042>.

### Case Study 2: Using CPB to Create an Example BA for Similar Projects

IPaC’s CPB can also be used to create a sample BA that local agencies can use as a template when consulting with USFWS on similar projects. In West Virginia, FHWA, in cooperation with the West Virginia Division of Highways (WVDOT) and the



Texas blind salamanders live in total darkness. Although they have eyes, they are located under their skin, leaving them totally blind. They are only found in Edwards Aquifer in Texas.

Source: Ryan Hagerty, USFWS.



USFWS West Virginia Ecological Services field office, created an example BA in CPB for a commonly occurring project type—bridge replacement. In the future, this example BA will be used to develop BAs for other bridge replacement projects in West Virginia.

By creating an example BA, FHWA has provided partner agencies in West Virginia with a clear place to start their analyses. The template provides details on the scope and sample language expected by the USFWS, as shown in the following excerpts.

WVDOH described the habitat present in the action area:

“In West Virginia, the Gauley River rises in the Monongahela National Forest on Gauley Mountain in Pocahontas County as three streams, the North, Middle, and South Forks, each of which flows across the southern extremity of Randolph County and converges in Webster County...Within the project area on the Gauley River, the stream substrate is composed of mainly boulder and cobble, with a good amount of sand... The existing piers are founded on bedrock, which is below a layer of sand...The riparian zone is somewhat vegetated and harbors plant life generally associated with riparian corridors, with typical streamside species such as sycamore (*Platanus occidentalis*), maples (*Acer* spp.), black cherry (*Prunus serotina*), willows

(*Salix* spp.), Japanese knotweed (*Reynoutria japonica*), and various woody shrubs...”

The agency also described the project’s purpose:

“The Bolair Bridge has been closed to vehicular traffic since 2017 due to safety concerns. The proposed plan is to demolish and replace the existing bridge over the Gauley River to restore traffic on Webster CR 20/23 in order to maintain residential access, school buses, mail, and emergency services. The new proposed bridge will be

a three-span, steel W-beam bridge with a wooden deck supported on two concrete piers...The temporary detour that has been in use since 2017 causes hardship for the community...This detour was not designed for the traveling public as a permanent route.”

WVDOH described how and where anticipated stressors would occur throughout the project area:

“Exposure of bare soil during site preparation activities could increase erosion...The stream characteristics, such as riffles, runs, or pools, will still function normally (USFWS, 2020). Potential habitat changes are possible during construction and restoration activities and will remain until after restoration is completed and fine sediments have been flushed through the watershed by storm events...We will use heavy duty silt fencing, silt socks, dirt bags, and streambank stabilizing measures to avoid sedimentation in the project location...”

WVDOH also analyzed specific effects to the candy darter—a small, colorful fish that is key to the local ecosystem. Candy darters are listed as federally endangered under the ESA and their conservation needs include dissolved oxygen, invertebrates, spring streamflow, shallow water depths, relatively warm water, and substrate from

### Key Terms:

**USFWS:** U.S. Fish and Wildlife Service

**ESA:** Endangered Species Act

**OSL:** Official Species List

**IPaC:** Information for Planning and Consultation

**DKey:** Determination Key

**CPB:** Consultation Package Builder

**BA:** Biological assessment

**BE:** Biological evaluation

**NLEB:** Northern long-eared bat

### 1) What is your effect determination for the Candy Darter?

No Effect

This effect determination is not available because you have determined in your analysis that the project will have effects on listed species.

Not Likely to Adversely Affect

All effects are beneficial, insignificant, or discountable. IPaC will facilitate getting concurrence from USFWS.

Beneficial effects have contemporaneous positive effects without any adverse effects to the species or habitat

Insignificant effects relate to the size of the impact and include those effects that are undetectable, not measurable, or cannot be evaluated.

Discountable effects are those unlikely to occur.

Likely to Adversely Affect

This determination is appropriate for all projects where the effects do not fit in with 'No Effect' or 'Not Likely to Adversely Affect' category. This determination requires formal consultation with USFWS.

Agencies use CPB to analyze species before making an effect determination.

Source: USFWS.

This conservation measure is used to address the following effects:

**Direct interactions**

crushing, deters movement, disturbance, entrapment

**Critical habitat**

Candy Darter Critical Habitat

### 1) How will you implement 'Design Project for Fish Passage'?

Using the implementation suggestions below, compile an implementation plan for 'Design Project for Fish Passage'.

STYLE **B** *I* U **¶** **≡** **🔗**

If an aquatic barrier cannot be removed or prevented, then design and install structures that will ensure safe, timely, and effective upstream and downstream passage of fish species and other aquatic organisms, necessary to maintain all life stages of these species. While fish passage structures should be designed to provide passage for a variety of species, focus on providing passage for listed or sensitive species.

Agencies can use the CPB to write conservation measures for the project after species and critical habitat analyses are completed.

Source: USFWS.

small gravel to boulders. Candy darters are often affected by sedimentation, contamination, and other changes to rivers and streams from transportation activities. Considering all effects that were suggested by USFWS and expected to occur during their bridge construction project, WVDOH reached an effect determination of “likely to adversely affect” for the candy darter.

WVDOH used CPB to write conservation measures for the project using language suggested by USFWS. One conservation measure was developed for designing projects to allow fish passage, thereby reducing the barrier effects to the candy darter.

The document generated using IPaC's CPB contained all the information FHWA and WVDOH needed to complete the review and consultation on this project with the USFWS West Virginia field office. Because the non-Federal partners used CPB in IPaC, the final document was formatted consistently with other BAs and much of the administrative record was automatically recorded in the USFWS project-tracking system.

IPaC users can also share the IPaC project with other non-Federal partners or FHWA before completing the analysis. Future projects can follow this template while filling out CPB (or offline, if needed), which will streamline review time with the USFWS West Virginia field office. In the future, USFWS plans to improve CPB to allow a user to save templates such as this in IPaC so users can start their similar project in CPB from an established template.

Developing an example BA saves the lead Federal agency (in this case, FHWA) and the USFWS field office time and resources because the submitted BA contains the necessary information from the start. Future BAs that are written using the example BA and submitted to FHWA, and subsequently the USFWS West Virginia field office, are likely to be considered complete upon submittal and require less consultation time to review and revise.

## IPaC Resources & Contacts

IPaC has two platforms available for action agencies to use: production (or live) IPaC and beta IPaC. Production IPaC is found at <https://ipac.ecosphere.fws.gov/> and is intended to be used for real projects where the action agency is ready to analyze a project and send official documents to USFWS. On production IPaC, OSLs and DKey documents are automatically sent to the local field office for their review and are logged in USFWS's internal project tracking system.

Beta IPaC is found at <https://ipacb.ecosphere.fws.gov/> and is intended to be used for testing and training. Beta IPaC has the same functionality as production IPaC, but no official correspondence is created or distributed. Beta IPaC is highly recommended for new users or users who want to test different options in the system.

USFWS offers several on-demand IPaC and ESA section 7 training videos. Links are available through the IPaC homepage (<https://ipac.ecosphere.fws.gov/>) under “Helpful Videos.”

The USFWS IPaC team is continuously striving to improve its functionality and tools through new development and incorporating agency feedback. The team is also available to answer questions or schedule demonstrations. To provide feedback, ask questions, or schedule a demonstration, please contact [fwhq\\_ipac@fws.gov](mailto:fwhq_ipac@fws.gov).

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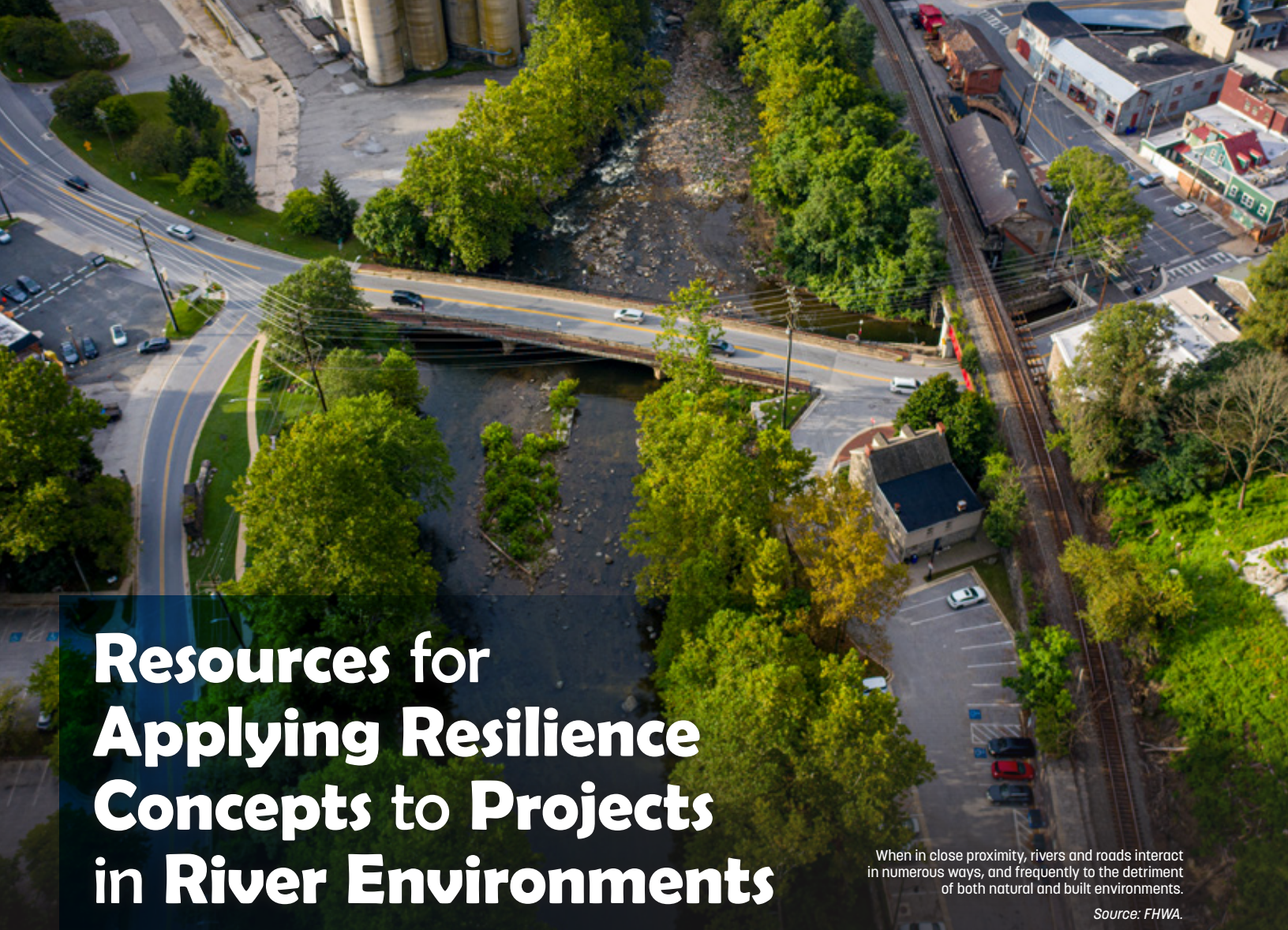
**VICTORIA FOSTER** is the national IPaC program coordinator. Previously, Victoria worked on species conservation issues at State and Federal environmental regulatory permitting agencies in Florida.

See <https://ipac.ecosphere.fws.gov/> for more information, or contact the National IPaC team, [fwhq\\_ipac@fws.gov](mailto:fwhq_ipac@fws.gov), or contact Daniel Buford with the FHWA, [daniel.buford@dot.gov](mailto:daniel.buford@dot.gov).



The Colorado hookless cactus is a barrel shaped with funnel-shaped or bell-shaped pink to violet flowers.

Source: Bekee Hotze, USFWS.



# Resources for Applying Resilience Concepts to Projects in River Environments

When in close proximity, rivers and roads interact in numerous ways, and frequently to the detriment of both natural and built environments.

Source: FHWA.

The Federal Highway Administration develops resources to aid transportation professionals with recognizing, understanding, assessing, and accommodating natural river functions. Preserving and enhancing these functions may lead to more resilient transportation projects.

by **ERIC R. BROWN**, **LAURA GIRARD**, and **JAMES NEIGHORN**

A river presents a particular challenge for highway projects. Its complex natural conditions and functions vary with both time and location within the river corridor. Careful assessment and consideration of rivers is paramount for the safe, resilient, and ecologically sensitive planning, design, and operation of highways.

Federal, State, and local transportation project teams regularly build highway projects in river environments. To meet the needs of these diverse teams, FHWA is developing a variety of high-quality resources and engaging, interactive training—including online and instructor-led courses, immersive and virtual reality (VR) experiences, videos, and protocols—to help teams acquire the knowledge they need to be successful.

## Waterway-Road Interactions and Resilient Design

Paul Wirfs, State hydraulic engineer for the Oregon Department of Transportation, has spent his career working on infrastructure projects. “It is vitally important to understand the dynamics of the natural and built environment,” says Wirfs. “Today’s hydraulic engineering professionals are challenged daily with balancing environmental and infrastructure considerations while also providing practical design solutions. The riverine environment must be treated like a living organism in order to provide resilient hydraulic engineering solutions.”

FHWA courses and related resources focus on core themes of river science. One prominent theme upholds that the preservation and enhancement of natural river

functions may improve the resilience and sustainability of highway projects.

FHWA resources identify four primary, natural river functions as follows:

1. Conveyance and storage of water, sediment, wood, and debris.
2. Channel evolution, including side-to-side and vertical movements.
3. Habitat within the channel, along the streambank (riparian) zones, and in the floodplain.
4. Connectivity of the channel in the long-stream (direction of flow), lateral, and vertical directions.

The FHWA resources introduced in this article explain how project planning and design efforts that preserve and restore these river functions in a holistic manner may significantly reduce adverse interactions

between rivers and infrastructure. Preserving natural river functions has many potential benefits, including lowered risk of roadway overtopping, less erosion and more stable stream banks, and reduced scour at bridge foundations.

### Transportation Infrastructure and Aquatic Organism Passage

Another important theme covered by FHWA resources is Aquatic Organism Passage (AOP). Effective AOP (through stream reaches and bridge and culvert openings) relies on connectivity, and specifically long-stream connectivity. When bridges and culverts disrupt natural flow patterns, fish and other aquatic life may be cut off from large swaths of the habitat they use for spawning and feeding.

In the United States, restoring AOP at bridge and culvert locations is increasingly a priority, as evidenced by the proliferation of laws and regulations, design procedures, and increasing project expenditures aimed at improving ecological connectivity and restoring natural river conditions. Infrastructure owners and environmental agencies continue to seek improved AOP design approaches to road-stream crossings that produce measurable results.

### Riverine Projects Require Multidisciplinary Teamwork

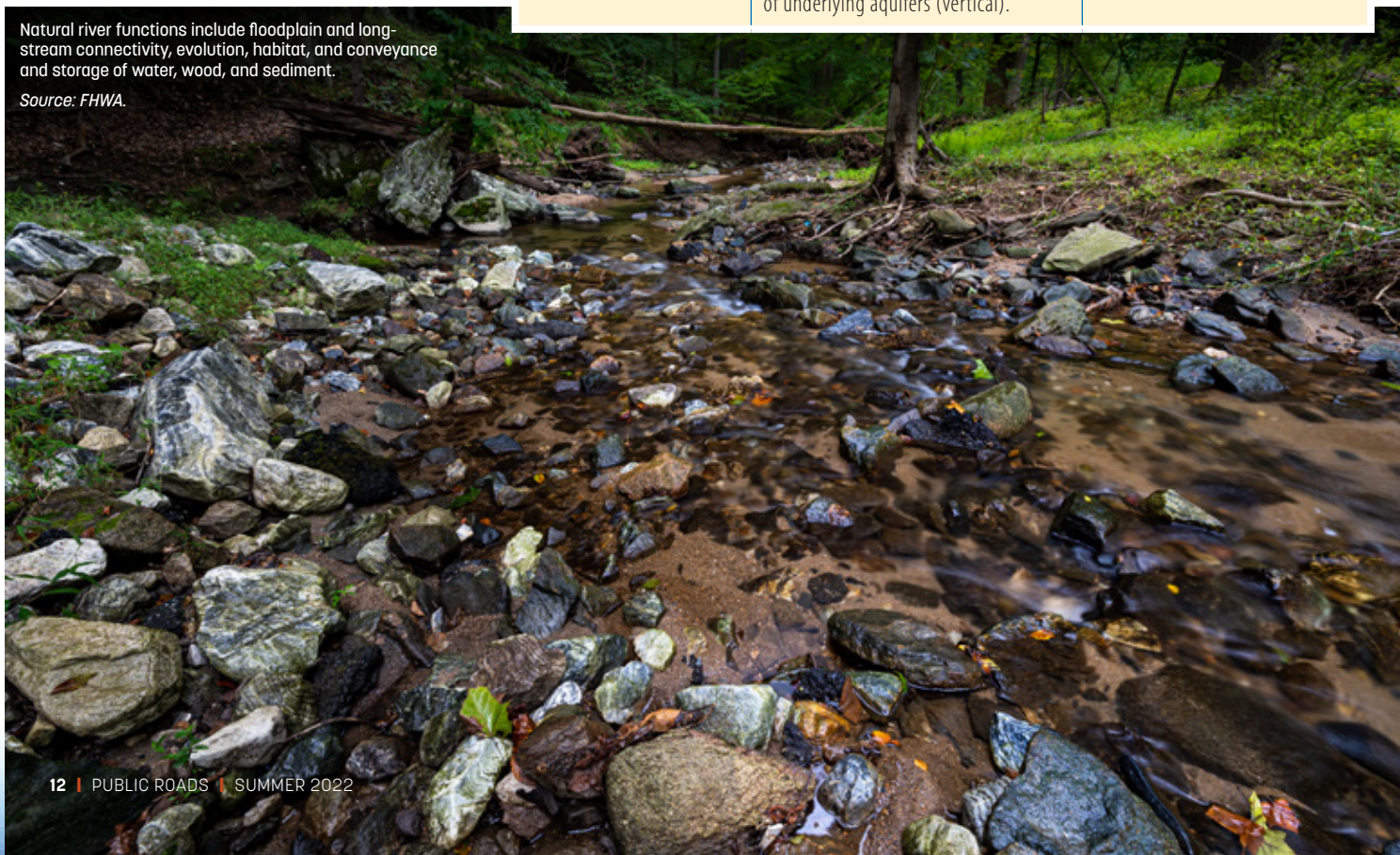
Highway projects in river environments require close collaboration among many

## Example Benefits of Preserving Natural River Functions

Natural River Function	Description	Example Infrastructure Benefits by Preserving River Function
<b>Conveyance and storage</b> (water, sediment, wood, and debris)	River channels move water, which in turn carries sediment, wood, and debris. Floodplains temporarily move and store water, sediment, and wood during floods that crest the channel banks.	Maintaining channel and floodplain conveyance and storage may lower risks of bridges and culverts becoming plugged with sediment and wood, which could trigger roadway overtopping and other failures.
<b>Evolution</b> (changing location, planform shape as seen from above, and vertical profile)	Natural rivers continually move from side-to-side (lateral migration) and adjust their bed elevations (aggradation is upward movement and degradation is downward movement) as soil is eroded in one location and deposited in another.	Allowing for some space adjacent to the existing channel for channel evolution to occur may avoid triggering some unintended up- and downstream soil erosion and deposition resulting from infrastructure in and adjacent to the channel.
<b>Habitat</b> (within the channel, streambank riparian zone, and floodplain)	Vegetation, woody material, rocks, overhanging banks, and other natural materials and features provide nutrients, shade, shelter, and spawning areas to fish and other aquatic life.	Natural habitat and features may promote stable stream banks, for example deep, dense root masses of vegetation effectively hold soils in place. Stable vegetated banks have a lower risk of erosion and movement.
<b>Connectivity</b> (long-stream, lateral, and vertical)	Rivers in natural conditions allow for the movement of water, sediment, wood, nutrients, and aquatic organisms up- and downstream (long-stream), into and out of floodplains (lateral), and in and out of underlying aquifers (vertical).	River connectivity allows flood flow energy to spread into the floodplain, potentially lowering scour (erosion) potential at bridges and culverts.

Natural river functions include floodplain and long-stream connectivity, evolution, habitat, and conveyance and storage of water, wood, and sediment.

Source: FHWA.





These two “perched” (outlet higher than the streambed) culverts may act as barriers to AOP, thereby disrupting long-stream connectivity and habitat functions of a river or stream. Fish trying to swim upstream would likely be unable to navigate the jump heights and the shallow water depths in the culverts.

Source: FHWA.

offices, disciplines, and skill sets to realize successful outcomes. Multidisciplinary teamwork necessitates that project members with a wide range of experience and duties have knowledge of key river science vocabulary and concepts.

Greg Bergquist, environmental protection specialist with the FHWA Central Federal Lands Highway Division, recognizes how multidisciplinary teams develop holistic and resilient transportation projects, emphasizing the specialized knowledge required for river environments: “Understanding river and stream processes and considering how those processes affect the built environment are essential in the holistic design of transportation infrastructure in and around waterways.”

Bergquist notes teams that share a framework for understanding river functions can communicate and collaborate more effectively. “Interdisciplinary design teams can consistently assess the root causes of conflicts between infrastructure and the river environment by utilizing structured frameworks to evaluate river functions,” Bergquist says. “These frameworks can foster opportunities for improved communication and collaboration in determining solutions that are both resilient and context sensitive.”

Engineers and environmental scientists may, through education and experience, be well equipped for working in and around river settings; however, other professions often lack the knowledge, tools, and confidence to practically apply key river science concepts to their projects. So how do transportation professionals new to river science and engineering get up to speed?

### FHWA Training and Resources

FHWA maintains an abundance of technical information and training resources related to river science and engineering, the majority of which may be accessed through the agency’s hydraulic engineering website (<https://www.fhwa.dot.gov/engineering/hydraulics/>). The sheer volume of information may seem daunting to the inexperienced.

FHWA recognizes the specific needs of new learners. The Rivers and Roads (R&R) Connection initiative (introduced in the Autumn 2020 issue of *Public Roads Magazine*) is primed to help novices in river science and engineering quickly learn fundamental, practical knowledge and procedures.

A recently completed R&R product is the National Highway Institute (NHI) Web-based training course 135096, *Roadway Interactions with Rivers and Floodplains: Basic Concepts*. This free training introduces participants to river terminology and functions, river-infrastructure interactions, and resilient design in river environments.

A new FHWA technical manual, *Hydraulic Engineering Circular 16 (HEC-16), Highways in the River Environment: Roads, Rivers, and Floodplains, Second Edition*, will be available in fall 2022. Together, this new manual and course 135096 provide engaging entry points for learners with limited time and who may initially feel intimidated by river science. HEC-16 provides information for understanding, assessing, and addressing interactions between river functions and transportation infrastructure. The manual

adopts a holistic assessment approach by illustrating not only the effects of rivers on roads and bridges, but also the effects of roads and bridges on rivers and their floodplains.

Instructor-led training course NHI 135097, *Roadway Interactions with Rivers and Floodplains*, is another companion course to HEC-16 that will be available in fall 2022. It provides overviews of the following topics:

- Federal policy pertaining to highways in the river environment.
- Concepts important for planning, design, construction, and maintenance of transportation infrastructure in river settings.
- Practical tools in hydrology and hydraulics, fluvial geomorphology (i.e., river science), and sediment transport modeling.
- River biology.
- Specialty topics including flows at river confluences, ice flows, wood in rivers, human-generated debris, water quality, invasive species, beaver activity, mud and debris flows, alluvial fans, tidally influenced and tidally dominated rivers and streams, and inspection and monitoring.

HEC-16 and the two NHI courses constitute a “starter kit” for quickly training individuals in the basics of river science and engineering.

### Field Scoping Videos

To complement the technical manual and courses, FHWA recently completed a series of five videos titled “Hydraulic Engineering:



Large river crossings, such as the U.S. 101 bridge over the Elwha River in northern Washington State, present ideal opportunities to study river ecology, functions, and both positive and negative interactions with infrastructure.

© 2021. Casey Kramer.



The Elwha River VR site visit provides workshop participants opportunities to explore several locations within the river to assess natural functions and changes resulting from two dam removals.

Source: FHWA.

Field Scoping Videos” to help teams identify and categorize problems observed during project visits. The videos are intended to introduce good practices and procedures of project reconnaissance (such as visual field assessment, data collection, and data interpretation) necessary for the hydraulic design and maintenance of transportation infrastructure. The specific field scoping video topics cover bridges, river and stream channels, highway drainage (culverts, ditches, medians, pavements, and storm drains), drainage maintenance projects, and pre-field visit data collection. The videos are available at <https://www.fhwa.dot.gov/engineering/hydraulics/media.cfm>.

### Elwha River Immersive Workshop

FHWA is also finalizing development of the one-day Stream Technology Immersive Learning Environment (STILE) workshop, currently scheduled for completion during summer 2022. This workshop will teach basics of river functions and river-road interactions through the use of a physical stream model (known as a stream table) and a VR site visit of a river crossing, the U.S. 101 bridge over the Elwha River in northern Washington State. To view a short stream table demonstration, please visit <https://www.youtube.com/watch?v=FeLff5a8MeE>.

The Elwha River offers an ideal learning environment to examine essential river system considerations and river-road interactions. Olympic National Park and the recently deconstructed Glines Canyon Dam lie upstream of the U.S. 101 bridge.

Large wood and sediment collect at the U.S. 101 bridge piers. Changes in any river system may alter local conditions at highways, bridges, and culverts, which may necessitate assessment and possible remediation by infrastructure owners.

Source: FHWA.

Downstream of the crossing are the recently deconstructed Elwha Dam and the confluence with the Strait of Juan de Fuca.

The dam removals fostered the return of long-stream connectivity and salmon migration, sediment and wood conveyance, and habitat reestablishment. As natural river functions returned, flow conditions at the U.S. 101 bridge also changed. Through the VR experience, workshop participants will travel to the bridge site to explore river channel lowering, large wood material buildup at the bridge piers, and other results that necessitate actions by the bridge owner. They will also learn about tools and tips for conducting river assessments. The Elwha River VR site visit also touches on AOP, using salmon migration as an example.

### AOP Monitoring Protocol

Another FHWA activity dives into the details and nuances of AOP. To assess the effectiveness of culverts and bridges to pass

aquatic organisms, FHWA Federal Lands Highway Division staff led an effort to develop a multi-stage AOP monitoring protocol. The protocol, which was field tested in 10 States, consists of a stream assessment based on observations and measurements by a multidisciplinary team of two or three trained staff (e.g., engineers and biologists) using available and easy to use tools. Required data includes channel and structure (bridge or culvert) geometry, slope, bed material composition, and features that may potentially limit passage. These data are collected in both up- and downstream channel reaches and within crossing structures.

The protocol developers created inspection forms compatible with mobile platforms and for use on tablets or phones. Future users may modify the forms to suit their specific needs. Use of readily available personal equipment and mobile devices with GPS capabilities allows teams to quickly





Using instructions provided by the FHWA AOP monitoring protocol, two engineers measure and record flow depths through a large culvert with a fish friendly natural rock bottom.

Source: FHWA.

and consistently complete multiple georeferenced inspections per day. Teams can upload data directly into their database and generate formatted reports.

Assessment team members can consolidate the collected information into a dataset to be used to identify sites with potential passage issues requiring either immediate action or a detailed analysis. Data may also be used to evaluate structure resiliency, life cycle costs, and other impacts to stream systems, and to inform improvements to design, construction, and maintenance practices.

“Although not typically part of the project delivery process, monitoring of various stream metrics is essential in understanding how a water crossing is achieving project goals and functioning over time. The FHWA AOP monitoring protocol is a great tool that brings a multidisciplinary team together to assess how a crossing allows for the natural movement of water, sediment, and woody material, which is essential for maintaining natural processes and passage for various aquatic species,” says Casey Kramer, a civil engineer and codeveloper of the monitoring protocol. “With various geomorphic settings, species of interest, and acceptable risks to infrastructure, designing a water crossing that considers these and other metrics, on a project-by-project basis, is critical to achieve project goals and provide resilient transportation infrastructure to the traveling public.”

## Looking Ahead

By using concepts presented by these resources and tools, design teams may enhance the resilient design and operation



of transportation infrastructure in riverine settings. FHWA continues to develop resources for educating practitioners and students in the understanding, assessment, and application of natural river functions in their transportation projects. Planned future efforts include development of additional training resources and advanced assessment methods. For more information on R&R activities, please reach out to the authors or your FHWA hydraulic engineering point of contact.

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**JAMES NEIGHORN**, PE., is the hydraulic discipline champion with FHWA's Office of Federal Lands Highway, where he supports the hydraulic discipline's program and project delivery. Neighorn holds a B.S. in civil engineering from Oregon State University.

For more information, see [www.fhwa.dot.gov/engineering/hydraulics](http://www.fhwa.dot.gov/engineering/hydraulics) or contact Eric R. Brown at 202-366-4598 or [eric.r.brown@dot.gov](mailto:eric.r.brown@dot.gov).

A gravelometer is used to measure the representative sizes of gravels and small cobbles found on river channel beds. Engineers use results of sediment analyses to inform project designs: for example, depths of bridge foundations.

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## FHWA Rivers and Roads Resources

FHWA's latest learning resources:

- *Roadway Interactions with Rivers and Floodplains: Basic Concepts/135096*: ([https://www.nhi.fhwa.dot.gov/course-search?tab=0&cat=7&srt=10&sf=0&course\\_no=135096](https://www.nhi.fhwa.dot.gov/course-search?tab=0&cat=7&srt=10&sf=0&course_no=135096)). This free Web-based course from NHI presents fundamental river terminology and processes.
  - *Roadway Interactions with Rivers and Floodplains/135097* (available fall 2022): This NHI three-day, instructor-led training targets all transportation professionals and emphasizes interdisciplinary and interagency collaboration.
  - A four-part Web-based training series (142081, 142082, 142083, and 142084) on resilient highway project development and design (<https://www.nhi.fhwa.dot.gov/course-search?tab=0&cat=10&srt=10&sf=0&res=1>). These free NHI Web-based courses can be completed as standalone training or in preparation for 142085.
  - *Addressing Climate Resilience in Highway Project Development and Preliminary Design/142085* (available summer 2022). This course represents current understanding of the engineering approaches, and underlying physical relationships, on how extreme weather resilience can be incorporated into surface transportation project decisionmaking.
  - *Highways in the River Environment: Roads, Rivers, and Floodplains/HEC-16* (available fall 2022): This reference manual presents practical planning, assessment, design and maintenance concepts, methods, and tools associated with river and road interactions.
  - Stream Technology Immersive Learning Experience (STILE) workshop (available fall 2022): This one-day workshop will feature hands-on activities with a physical stream model and a VR site visit to a major crossing of the Elwha River.
  - Field scoping/reconnaissance videos for bridges, river channels, culverts, and roadway drainage features (<https://www.fhwa.dot.gov/engineering/hydraulics/media.cfm>).
  - *Riverine Nature-Based Solutions (NBS) for Highway and Transportation Resilience*: This white paper explores the use of riverine NBS in transportation projects and will inform the development of an implementation guide.
  - Written procedures and forms for conducting assessments of culverts designed for aquatic organism passage (available by request).
- Please contact any of the authors to discuss these and related FHWA resources.

# KEEPING AMERICA MOVING AND ACCESSIBLE

How does FLH meet their mission in adverse conditions? With tenacity, ingenuity, and endurance.

A winding road in Badlands National Park, North Dakota.  
© wakr10 / AdobeStock.com

by **ADAM LARSEN** and **BRANDON STOKES**

Imagine traveling on winding roads in the North Dakota Badlands, on the isolated forested roads of the great Northwest, or witnessing the raw beauty of Eastern California's Death Valley at sunset. These may sound like stunning views or vacation destinations, but they could also be lonely roads without fuel stations, the necessary routes to transport freight packages in inclement weather, or roads to access emergency facilities during a wildfire. The roads built across the Nation's National Parks, the national conservation areas managed by the Bureau of Land Management, and other wide-open spaces—including Tribal Nations and national forests—can become anxious ordeals in times of emergencies.

The Federal Highway Administration's Office of Federal Lands Highway (FLH) serves as a conduit between road managers and the diverse population that need to transverse these types of roads—no matter

the reason. So, how does FLH complete their mission in the face of adverse conditions like weather, wildfires, pandemic shutdowns, and other extremes? What fuels the FLH team to serve the public in all types of extreme situations? In a word, tenacity! Below are some descriptive actualities of FLH staff overcoming challenges and establishing partnerships to keep America moving and accessible.

## How Does FLH Work through the COVID-19 Pandemic? With Ingenuity and Virtual Reality. >>>

FHWA is required, under Title 23 of the Code of Federal Regulations (CFR), to provide oversight of functions that utilize Federal-aid for design; plans, specifications, and estimates; contract awards; and inspections with respect to projects both on and off the National Highway System. Further, FHWA provides technical

assistance to recipients of Federal-aid to ensure the requirements of Title 23 of the CFR are met.

Oftentimes, site visits are carried out at the beginning of projects to realize the projects' scope; the scope helps to determine the related activities, deliverables, subprojects, and resources associated with completing the project for successful execution. Site visits—examinations of a location's characteristics to accurately design the right solution for the site's context—continue throughout the project delivery. This person-to-person contact is essential for field verification and has been a mainstay of doing business; however, due to the rapid spread of COVID-19, visitations became difficult, if not impossible, to conduct.

With the COVID-19 restrictions on travel, staff within FLH's Office of Tribal Transportation (OTT) had to find new ways to conduct site visits and carry out site



Sara Yockey, a transportation planner, mounts a virtual tours camera kit onto the roof of her vehicle. The camera kit is easily installed onto most vehicles and does not require special equipment.

The virtual tours camera kit provides 360-degree video captures of the road and roadside features in using two lenses, one forward facing and one rear facing.

Source: FHWA.



resumes, FLH staff expect to still make use of the camera kit to help document project visits.

Video from a virtual tours camera kit is significantly better than the cell phone images that were traditionally used since video allows for 360-degree viewing—viewing in any direction from the camera’s location—as if the viewer was physically on site. Footage from the virtual tours camera kits can then be used for video logs, asset or risk management, safety studies, grant applications, and more. For a project team, virtual tours are the next best thing for accomplishing tasks when an in-person visit is not feasible due to travel or gathering restrictions. “The virtual tours camera kit not only allows our team to visit projects while under travel restrictions, but it also provides an opportunity to obtain advice from experts who may otherwise not be available to visit the project” says Elizabeth Romero, program administration manager within the OTT.

OTT now has virtual tours camera kits that can be loaned to Tribal governments. The camera kits are sent to Tribal partners to mount on their vehicles for a drive-through of a road project, or to mount on a tripod for capturing static images at various road locations. FLH processes the Tribes’ videos and posts them online for easy viewing, sharing, and overall use.

The camera kits were first deployed to new construction at the Navajo Nation where roundabouts had recently been installed. The virtual tours camera kit not only permitted FLH’s safety engineers to conduct oversight responsibilities, but the resulting video was shared and permitted FHWA engineers with expertise in roundabout designs to weigh in virtually. The engineers were able to offer comments about the project that improved its design and the design of similar, future projects.

In like manner, a virtual RSA was conducted at the Tohono O’odham Nation

in south central Arizona. The number of people allowed to gather at the Tohono O’odham Nation’s facilities was limited due to COVID-19 restrictions. Such restrictions hampered the process by which the RSA team seeks to meet with and gather a variety of input from stakeholders. Typically, input is collected through in-person discussions on how routes are managed and to review available data. Then, the team drives their vehicles on the route to pinpoint and examine concerns and to capture photographs for an RSA findings report. For this virtual RSA, before its start-up or kick-off meeting, OTT partnered with Jeff King, a safety specialist at the FHWA Arizona Division, to capture images and publish a virtual tour in using a virtual tours camera kit. As a result, a map was generated that displays both crash data and links to the corresponding crash locations in the virtual tour video. This information enabled team members to participate in the RSA that would have otherwise been unable to contribute. Images were also extracted from the virtual tour for use in the report.

Furthermore, a crowdsourcing feature was added to the Tohono O’odham Nation study to gather input from the RSA team and other Tohono O’odham Nation stakeholders. An online data collection map

inspections on projects for oversight and technical assistance functions. The ingenuity of FLH staff came to the rescue so that projects could continue to be scoped, designed, and inspected—virtually. OTT assembled a virtual tours camera kit. They fashioned a camera kit so that it could be boxed and mailed as a package to their Tribal partners. The kit was equipped with a magnetic mount so that the camera could be attached securely to the roof of a moving vehicle to capture spherical video and photos of a project’s elements and surroundings from all directions. Once the video was recorded, it could be played back online via a desktop computer or tablet. Hence, projects continued to be delivered despite the unanticipated challenge of no contact during the height of the pandemic.

OTT has deployed the camera kit to assist with project close outs, asset management, virtual road safety audits (RSAs), and final construction inspections. As travel

## Road Safety Audits

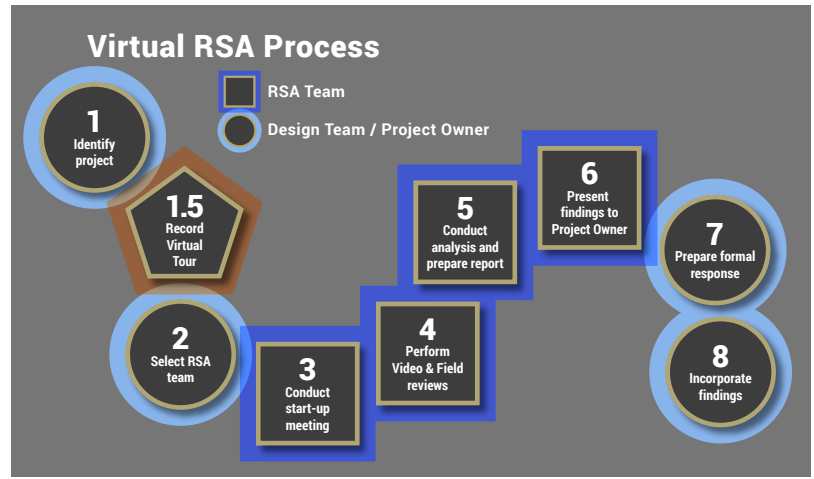
An RSA is the examination of an existing or future road or intersection by an independent, often multidisciplinary, team.

The goal of an RSA is to identify elements of the road that present a safety concern, and what opportunities exist to eliminate or mitigate the safety concern. This type of audit considers all potential road users, not only motorized traffic. Therefore, equitable solutions for all road users are considered in the final resolution options.



HollyAnna Littlebull, an engineering safety traffic coordinator for the Yakama Nation, carries a virtual tours camera attached to a tripod on her way to evaluate bus stops for pedestrian safety. As COVID-19 restrictions taper, staff expect to still make use of the camera kit to help document project visits.

@ Yakama Nation.



Flowchart of the virtual road safety audit process.

Source: FHWA.

(<https://fhwapolicy.maps.arcgis.com/apps/CrowdsourceReporter/index.html?appid=3307bc8a86e14ca7b81d5487e12cffac>) was generated. It includes a simple form that allows users to geospatially locate areas of concern, note any issues, and provide additional comments as well as files, such as photos. This functionality is straight-forward and simple to set up using typical industry solutions for geographic information systems (GIS).

A FLH research project entitled, Development of Safety and Traffic Data Collection System and Analysis Framework for Federal Lands Highway, is underway. This project is examining both common and customized solutions for using GIS to improve transportation safety for partner agencies such as Tribal Nations, Federal Land Management Agencies, and State and

local governments. The project has reviewed current practices and research, developed a safety and traffic data framework and schema, and is currently conducting case studies for partners to collect and analyze data in support of RSAs, safety action plans, or other projects. For more information on the research project, visit <https://highways.dot.gov/federal-lands/programs-planning/studies/safety-traffic-gis-framework>.

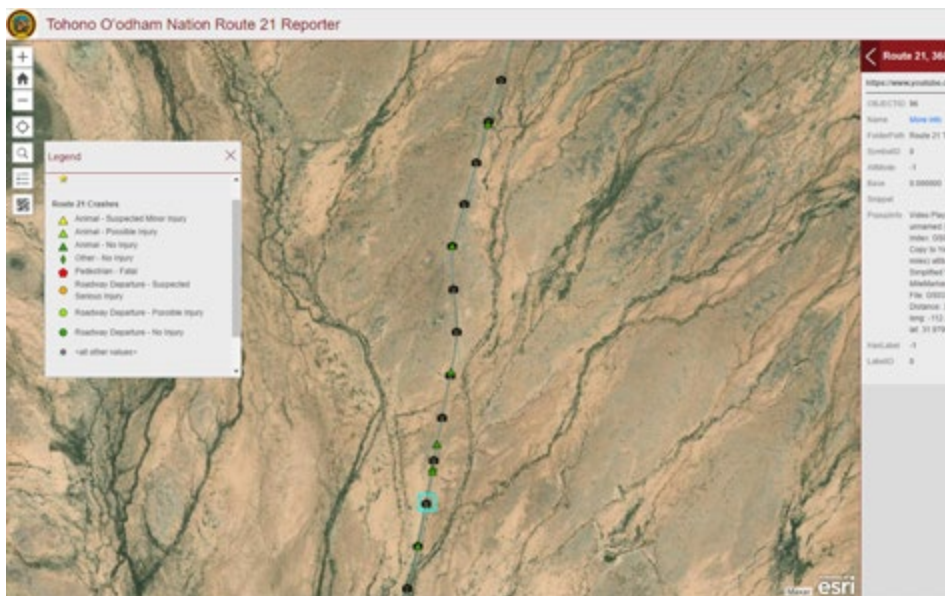
According to Matt Hinshaw, highway safety engineer with FLH, using GIS-based tools can greatly improve the impact and efficiencies of safety efforts like the Tohono O’odham Nation is conducting. “We are excited about the potential for using GIS-based data collection and analysis tools to improve our partners’ ability to improve their safety analysis capabilities by leveraging the data they already have, utilizing

open-source and other publicly-available tools such as the University of Wisconsin-Madison’s CurveFinder application, and applying our data analysis framework,” he says. “These tools make it easier to review broad road networks, especially for rural and often lower-volume roadways, and determine cost-effective systemic improvements that can be included as part of a safety action plan, RSA, and other capital or maintenance-type projects.”

### How does FLH Keep Denali National Park Accessible? With Endurance.

FLH responds to the needs of its partner agencies. As such, with the National Park Service (NPS), FLH will supply and assign several dozen engineers and inspectors to oversee construction of a new 400-foot (122-meter) bridge in Alaska’s Denali National Park. This bridge will span the actively moving Pretty Rocks landslide. Since there is nearly 24 hours of daylight during summers in Alaska, FLH staff and contractors will work around the clock, full days and nights, to usher this project to completion, to restore road access to affected areas. Construction is scheduled to start in the summer of 2022 and be completed by fall of 2023. The project also consists of reconstructing a section of the park’s Denali Park Road. Ground anchors will likely be needed to stabilize the rock mass at the proposed bridge abutments—and the new bridge will likely require realignment of the Denali Park Road and excavation at either end of the bridge.

Construction will take place at mile-post 45.4, a section of the 92.5 miles (148.9 kilometers) long Denali Park Road that was closed to traffic due to significant changes by ongoing movement of the



The Tohono O’odham Nation Route 21 Crowdsource Reporter is an online mapping tool that displays the types of crashes that occurred along a particular route as well as points on the route that were documented via the virtual tours camera kit.

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Pretty Rocks in Alaska's Denali National Park is named for the reddish-brown basalt and the varying rock types in a compressed site.

Source: FHWA.

landslide. Rock is steadily slipping into the valley floor below, causing the access road to shift. NPS could no longer safely maintain access, and had to close the road to all traffic, affecting tourists, concessionaires, and in-holders (landowners and lodges with the Kantishna community).

During the summer of 2021, the Pretty Rocks landslide, at milepost 45.4, accelerated from approximately 2 inches (5.1 centimeters) per day to over 1 foot (0.3 meters) per day. A year prior, in the summer of 2020, the road's elevation dropped 30 feet (9.1 meters) over a few months. Nonetheless, Pretty Rocks is actually considered a rock glacier—a relatively slow-moving landslide.

Due to the increase in movement of Pretty Rocks, the remaining 47 miles of the Denali Park Road, beyond milepost 45.4, will remain inaccessible to traffic until the construction project is complete. Prior to



Field crews from the Western Federal Lands Highway Division visit the Pretty Rocks landslide to scope potential remedies for the land glacier as seen on the right side of the photo extending from the road into the valley below.

Source: FHWA.



The Denali Park Road is nearly 93 miles, running east to west. Locations are usually referred to by their mile number, meaning how many miles they are from the eastern end (park entrance, Mile 0). The project location is near Mile 46, Polychrome Overlook.

@ NPS Image.

2020, the Denali National Park received over 600,000 visitors annually, mostly accessing the road by bus. The road is still accessible up to the project location at milepost 45.4.

### Conclusion:

In addition to a commitment to tenacity, ingenuity, and endurance, the staff of FLH utilize their expertise, physical strength, and problem-solving skills to help keep America accessible and moving. In the wake of COVID-19 travel restrictions, FLH performed their mission through ingenious solutions such as shipped camera kits and the use of desktop GIS-data to identify and remedy safety problems along roads in remote Tribal lands. Furthermore, engineers were quick to design a solution for a complex land glacier in Denali National Park so that patrons can access this national,

treasured destination. When opportunity strikes, no matter the time of day, night, or location, FLH is there to assist its partners and the traveling public to reach destinations across the Nation with the confidence of a safe and reliable roadway.

**ADAM LARSEN** is a safety engineer within the FHWA Office of Tribal Transportation, providing safety technical assistance to Tribes and managing the Tribal Transportation Program Safety Fund.

**BRANDON STOKES, P.E.**, is an experienced civil engineer and project manager with the FHWA Office of Federal Lands Highway. He currently manages such projects as the Denali National Park and Reserve, the Federal Lands Access Program, and the Emergency Relief for Federally Owned Roads.

For more information, contact Adam Larsen ([adam.larsen@dot.gov](mailto:adam.larsen@dot.gov)) or Brandon Stokes ([brandon.stokes@dot.gov](mailto:brandon.stokes@dot.gov)).

### On A Mission

The mission of the U.S. Department of Transportation is ensuring that America has the safest, most efficient, and modern transportation system in the world, which boosts our economic activity and global competitiveness and enhances the quality of life in communities both rural and urban.

The mission of the FHWA Office of Tribal Transportation is:

*Through mutual respect and understanding, enhance the quality of life in Tribal communities by supporting the Tribes' delivery of transportation programs.*

For more information, visit <https://highways.dot.gov/federal-lands/programs-tribal>.

# ADDRESSING CLIMATE CHANGE: A look inside Minnesota Clean Energy and Connectivity Projects

## MnDOT Commits to Climate Action.

by SIRI SIMONS, JESSICA OH, and DAVID SCOTT

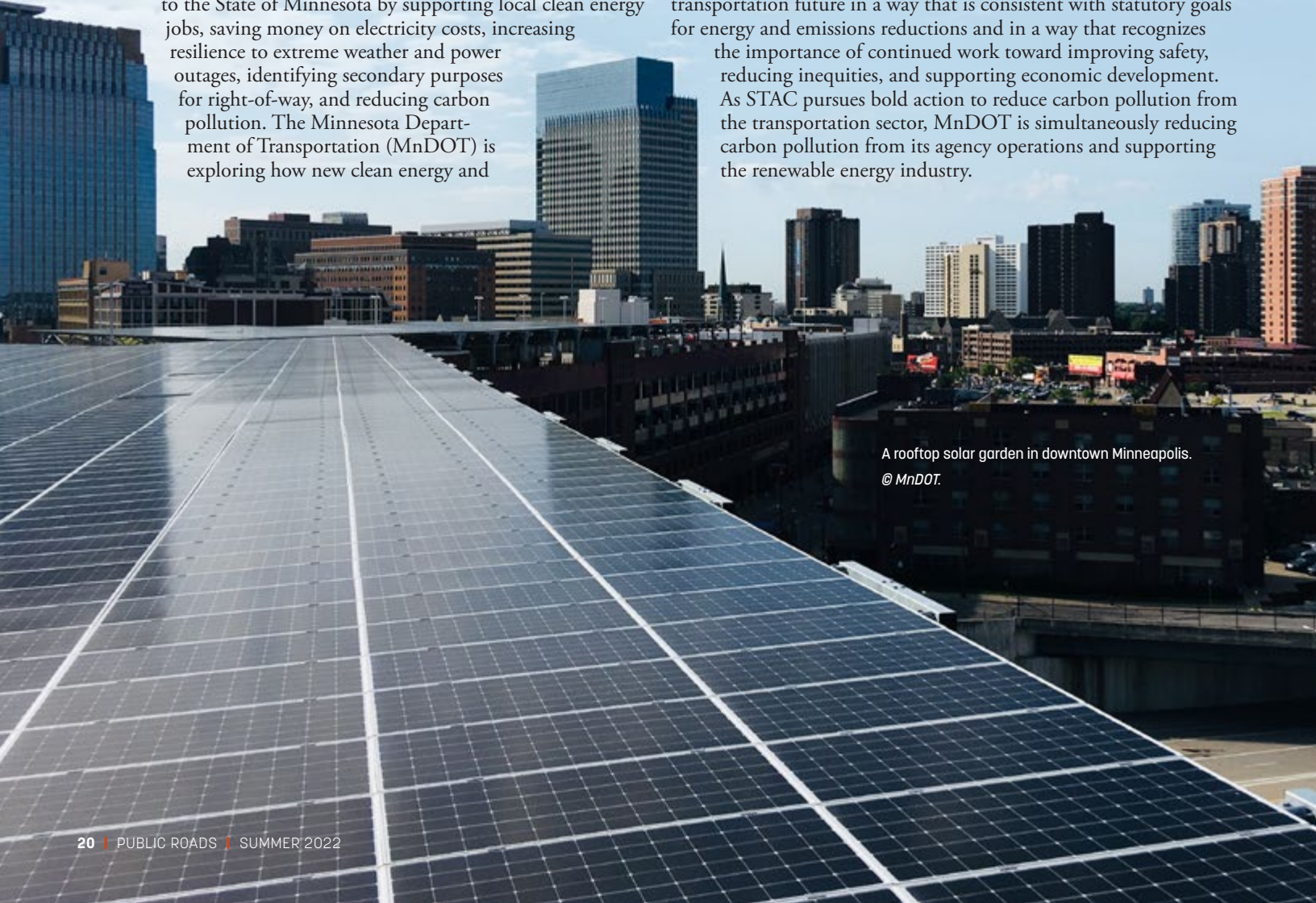
In the words of American horticulturist Liberty Hyde Bailey, “A garden requires patient labor and attention. Plants do not grow merely to satisfy ambitions or to fulfill good intentions. They thrive because someone expended effort on them.” The same can be said of a solar garden that harvests large amounts of electricity.

Climate change is impacting Minnesota; the transportation and electric sectors are the largest two sources of carbon pollution, and the weather is getting warmer and wetter, including frequent, intense, and damaging rainfalls. The impacts can be seen across the State, from the increased severity and regularity of floods and wildfires to the worsening air quality that harms public health.

The use of solar energy can arrest these worsening effects of climate change. For this reason, solar energy projects are beneficial to the State of Minnesota by supporting local clean energy jobs, saving money on electricity costs, increasing resilience to extreme weather and power outages, identifying secondary purposes for right-of-way, and reducing carbon pollution. The Minnesota Department of Transportation (MnDOT) is exploring how new clean energy and

connectivity projects can leverage the full value and productivity of existing highway right-of-way to meet sustainability and clean energy goals.

Past work to reduce carbon pollution has been directed by the Minnesota Legislature and through internal MnDOT leadership in related plans, goals, and performance measures. The State of Minnesota is not currently on track to meet emission reduction goals under Minnesota’s Next Generation Energy Act; the need to take bold action is urgent. Therefore, in 2020, MnDOT convened a new Sustainable Transportation Advisory Council (STAC), following recommendations outlined in the agency’s 2019 *Pathways to Decarbonizing Transportation in Minnesota* report. STAC is charged with helping Minnesota transition to a low-carbon transportation future in a way that is consistent with statutory goals for energy and emissions reductions and in a way that recognizes the importance of continued work toward improving safety, reducing inequities, and supporting economic development. As STAC pursues bold action to reduce carbon pollution from the transportation sector, MnDOT is simultaneously reducing carbon pollution from its agency operations and supporting the renewable energy industry.



A rooftop solar garden in downtown Minneapolis.  
© MnDOT.

## The First Stage of Commitment

In April of 2019, the Governor of Minnesota issued Executive Order (EO) 19-27 ([https://mn.gov/governor/assets/2019\\_04\\_04\\_EO\\_19-27\\_tcm1055-378973.pdf](https://mn.gov/governor/assets/2019_04_04_EO_19-27_tcm1055-378973.pdf)) that directed State agencies to reduce greenhouse gas (GHG) emissions 30 percent from 2005 levels by 2025 and reduce facility energy use 30 percent from 2017 levels by 2027. In late 2018, MnDOT established a chief sustainability officer and two sustainability coordinator positions in the Office of Sustainability to work with key partners and stakeholders to champion long-term, cost-effective investments that improve energy efficiency, renewable energy, transportation electrification, and resource conservation. In 2019, as a follow up action, MnDOT created an assistant commissioner role to lead a Sustainability and Public Health Division to address the climate crisis and improve public health for all Minnesotans, especially the vulnerable populations who will be most impacted by the effects of climate change.

The MnDOT Sustainability and Public Health Division has five focus areas that connect back to agency and statutory transportation and climate goals. The focus areas include:

1. Reducing carbon pollution from the transportation sector in all modes.
2. Increasing operational efficiencies that support EOs, including efforts to reduce fuel consumption and energy use, and investments in solar projects.
3. Improving resilience of the transportation system to climate change and other natural and human disruptions.
4. Promoting public health in transportation decisionmaking.
5. Developing creative strategic partnerships with nontraditional partners to improve the lives of people and communities in Minnesota.

## Community Solar Projects

To reduce GHG emissions from agency operations, meet agency energy needs, reduce long-term operational costs, support cost planning, and improve agency resilience, MnDOT is pursuing solar energy on its right-of-way areas and through community solar garden subscriptions. MnDOT holds subscriptions to two community solar gardens on agency property and 15 community solar gardens off-site. One early effort was an agreement with a nonprofit community solar garden developer to install a 1.4 megawatt solar garden on the top of



A rooftop solar garden on the ABC Ramps Mobility Hub in downtown Minneapolis.

© MnDOT.

a large downtown Minneapolis Mobility Hub and parking garage, known as the ABC Ramps Mobility Hub. The 3,760 elevated solar panels in this solar garden provide weather coverage for vehicles without losing any parking spaces. MnDOT is a backup subscriber for 20 percent to 40 percent of the energy produced for 25 years, and bill credits offset MnDOT Metro District electricity costs for lighting on Interstate 394 in Hennepin County. The agency saves \$.01 per kilowatt-hours of electricity generated by the project.

## Solar Gardens Defined

Community Solar Gardens (also called Community Solar and Community-Shared Solar) are centrally located solar photovoltaic (PV) systems that produce electricity for participating subscribers. They are a way for people in Minnesota to benefit from solar PV systems without installing their own stand-alone project. Programs vary by utility in Minnesota; many cooperative utility customers can subscribe to a project owned by their local utility.

In 2019, MnDOT issued a request for proposals to purchase community solar garden subscriptions for facilities and operations serviced by the servicing electrical utility. In October 2019, the agency

announced two 25-year agreements with local community solar garden developers to purchase 7.4 million kilowatt-hours annually from 14 different gardens within the State to support agency operations in 18 counties. This is equivalent to approximately 24 percent of the agency's total annual electricity use. "MnDOT has partnered with private industry and nonprofits to support solar energy as a way to save money on electricity, reduce pollution, and lead by example in the transition to a low carbon economy," says Tim Sexton, MnDOT's chief sustainability officer.

## MnDOT's Solar Project Guiding Principles

As MnDOT gains more and more experience in solar projects, past operations and successes are reviewed. From it, MnDOT has identified a set of guiding principles to promote consistency with the agency's vision and mission, and to support the sustainability goals declared in the annual *MnDOT Sustainability and Public Health Report*. The following principles will evolve as more experience is acquired and input is received:

- Solar projects should generally be cost-neutral or save money for the agency.
- MnDOT may pursue solar projects with higher costs if the project supports the agency's vision (e.g., improve access to renewable energy by low-income residents).
- Solar projects should support agency goals around equity and diversity in contracting.
- Renewable energy credits (RECs) should help MnDOT meet agency sustainability goals for renewable energy and to reduce carbon pollution. When RECs are available for a solar project, costs should be estimated with and without RECs. Decisions about



A 1 megawatt community solar garden in Afton, MN. This location was formerly a gravel pit.  
© MnDOT.

purchasing RECs, or replacement RECs, should weigh the cost of the RECs against the financial viability of the project. Projects without RECs advance agency renewable energy goals and the spirit of EO 19-27, while purchasing RECs help MnDOT make progress toward the GHG emissions reduction goal in EO 19-27.

- Solar projects should offset as much annual average energy load as possible, while minimizing excess energy returned to the grid. MnDOT does not want to become net energy producers.
- All new building projects and roof upgrades should evaluate the potential to install cost effective solar panels.
- When MnDOT receives unsolicited solar proposals in MnDOT right-of-way, staff may gather additional information to explore new ideas. Once a potential project is identified, the agency may explore posting a competitive solicitation.

MnDOT worked with a second community solar garden developer to construct a 1 megawatt community solar garden on

agency property at a former gravel pit south of Interstate 94, near the city of Afton. Project development started in 2016 and was completed in fall 2020. MnDOT receives lease payments and subscribes to 40 percent of the total subscriptions for energy produced at the site. Bill credits from this community garden offset electricity costs for the MnDOT Metro District headquarters building in Roseville, MN, which was the first ground-mounted community solar garden project on MnDOT-owned property. MnDOT is continuing to work with the same developer to add a second 1 megawatt community solar garden at the same site in 2022. Bill credits from this garden will be assigned to MnDOT facilities in the Twin Cities area.

MnDOT will continue to seek out opportunities to support solar energy on and off the right-of-way. Recently, MnDOT installed the agency’s first solar array outside of utility company, Xcel Energy, territory at the MnDOT facility in Morris, MN. The 150 kilowatt array demonstrates the feasibility of installing solar at agency headquarters and truck stations throughout the State. Going forward, the agency will update

facility design standards for truck stations to include solar on new construction when it’s cost-effective.

MnDOT is also exploring collaborations with Tribal nations and other stakeholders to advance joint carbon reduction and economic development goals. “We’re exploring innovative partnership models that go beyond MnDOT energy needs and offer benefits to the State of Minnesota more broadly,” says Levi Brown, MnDOT’s director of Tribal affairs.

### Advancing Clean Energy and Connectivity through Next Generation Highways

To support Federal and State goals for decarbonizing the economy and electrifying transportation, additional electricity transmission is needed to incorporate renewable resources, serve new loads (especially for electrical vehicle (EV) charging) and improve grid reliability. Recognition of the need for investments in the electricity grid were apparent in the Infrastructure Investment and Jobs Act (IIJA), signed into law on November 15, 2021. In 2021, MnDOT joined a feasibility

### Lessons Learned from Siting Solar Gardens

- Start with underutilized right-of-way that will not interfere with future transportation needs.
- Consider sites with opportunities for co-benefits for air quality improvements.
- Propose strategic locations for commercial solar developers with high solar potential.
- Select a site that can accommodate native plants and pollinator habitats.
- Seek early and frequent coordination with solar garden developer and internal offices for efficient project implementation.

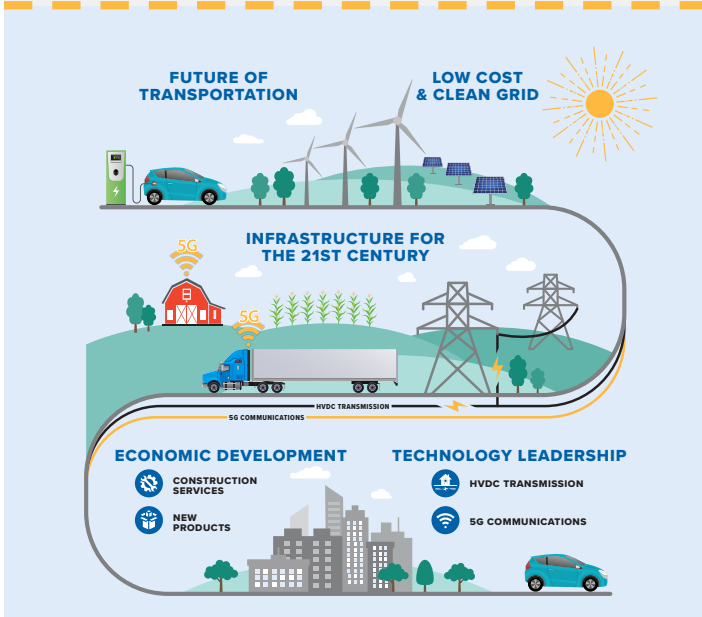


Solar Garden installation at a MnDOT operations and maintenance building in Morris, MN.  
© MnDOT.



# Next Generation Highways

CO-LOCATING THE TRANSPORT OF VEHICLES,  
ENERGY, AND INFORMATION



Next Generation Highways.

@ NGI Consulting. Graphic created by FHWA.

assessment to evaluate technical and regulatory considerations for Next Generation Highways—highways that strategically co-locate buried high-voltage direct current (HVDC) transmission lines with broadband in highway right-of-way. Through its Next Generation Highways work, MnDOT is evaluating whether existing highway right-of-way can be used to accelerate the siting and permitting of new buried transmission lines. “The development of new transmission infrastructure can take seven to 10 years for a single large-scale project,” said Laura Rogers, deputy director for The Ray, MnDOT’s nonprofit feasibility assessment partner. “Our roadsides are part of the solution hiding in plain sight. By leveraging the public right-of-way for transmission siting, we can expedite the grid expansion that we need to support connected and electric transportation.” The development timeline for electrical transmission must be reduced for Minnesota to have the electric grid it needs for government, people, and businesses to achieve their climate goals. The NextGen Highways Workgroup believes that the decade-long transmission development timeline could be reduced to five years or less through the siting of buried HVDC transmission in interstates and other existing highway rights-of-way. Notably, there is significant societal value to be realized from this reduction in the permitting timeline for a typical large-scale transmission project.

MnDOT activated a NextGen Highways workgroup with more than a dozen offices including Utility Accommodation, Intelligent Transportation Systems (ITS), Right of Way, and Connected and Autonomous Vehicles to evaluate the safety, statutory environment, and long-term planning implications of this model. It became immediately clear that this analysis could align many different internal planning efforts to leverage highway right-of-way to meet future needs—connected and autonomous ITS investments, EV charging infrastructure, and State fiber assets—in a strategic way. MnDOT, like many State departments of transportation, has a prohibition on longitudinal utilities in controlled access environments. Allowing a buried transmission line in interstate rights-of-way would be a significant shift in policy for MnDOT.

“Nationally, interest in these alternative uses of rights-of-way to support modernizing the grid and decarbonization goals is increasing. Leveraging existing highway rights-of-way for clean energy and connectivity projects are attracting the attention of the Department of Energy and USDOT to address insufficient transmission capacity and the need for a more resilient electric grid in the United States” Sexton says.

Several considerations are central to MnDOT’s analysis, including addressing future utility relocation expenses, public-private partnership models, siting limitations, and maximizing dig-once coordination for additional State fiber needs. The analysis, or feasibility assessment, has underscored the need for coordination among other State agencies including the Public Utilities Commission (PUC) and the Minnesota Department of Commerce. MnDOT is evaluating how its jurisdictional authority over highway right-of-way interacts with the transmission siting and permitting process conducted by the PUC and Department of Commerce. The assessment was published in April 2022 (<https://www.buildngi.com/work-1/nextgen-highways>) and additional short-term actions include more coordination with statewide broadband expansion plans, updates to MnDOT utility accommodation policies and process, and analysis of priority corridors to pilot the co-location of fiber with buried HVDC transmission lines.

**SIRI SIMONS** is the sustainability program supervisor in MnDOT’s Division of Sustainability and Public Health. She leads and coordinates statewide transportation sustainability efforts, including the Clean Transportation Pilot Program, statewide EV planning, and the Governor’s Climate Change Subcabinet - Transportation Action Team.

**JESSICA OH** is MnDOT’s strategic partnerships director in the Sustainability and Public Health division. In her role, she facilitates public-private partnerships supporting quality of life, public health, alternative uses of right-of-way, and clean energy and connectivity projects.

**DAVID SCOTT** is the deputy division administrator with the FHWA Minnesota Division and oversees general operations. He holds a B.S. in civil engineering from the University of Massachusetts.

For more information, see <http://www.dot.state.mn.us/sustainability/>, <http://www.dot.state.mn.us/sustainability/solar.html>, and <http://www.dot.state.mn.us/sustainability/docs/2019-sustainability-report.pdf>, or you may contact David Scott ([david.scott@dot.gov](mailto:david.scott@dot.gov); 651-291-6103) or Siri Simons ([siri.simons@state.mn.us](mailto:siri.simons@state.mn.us); 651-366-4834).



Burying transmission lines will prove beneficial and could support clean energy efforts.

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# Exploring the Transportation Pooled Fund Program—

## Advancing Research and Innovation Through Collaboration

The TPF Program helps to solve common transportation problems at a fraction of the cost by leveraging partnerships across the transportation sector.

by **PATRICIA SERGESON**

We are in an unprecedented time of opportunity and need in transportation. Following the enactment of the Bipartisan Infrastructure Investment and Jobs Act into law in November 2021, identifying proven research, innovation, and new technologies to meet the pressing needs of the transportation sector has become even more important. Transportation stakeholders face a multitude of issues from safety concerns to bridge degradation. Many of these issues are not unique to one area or agency. The Transportation Pooled Fund (TPF) Program provides an opportunity for stakeholders to address common concerns by collaborating to leverage resources, funding, and expertise to study projects of common interest.

The research and innovation conducted through the TPF Program not only helps address stakeholders' shared transportation problems, but also advances the state of practice. One of the Federal Highway Administration's strategic goals is to "lead in the development and deployment of innovative practices and technologies to improve the safety and performance of the Nation's transportation system." This goal is further described in the U.S. Department of Transportation's innovation principles, including allowing for experimentation and failure, providing opportunities to collaborate, and being flexible and adaptable as technology changes. FHWA is helping to accelerate this goal and the innovation principles through its investment and facilitation

of the TPF Program. Many TPF studies have produced research, new innovations, or best practices that were later adopted and institutionalized around the world. The TPF Program has demonstrated that it helps to save time and resources, increases knowledge transfer, and produces proven research and innovations that improve the state of the practice.

### What is the TPF Program?

The TPF Program is a collaborative program that has existed for more than 45 years. It creates an opportunity for partners to pool their funds, subject matter expertise, and resources to conduct high priority research to meet a wide variety of shared transportation problems. Being able to pool funds allows participants to get more out of the study than if they conducted the study on their own. By pooling funds and expertise, participants develop innovative solutions with a smaller investment while also extending the reach and impact of their research. Projects that previously could have been cost prohibitive become much more achievable through participation in the TPF Program. By offering hundreds of active pooled fund studies, the TPF Program assists partners in finding and funding projects applicable to their agency's needs.

Since 2003, the TPF Program has processed more than \$615 million in collaborative funding. As of February 2022, there were over 167 active projects and 10 open solicitations. One hundred



The Transportation Pooled Fund Program enables State departments of transportation, and other public and private entities, to combine resources to address transportation-related challenges. By combining efforts and resources on high-priority highway research topics such as high friction surface pavement treatments, steel bridge maintenance, and bicyclist and pedestrian safety, our Nation's transportation agencies can advance solutions that stimulate economic growth, advance equity, and improve safety.

Source: FHWA.

fourteen of those active projects were led by State departments of transportation (DOTs) and 53 were led by FHWA, and span a wide array of topic areas. The diverse topics allow transportation partners

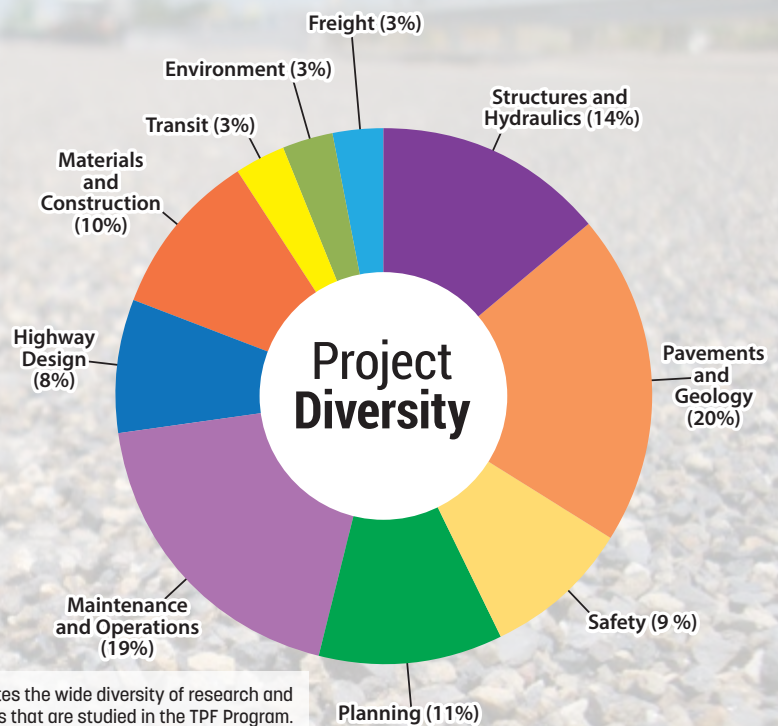
to remain nimble and focus on solving their specific transportation issues while stretching their funds to learn about a wide array of topic areas.

### TPF Program by the Numbers

TPF Program Area	Total	FHWA	State DOT
Active projects	167	53	114
Total funding (active and closed projects)	\$614,886,428	\$236,479,186	\$378,407,242
Total active project funding	\$319,206,130	\$133,310,351	\$185,895,779
Open solicitations	10	0	10
Completed projects	446	177	269

An overview of the TPF Program funding and current projects.

Source: FHWA.



This graphic demonstrates the wide diversity of research and innovation topics that are studied in the TPF Program.

Source: FHWA.



## Save Time and Resources

One of the greatest benefits of the TPF Program is the ability to leverage limited funds and increase a partner's return on investment (ROI). By pooling funds, some agencies are able to participate in larger-scale research efforts that would otherwise not be feasible. Through collaborative partnerships, agencies can solve shared problems at a fraction of the cost of conducting the research alone.

Iowa DOT's participation in the TPF Program is one example of successful collaborative partnerships. Iowa DOT currently works with more than 48 State partners on their 20 active pooled fund projects. By working with these partners, Iowa DOT has documented that the average pooled fund returns a benefit of 18 times greater than its cost to Iowa DOT.

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**“By sharing the research cost and oversight with other State DOTs through the Federal TPF Program, Iowa DOT has found a way to get the best of both worlds: cutting-edge research within an established budget.”**

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“Iowa DOT is always on the lookout for new materials, methods, and technologies that can help improve safety, increase efficiency, and save money. However, transportation research projects can be expensive, and often Iowa is interested in lines of inquiry that might duplicate efforts of other States with similar needs. By sharing the research cost and oversight with other State DOTs through the Federal TPF Program, Iowa DOT has found a way to get the best of both worlds: cutting-edge research within an established budget,” says Khyle Clute, Iowa DOT State planning and research engineer.

Iowa DOT has found that without participating in these pooled fund studies,

it would take 67 years to fund the same amount of research. Pooled Fund studies help partners to join together and share the benefits of the research results.

Washington State DOT (WSDOT) also explained the value and benefit of their participation in the TPF Program. “WSDOT participated in a total of 38 transportation research pooled funds of all sizes in FY 2020, contributing \$2,126,500 to the \$51,364,973, raised by the collective effort of participating States and others for these projects,” says Jon Peterson, multi-modal research manager, research and library services for WSDOT's transportation safety and systems analysis division. “By combining our funds with the other States, in return for every \$1 dollar of pooled fund investment during this time period, WSDOT benefitted from an estimated \$24 dollars of research power, sparking innovation, and enabling us to implement new, promising techniques into agency processes and project design.”

While the specific ROI varies by partner, WSDOT and Iowa DOT are both great examples of how States can use limited funding to meet their needs through participation in the TPF Program.



## Partnerships and Collaboration

Another advantage of joining the TPF Program is the knowledge transfer that occurs via partnerships and collaboration. Every TPF study is assigned an FHWA subject matter expert in that research topic area. In addition, each study forms a Technical Advisory Committee that includes agency representatives and subject matter experts from all partners. This allows for knowledge and technology transfer across staff at different agencies. Participants are able to learn from each others' experience and form connections that not only can assist with that specific research but also benefit in other areas as well.

The Smart Work Zone Deployment Initiative (SWZDI), study number TPF-5(295), is a great example of the benefits that come through the partnerships and collaboration of the TPF Program. Partners have built momentum from the relationships developed by sharing experiences and lessons learned. SWZDI partners include State DOTs, universities, State Local Technical Assistance Programs (LTAPs), and industry professionals.

In 2019, there were 762 crashes related to work zones and 842 fatalities, according to data from the National Work Zone

Safety Information Clearinghouse on the American Road & Transportation Builders Association's website. SWZDI has leveraged partnerships to produce more than 90 studies, evaluations, and research products addressing safety and mobility in work zones. The study topics change every year to adapt to the most pressing safety needs of the different partners. For a list of completed SWZDI studies from 2000 to 2022, visit <https://swzdi.intrans.iastate.edu/research/completed/>. One example of the completed research is the use of portable variable speed limit signs to improve safety and operational efficiency. The goal of this system is to provide a dynamic means to reduce speeds as needed in active construction zones.

Other topics studied include driveway assistance devices, autonomous/connected vehicles in work zones, a smartphone-based prototype system for incident work zone management driven by crowd-sourced data, evaluation of temporary work zone pavement markings, and many more. The TPF SWZDI study has served as a research arm to help solve common problems of the partner agencies.

“The SWZDI pooled fund provides an approach for members to do initial or follow-up explorations of tools, technologies, and methodologies that may help improve the mobility and safety of work zones,” says Iowa LTAP Director and SWZDI Program Manager Keith Knapp. “It also provides a venue for member States to network, collaborate, and communicate



Example of a warning sign used in traffic control zones.

Source: FHWA.



“This pooled fund study has been invaluable to both MDOT and the staff in the safety programs area.”

High friction surface treatments, one of the proven low-cost safety countermeasures studied by TPF-5(317), reduces crashes at horizontal curves up to 48 percent.

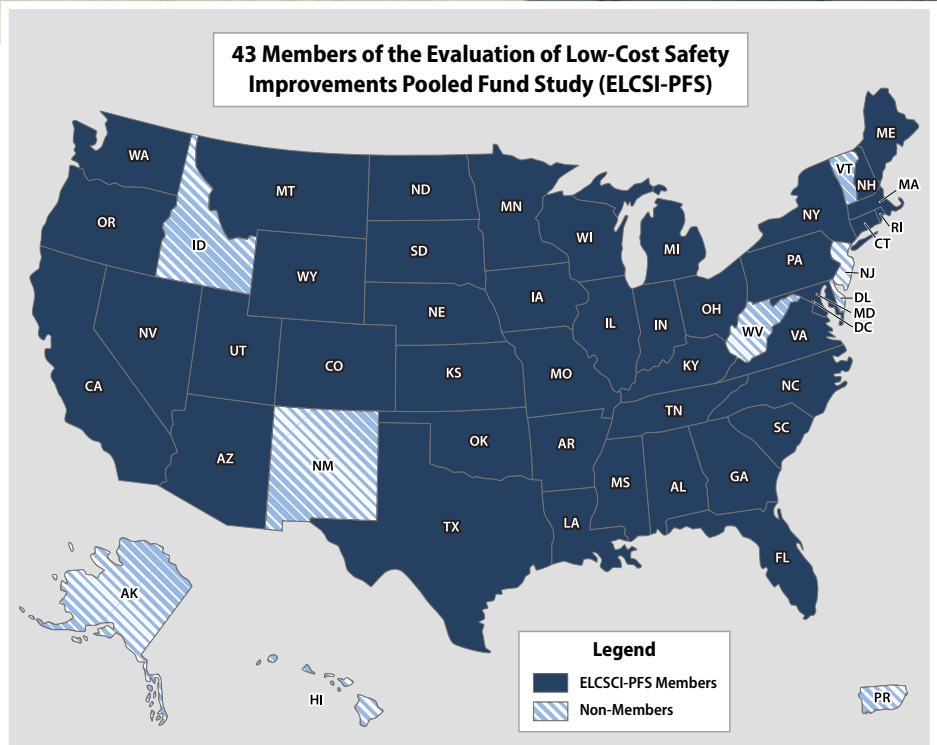
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about their experiences, needs, and approaches with a wide range of existing and proposed work zone issues.”

Partnerships across agencies, like those formed in the SWZDI study, help with continuity. Many organizations and agencies have consistent staff turnover and changes. TPF studies provide a means for new staff at those organizations to learn through documented past challenges and lessons learned, and by meeting other subject matter experts who can share their institutional knowledge. SWDZI members have also seen this benefit.

Another great example of using partnerships and collaborations to move innovation forward is the Evaluation of Low-Cost Safety Improvements Pooled Fund Study (ELCSCI-PFS), study number TPF-5(317). This study has one of the largest participation rates, with more than 43 partner agencies.

“This pooled fund study has been invaluable to both MDOT (Michigan DOT) and the staff in the safety programs



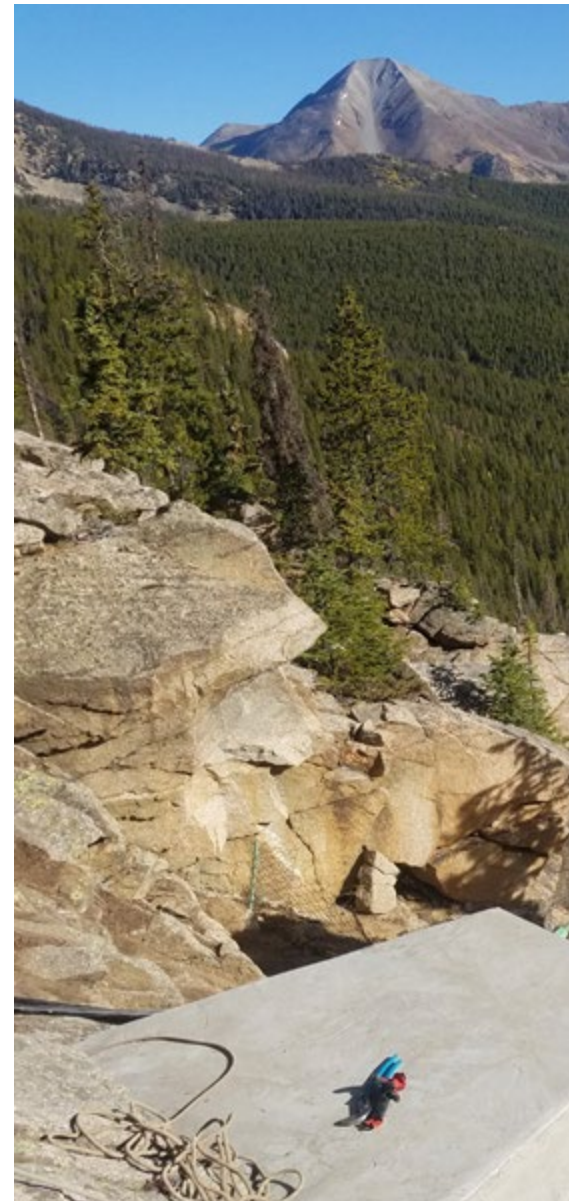
The Low-Cost Safety Improvements Study works with more than 43 partner agencies.

Source: FHWA.



The Transportation Avalanche Research Pool study evaluated avalanche mitigation technology that uses a hydrogen/oxygen gas mixture housed inside an open cone shell to create pin-point explosions to trigger avalanches. The structure is semipermanent and positioned in known avalanche start areas before the snow season begins.

© 2019 Colorado Department of Transportation.



area. The annual meeting allows various staff members to learn about new and improved low-cost safety improvements and, more importantly, to network and learn from fellow DOTs and researchers,” says Mark Bott, engineer of traffic and safety for MDOT.

Through collaboration, the study has issued over 60 publications studying low-cost safety countermeasures.



### Institutionalizing Proven Innovations and Best Practices

The research produced by partners in the TPF Program has helped to influence and improve the state of the practice. Several studies have produced research and innovations that have been later adopted as an institutionalized best practice. The ELCSI study has helped to

document safety solutions for budgets of all sizes. While some countermeasures may appear to be minimal, they have been proven to reduce crashes. With an estimated 36,096 traffic-related deaths in 2019, this study helps evaluate potential low-cost improvements by their benefit to cost ratio, overall effectiveness, and other technical information (material, design, and construction). The proven research, technologies, and innovations from the study have been incorporated as institutionalized best practices across the country. Countermeasures such as wrong-way alert systems, mumble strips, increased retroreflectivity, improved curve delineation, and many more are included in some of the published reports.

“ELCSI will continue to be pertinent and valuable to highway practitioners and stakeholders for years to come,” says Roya

Amjadi, research highway safety specialist, FHWA’s Office of Safety Research & Development.

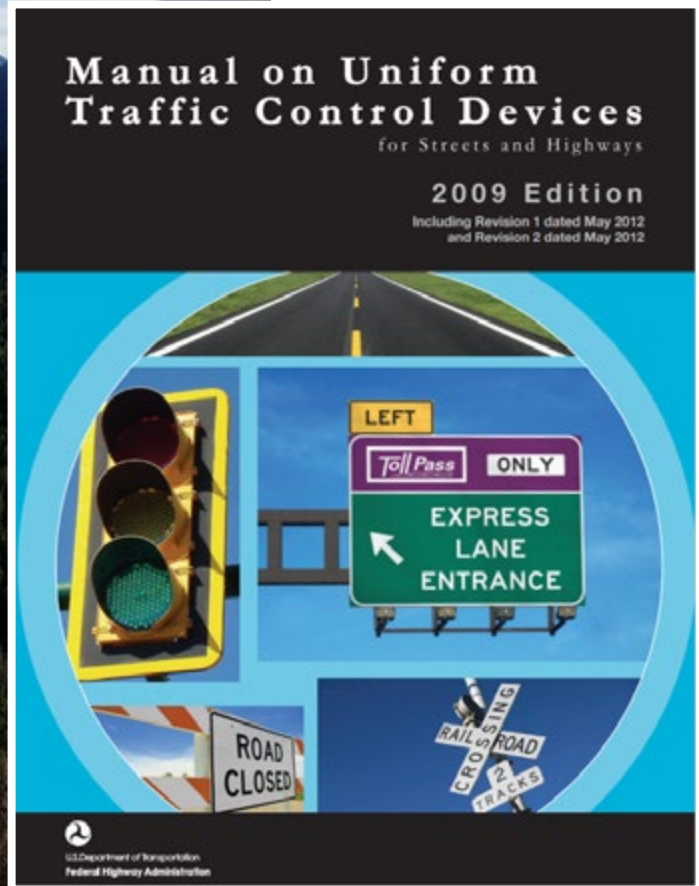
Another TPF study that stakeholders have seen benefits from is the Transportation Avalanche Research Pool (TARP), study number TPF-5(337). The TARP study explores research related to avalanche mitigation equipment to improve the safety and efficiency of highway transportation in mountain corridors. Reducing the avalanche hazard to transportation corridors is crucial to the winter operations of agencies around the world. Participation in this study includes State DOTs and international partners facing similar pressing avalanche hazard issues. TARP has studied various remote avalanche control systems to perform hazard mitigation without any needed human interaction.

“TARP is one of the most successful



The TPF-5(337) study looked at the effectiveness of remote avalanche control systems to reduce avalanche hazards along highway corridors.

@ 2019 Colorado Department of Transportation.



The TCD Consortium Pooled Fund study has led to changes that have been incorporated into the MUTCD. The MUTCD establishes the minimum traffic control device standards to ensure uniformity of traffic control devices across the Nation.

Source: FHWA.

pooled funds I have participated in, and having international partners adds a lot of perspective and value to our group,” says Jamie Yount, winter operations program manager at Colorado DOT. “TARP brings almost all of the highway avalanche programs in North America together for a strong collaborative effort that has produced valuable research that has delivered meaningful results on the highway.”

Many of the innovations identified in the TPF-5(337) study have been further developed and implemented in mountain corridors around the world. According to one of TARP’s international partners, “We (Milford Roads) find the TARP work hugely valuable, and many innovations discussed or developed there [are ones] we have picked up or developed further,” says Kevin Thompson, Milford Road alliance manager, Fiordland, New Zealand.

Research conducted through TPF studies allows for States to stay agile and adopt some of the most current up-to-date innovations and best practices. For example, the Traffic Control Device (TCD) Consortium, study number TPF-5(447) demonstrates how research can continue to adapt to the needs of transportation agencies. The purpose of the TCD study is to address emerging traffic control device (TCD) research needs by evaluating the efficacy of novel TCDs for potential incorporation into the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) to best meet agencies’ changing needs.

“The TCD Pooled Fund study provides a venue for collaboration and information sharing among members,” says Laura Mero, FHWA research psychologist.

The TPF-5(447) study conducts cutting edge research to provide local and State

agencies with a faster response to both their existing TCD needs, as well as emerging needs brought on by new technologies.

“The TCD Consortium Pooled Fund Study has proven to be an invaluable mechanism for providing timely, efficient human factors evaluation of a variety of new concepts and applications for the MUTCD,” say FHWA’s Martin (Marty) Calawa, transportation specialist, and Kevin Sylvester, lead transportation specialist. “A great number of changes found in the 2009 MUTCD were supported by the results of this Pooled Fund project, as well as a number of interim approvals, so that road users could benefit without having to wait for the next edition of the MUTCD,” say Calawa and Sylvester.

The TCD Consortium Pooled Fund study results have led to significant changes that have been incorporated into the

MUTCD, influencing design and construction standards across the country.

These studies are examples of the great work that is being done through collaboration and partnerships in the TPF Program. More details about study results are posted to an interactive TPF website at <https://www.pooledfund.org/>. The posted results not only benefit those that are part of the TPF study, but also other partners that would like to learn about the topic.

### Program Participation

For interested participants, TPF studies must be initiated and led by either a State DOT or FHWA. The TPF Program is unique in that it allows for a wide variety of partners to participate and collaborate. For example, the program embraces public/private partnerships and international organization participation. The following types of agencies are encouraged to join as study partners:

- FHWA.
- State DOTs.
- Federal agencies.
- Regional and local agencies.

- Academic institutions.
- Associations.
- Private industry.
- Foreign entities in positive standing with the U.S. Government.

### Looking to the Future

The TPF Program has produced high value research and innovations that have been adopted and institutionalized by partner agencies around the world. It serves as a great resource to leverage limited funds to address important transportation issues. Through collaboration, transportation agencies can adapt as technology changes, experiment, learn from failures, reduce duplicate research practices, build on each other's successes and expertise, and improve the transportation system. The TPF Program is excited for the future research that will be conducted to address stakeholders' needs and improve the transportation system.

To help support this future research, there will be enhancements to the TPF website, updated manuals, and new training on the TPF process. Also, a biennial TPF Excellence Award will be launched, which will recognize two TPF studies each cycle

that have made a significant impact toward advancing national research efforts through meaningful partnerships and collaboration. The award will be a great opportunity to highlight the work achieved through the TPF Program.

New solicitations and projects are posted every month on the TPF website, as well as updated resources for the program and opportunities to help meet your agency's needs and goals. For more information about initiating a Pooled Fund study and viewing a list of open solicitations, visit the TPF website at <https://www.pooledfund.org/> or contact Tricia Sergeson at [patricia.sergeson@dot.gov](mailto:patricia.sergeson@dot.gov).

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**PATRICIA SERGESON**, MPA, PMP, is the TPF program manager and State planning and research, subpart B funding point of contact with FHWA's Turner-Fairbank Highway Research Center in McLean, VA. She has a master's degree from Rutgers University in public administration, and two bachelor's degrees—one in political science and another in foreign languages (Spanish) from Washington State University.

## TPF Global Partner Participation

### CANADA

#### Alberta

- City of Edmonton

#### British Columbia

- 360° Networks, Vancouver
- BC Hydro, Vancouver
- British Columbia Ministry of Transportation & Infrastructure, Nelson
- Greater Vancouver Area
- Transport Canada, Richmond

#### Manitoba

- Manitoba Infrastructure, Winnipeg
- Manitoba Transportation, Winnipeg

#### Ontario

- Greater Toronto Area
- Ontario Ministry of Transportation, St. Catherine
- Royal Military College of Canada, Kingston
- Transport Canada, Ottawa

#### Quebec

- Quebec Ministry of Transportation, Quebec City

#### Saskatchewan

- International Road Dynamics, INC, Saskatoon

### NETHERLANDS

- HITEC, Amsterdam

### NEW ZEALAND

- Milford Road, Dunedin

### TURKEY

- GanTek, Istanbul

### UNITED KINGDOM

- University of Nottingham

The Transportation Pooled Fund Program collaborates with partners all over the world.

Source: FHWA.





# CARMA<sup>SM</sup> Products Pioneer Cooperative Driving Automation Research

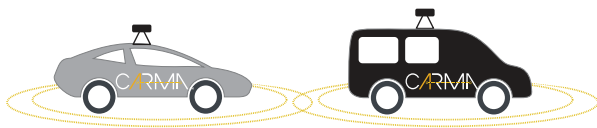
Cooperative driving automation (CDA) research is the key to creating a safer and more efficient transportation system. The CARMA product suite provides the necessary software to enable this research.

All four products (CARMA Cloud<sup>SM</sup>, CARMA Platform<sup>SM</sup>, CARMA Streets, and CARMA Messenger) work together with V2X (Vehicle-to-Everything) Hub, a separate system that enables networked, wireless communications between automated vehicles, infrastructure devices, and personal communications devices.

These tools are available online for collaboration and are currently being used in a set of research tracks examining the impact of CDA on traffic, reliability, and freight operations.

## CLOUD

CARMA Cloud is a set of cloud-based, open-source software services enabling communication and cooperation between cloud services, vehicles, infrastructure, and road users.

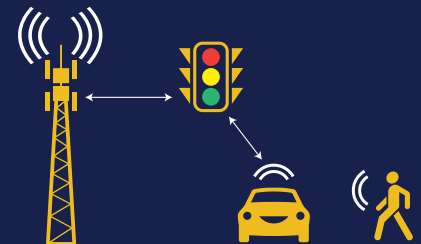


## PLATFORM

CARMA Platform is a vehicle-based platform that enables automated vehicles to interact and cooperate with road elements, such as other vehicles, infrastructure, and pedestrians.

## STREETS

CARMA Streets is an infrastructure-based system that allows automated vehicles to share information with other vehicles and infrastructure to enable cooperation and improve transportation operations and safety.



## MESSENGER

CARMA Messenger is a vehicle-based system for non-automated vehicles, and enables their communication with other road entities to allow participation in the CDA network.

Download CARMA products at <https://github.com/usdot-fhwa-stol>.  
Learn more at <https://highways.dot.gov/research/operations/CARMA-products>.



PANDA is expected to extend FHWA's capabilities by using diverse research findings to address the varied needs of FHWA's disciplines.

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

## Public Information and Information Exchange

### FHWA's PANDA to Advance Data-Driven Innovation

The Path to Advancing Novel Data Analytics (PANDA) is a data science laboratory being established at the Federal Highway Administration's Turner-Fairbank Highway Research Center in McLean, VA. PANDA will be both a physical and virtual space, providing access to cutting edge analytic tools—including artificial intelligence (AI) and machine learning (ML)—for research across multiple transportation disciplines. FHWA personnel, other agencies, and external partners can utilize PANDA to conduct research using their own data or Federal datasets. "It is commendable that a government agency is leading in establishing an AI/ML lab, which is usually done by private industry," says Vidya Mysore, a senior multi-disciplinary program specialist at the FHWA Resource Center.

PANDA will enable testing and application of new and novel analytic techniques developed through other research efforts. Though PANDA will be a neutral site where traditional and non-traditional data sources are tested and where analytics will be segregated so that there's no interference with normal IT

operations, PANDA is expected to extend FHWA's capabilities by using the diverse research findings to address the varied needs of FHWA's disciplines.

Two projects are underway to establish PANDA. The Minimum Viable Product project and the Initial Operating Capability project will provide a connection to the U.S. Department of Transportation's common operating environment and cloud-based analytics tools, and will provide means for cataloging use-cases into datasets, respectively. The common operating environment standardizes IT across USDOT and promotes consistent cybersecurity practices. The Initial Operating Capability project will be developed spanning FHWA's Infrastructure Research and Development (R&D), Operations R&D, Safety R&D, Transportation Policy Studies, Highway Policy Information, Freight Management, Environment and Planning disciplines.

FHWA will initially operate the PANDA lab for two years after its opening in 2022. A report will then be produced, summarizing the operation of PANDA, lessons learned, and research conducted.

## Keep It Moving: New Mexico's First Continuous Flow Intersection

New Mexico's U.S. Route 550 (U.S. 550) Corridor is a well-traveled, local, and regional roadway. In November 2021, the New Mexico Department of Transportation (NMDOT) reached a significant milestone on this roadway with the debut of the State's



Screenshot from an educational video NMDOT published to help drivers understand how the State's first continuous flow intersection works.

@NMDOT.

first ever continuous flow intersection (CFI)—an accomplishment two years in the making.

New Mexico's CFI was strategically placed at an intersection on U.S. 550—between New Mexico State Road (NM) 313 and NM 528—to improve traffic flow and reduce congestion. The CFI is also projected to contribute to the economic development of surrounding areas like Bernalillo, Santa Ana Pueblo, and Rio Rancho.

With the use of new traffic signals, the CFI uses a green light to allow southbound traffic and northbound traffic to turn left and safely cross oncoming traffic—concurrently, a red light signals oncoming traffic to stop. Eastbound and westbound traffic navigate into newly built lanes on the far left-hand side of U.S. 550. Northbound turning vehicles will no longer have to stop at the intersection and can continuously flow into traffic.

Because this CFI is the State's first, NMDOT developed a driver education video (<https://www.youtube.com/watch?v=bHiN6yhHGOo>) and simulations to help drivers become more familiar with the intersection. For more information on the U.S. 550 project, visit <https://keepmoving550.com/>

## PennDOT Updates 511PA, Adding Charging Stations and Customizable Alerts

The Pennsylvania Department of Transportation (PennDOT) recently updated 511PA—a free, 24/7 traveler information service designed to provide detailed and reliable traffic, transit, and weather. More specifically, 511PA offers news on roadway and bridge closures, weather alerts and forecasts, rest facility locations, active roadwork, live traffic cams, and more.

With the latest updates to 511PA, PA motorists are able to create even more personalized alerts, including selecting the type of alerts they would like to receive versus receiving all alerts. Categories include incidents, roadwork, general travel information, travel restrictions, and weather-related alerts.

Commercial drivers can benefit from two enhancements tailored to their needs. 511PA now includes locations for all bridges under legal height (less than 13 feet, 6 inches or 4 meters, 15 centimeters). This information can be viewed on the 511PA web map and is also available as an alert that can be heard in drive mode in using the 511PA mobile app. Another added feature in the mobile app is the ability to obtain alerts based on a driver's mode of transportation, whether it is a commercial or passenger vehicle. If commercial vehicle is selected, low-bridge and vehicle restrictions reports are turned on in drive mode by default.

511PA now also allows users to search for electric vehicle charging stations by connector type.

Information from 511PA can be accessed in several ways—by phone, the 511PA mobile app, social media, and online at <https://www.511pa.com/>.

An advertisement for 511PA.COM. It features a smartphone displaying the app interface with a map. Above the phone, there are icons for 'VISIT 511PA.COM OR DOWNLOAD THE FREE APP' and 'LIVE TRAFFIC CAMERAS', 'VEHICLE RESTRICTIONS', 'WEATHER ALERTS', 'ACTIVE ROADWORK', and 'TRAFFIC ALERTS'. At the bottom, there is the 511 logo and the text 'TRAVEL INFO TO GO Sign up for customized alerts!'.

511PA offers news on roadway and bridge closures, weather alerts, rest facility locations, live traffic cams, and more.

@PennDOT.

## Technical News

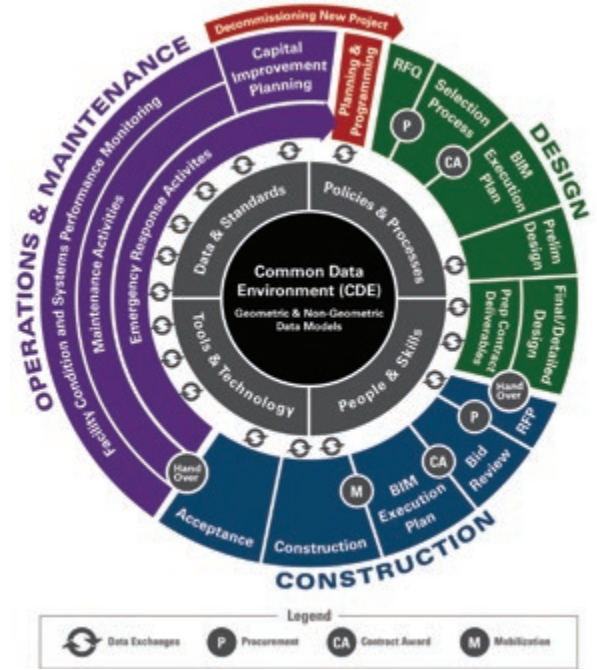
### FHWA BIM for Infrastructure Study Examines Better Project Delivery

The Federal Highway Administration's Global Benchmarking Program (GBP) champions the usage of proven, global technology innovations and best practices that improve highway transportation. One such innovation and best practice is Building Information Modeling (BIM)—a collaborative, digital approach for optimizing the design, construction, and life cycle of a project.

Once considered just for buildings, BIM is rapidly gaining acceptance in the building of transportation structures (e.g., highway and bridges), known as BIM for Infrastructure. With BIM, projects are built virtually and in real life, which enables the recognition of mistakes or challenges early on and the visualization of solutions. Upon completion of the project, the structure becomes part of a virtual collection of the asset data that an organization can use for future construction, decisionmaking, maintenance, operations, and asset management.

FHWA completed a National Strategic Roadmap (<https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/21064/index.cfm>) of structured activities to advance BIM for Infrastructure in the United States. This effort has been followed up with a pooled fund, TPF-5(480), that will build off the foundational work charted within the roadmap.

A recent GBP study documented how six foreign nations and their public agencies use BIM to better deliver transportation projects, manage assets, and provide related services. In studying these nations—the Netherlands, Norway, Denmark, Finland, Sweden, and the United Kingdom—GBP noted several key components and lessons for successful BIM implementation. Its benefits were recorded as well: cost savings and cost avoidance in the design, construction, and operations phases of a project; improved asset



BIM for Infrastructure life cycle for projects that use a design-bid-build contracting.

© 2016 Federal Ministry of Transport and Digital Infrastructure.

Modified by FHWA to include U.S. practices and life cycle phases and to reflect specific report recommendations.

information, storage, and accessibility; and improved strategic transportation project planning.

For more information on the international study, visit <https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/22048/22048.pdf>. For more information on TPF-5(480), visit <https://www.pooledfund.org/Details/Study/707>.

## Internet Watch

### Crash Reports Now Available Online through NDDOT

In March 2022, the North Dakota Department of Transportation (NDDOT) began offering a more rapid way of receiving crash reports.

Available at <https://www.dot.nd.gov/crashreport>, an online delivery system replaces the State's former, more time-consuming process, where request forms were printed, filled out, signed, and sent by mail to NDDOT. Now, insurance companies, law firms, citizens, and other individuals involved in vehicle crashes within the State, can obtain State of North Dakota crash reports, virtually instantaneously. When using the online service, at least two of the following pieces of data are required: The date of the crash, the motorist's last name, and the county the crash occurred. To further narrow large yielding results, users can enter in additional information such as the license plate number of the vehicle involved in the crash.

The online delivery system, however, only provides reports for traffic crashes that are reportable to NDDOT; a reportable crash in North Dakota is defined as a motor vehicle traffic crash which results in injury, fatality, or at least \$4,000 in total property

damage. This definition also comes with an exception: Crashes involving undomesticated animals (deer, bison, bear, wolf, moose, etc.) where no injury or fatality occurs, regardless of the property damage amount, are not reportable.



Insurance companies, law firms, citizens, and other individuals involved in reportable vehicle crashes within North Dakota can now obtain crash reports online.

© NDDOT.



Online NHI training provides transportation professionals with courses on bridge scour and stream stability.  
© 2015, Joseph Sohm / Shutterstock.

## Scour and Stability Highway Bridge Trainings are Now Virtual

by **STAN WORONICK** and **SABRINA SYLVESTER**

**P**resident Joe Biden signed the Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law or BIL, on November 15, 2021. This statute supports investment in infrastructure, which includes roads, highways, and bridges.

As we work toward cultivating the Nation's infrastructure, improving the stability and structure of highway bridges is imperative to the safety of our community. The Federal Highway Administration's National Highway Institute (NHI) has converted three comprehensive courses into an online format. The courses will provide transportation professionals with the best methods to create stable and sustainable highway bridges.

### Achieving Stream Stability and Scour Success on our Nation's Highway Bridges

NHI now offers three virtual instructor-led trainings (VILTs) for bridge inspectors and engineers that focus on the various scour and stream instability concepts, analysis techniques, and scour countermeasure designs for the riverine and bridge environment. The VILTs will explain how to identify countermeasures for stream instability and scour, and also describe a Plan of Action for scour critical bridges. These VILTs will provide transportation professionals with the knowledge to effectively improve highway bridge structures.

### Stream Stability and Scour at Highway Bridges (FHWA-NHI-135046V)

This comprehensive, virtual training provides methods to identify, analyze, and calculate various hydraulic factors that impact bridge stability. During the course, learners will identify stream types, recognize indicators of instability issues, and conduct an analysis of stream stability. They will also define and compute various types of scour, describe a Plan of Action for scour critical bridges, and describe open-channel hydraulics concepts in bridge scour and stream stability.

### Stream Stability and Scour at Highway Bridges for Bridge Inspectors (FHWA-NHI-135047V)

Designed specifically for bridge inspectors, this online hydraulics course is a concentrated version of *Stream Stability and Scour at Highway Bridges* (FHWA-NHI-135046V). This course explains how to detect hydraulic-related issues at highway bridges. Participants will learn the effects of stream instability, scour, erosion, and stream aggradation and degradation, as well as identifying effective scour countermeasures. The training focuses on visual cues to

detecting scour and stream instability problems and introduces portable scour monitoring instrumentation. Participants have the option of taking the course independently or as a group.

### Countermeasure Design for Bridge Scour and Stream Instability (FHWA-NHI-135048V)

This course provides an overview of scour countermeasures for stream instability and scour. Participants will learn how to correct stream instability and scour issues and apply hydraulics analysis techniques to countermeasure design to reduce the risk of scour to the Nation's bridges.

### Prerequisite Information

Course participants should be familiar with the fundamentals of stream stability and scour before taking any of the virtual instructor-led hydraulics courses listed. Consequently, NHI offers the following Web-based, on demand training at no cost to participants, as prerequisite courses:

- Stream Stability Factors and Concepts (FHWA-NHI-135086)
- Scour at Highway Bridges: Concepts and Definitions (FHWA-NHI-135087)

### How to Attend or Host a Course

NHI invites professionals interested in earning continuing education units or professional development hours to visit <http://bit.ly/NHIHome> and browse the complete digital course catalog. The catalog lists over 400 courses in 19 program areas.

To sign up for email alerts and to see when a particular course session is available, visit the description page for that course and then click on the "Sign Up for Session Alerts" link.

Interested hosts can submit a host request form or find more information about hosting NHI courses by visiting <https://www.nhi.fhwa.dot.gov/training/host.aspx?>.

NHI is an approved Accredited Provider by the International Accreditors for Continuing Education and Training (IACET). As an IACET Accredited Provider, NHI offers continuing education units for its programs that qualify under the American National Standards Institute/IACET Standard.

**STAN WORONICK** is a training program manager for hydraulics at NHI.

**SABRINA SYLVESTER** is a contracted senior marketing specialist for FHWA's NHI.

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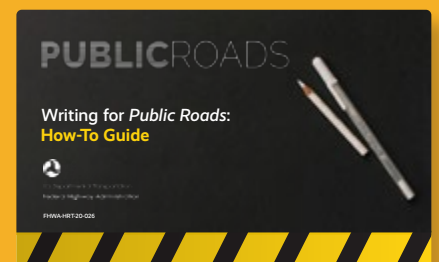
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