Summer 2022

the FOREFRONT

A Review of ERDC Publications

Collaboration across ERDC and beyond

Microbial "Fingerprints"

Assessing Storm Surge and Wave Hazards

Cleaning Up Harmful Algal Blooms

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

ITL
INFORMATION TECHNOLOGY LABORATORY

About *The Forefront*

As the main research and development organization for the US Army Corps of Engineers (USACE), the Engineer Research and Development Center (ERDC) helps solve our nation's most challenging problems. With seven laboratories under the ERDC umbrella, ERDC expertise spans a wide range of disciplines. This provides researchers an amazing network of collaborators both within labs and across them.

Many of the publications produced by ERDC through the Information Technology Laboratory's Information Science and Knowledge Management Branch (ISKM), the publishing authority for ERDC, are a testament to the power of these partnerships. Therefore, in this issue of *The Forefront*, we wanted to highlight some of those collaborations, across ERDC and beyond. Colored flags at the top of each page indicate the laboratories involved in each report (see the end of this issue for a full list of the laboratories and their lab colors), in addition to USACE red for district collaborators and gray for others. Through these collaborations, ERDC is continuing to demonstrate its value nationally and internationally.

Questions about the reports highlighted in *The Forefront* or others published by ERDC? Contact the ISKM virtual reference desk at erdclibrary@ask-a-librarian.info or visit ERDC Knowledge Core, ISKM's online repository, at https://erdc-library.erdc.dren.mil/. For general questions about editing and publishing at ERDC, you are also welcome to reach out to me at Emily.B.Moynihan@usace.army.mil. We look forward to continuing to be a resource for ERDC and seeing all the remarkable research that is yet to come.

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Cover Photo: Survey of Totopotomoy Creek in Virginia with Brandon Booker, ERDC-CRREL by the total station. (Photo by Dr. Gabrielle David)

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Opposite: The pier at ERDC's Field Research Facility in Duck, North Carolina; image taken by unmanned aerial system (UAS).

ERDC/ITL SR-17-1

Publications of the U.S. Army Engineer Research and Development Center

Appendix F: FY20 (October 2020–September 2021)

Compiled by James A. Dolan

Abstract: Publications issued October 2019 through September 2020 by the U.S. Army Engineer Research and Development Center (ERDC) are listed. The publications are grouped according to the technical laboratories or technical program for which they were prepared. Procedures for obtaining ERDC reports are included in the Preface.

http://dx.doi.org/10.21079/11681/42823

Previous publications

ERDC/ITL SR-17-1	http://dx.doi.org/10.21079/11681/21022
ERDC/ITL SR-17-1 App. A	http://dx.doi.org/10.21079/11681/22581
ERDC/ITL SR-17-1 App. B	http://dx.doi.org/10.21079/11681/27267
ERDC/ITL SR-17-1 App. C	http://dx.doi.org/10.21079/11681/31406
ERDC/ITL SR-17-1 App. D	http://dx.doi.org/10.21079/11681/34897
ERDC/ITL SR-17-1 App. E	http://dx.doi.org/10.21079/11681/39201

Recording results . . .

Each year, the Information Technology Laboratory's Information Science and Knowledge Management Branch (ISKM) releases a new appendix to *Publications of the U.S. Army Engineer Research and Development Center: October 1999–December 2015*, adding the past fiscal year's publications. The sixth appendix in this series, for FY21, contains 309 publications, a 12% increase over the previous fiscal year. Most notable is a 196% increase in ERDC Miscellaneous Papers (MP). The Information Science and Knowledge Management Branch actively campaigned to capture the journal article and conference paper output of ERDC researchers, which resulted in the dramatic increase. Any journal article or conference paper written by ERDC personnel can be published as an MP. Simply submit the original final manuscript, minus any publisher's copyrighted format, to your ERDC editor, and they will help you complete the process. (For more info, see "Why Should I Publish a Miscellaneous Paper and Is It Worth the Undertaking?" on page 43 of this issue of *The Forefront*.)

As this issue of *The Forefront* is highlighting collaboration, it is only fitting to note that report collaboration among ERDC laboratories grew from 24 in FY20 to 48 in FY21, a 100% increase!

ISKM is pleased to continue the annual compilation of ERDC publications. From the editors who mold thought, data, and fact into a quality, consistent ERDC publishing product to the librarians who apply their organizational and technical expertise to make these publications accessible, ERDC and its customers greatly benefit from this collaborative union. ☐

Article contributed by James A. Dolan, Librarian for the ITL Information Science and Knowledge Management Branch.

Opposite: This series captures 22 years of ERDC-published reports.

Above: Vicksburg is the home of ISKM's largest physical library, but a large collection of ERDC reports is also available online at https://erdc-library.erdc.dren.mil/. (Photo by James Dolan)

ERDC TR-21-6

Signal Propagation Modeling in Complex, Three-Dimensional Environments

By D. Keith Wilson, Daniel J. Breton, Lauren E. Waldrop, Danney R. Glaser, Ross E. Alter, Carl R. Hart, Wesley M. Barnes, Michael T. Ekegren, Michael B. Muhlestein, Manisha Mishra, M. Andrew Niccolai, Michael J. White, Christian Borden, and Ethan Fahy

Abstract: The Signal Physics Representation in Uncertain and Complex Environments (SPRUCE) work unit, part of the US Army Engineer Research and Development Center (ERDC) Army Terrestrial-Environmental Modeling and Intelligence System (ARTEMIS) work package, focused on the creation of a suite of three-dimensional (3D) signal and sensor performance modeling capabilities that realistically capture propagation physics in urban, mountainous, forested, and other complex terrain environments. This report describes many of the developed technical capabilities. Particular highlights are (1) creation of a Java environmental data abstraction layer for 3D representation of the atmosphere and inhomogeneous terrain that ingests data from many common weather forecast models and terrain data formats, (2) extensions to the Environmental Awareness for Sensor and Emitter Employment (EASEE) software to enable 3D signal propagation modeling, (3) modeling of transmitter and receiver directivity functions in 3D including rotations of the transmitter and receiver platforms, (4) an Extensible Markup Language/JavaScript Object Notation (XML/JSON) interface to facilitate deployment of web services, (5) signal feature definitions and other support for infrasound modeling and for radio-frequency (RF) modeling in the very high frequency (VHF), ultra-high frequency (UHF), and super-high frequency (SHF) frequency ranges, and (6) probabilistic calculations for line-of-sight in complex terrain and vegetation.

http://dx.doi.org/10.21079/11681/40321

Streamlining the complex . . .

Signal transmission and sensing are critical on the modern battlefield—not only for communication but also for signal detectability in general as it has implications for everything from predicting distances at which targets can be detected and recognized to planning routes to minimize audibility and visibility. This is all relatively straightforward when working on flat terrain.

However, working in complex environments, such as urban, forested, or mountainous areas, becomes more complicated as two-dimensional models can no longer accurately predict a signal's path. Therefore, the goal of this project was to expand on the capabilities of the Environmental Awareness for Sensor and Emitter Employment (EASEE) software, which ERDC had already created—and patented—to model signal propagation and to effectively account for three-dimensional space.

One of the benefits of this system is that Soldiers do not need to be sensor-technology experts to use the tools EASEE presents. "They can choose the best sensors and place them in the best locations for accomplishing their missions without necessarily understanding the details of the signal phenomenology and processing," Dr. Keith Wilson, lead author, explained. This is an important capability to ensure ease of use in the field, especially considering all the other technology that Soldiers must also master.

The project drew on expertise from both the Cold Regions Research and Engineering Laboratory (CRREL) and the Construction Engineering Research Laboratory (CERL) along with a contractor, Atmospheric and Environmental Research, Inc. The resulting robust software opens up additional opportunities for EASEE to support missions not only in urban and forested environments but also in the Arctic, and additional work is addressing Arctic-specific propagation concerns, such as responses to snow and ice, high surface albedo, dense fog, and extremely low temperatures.

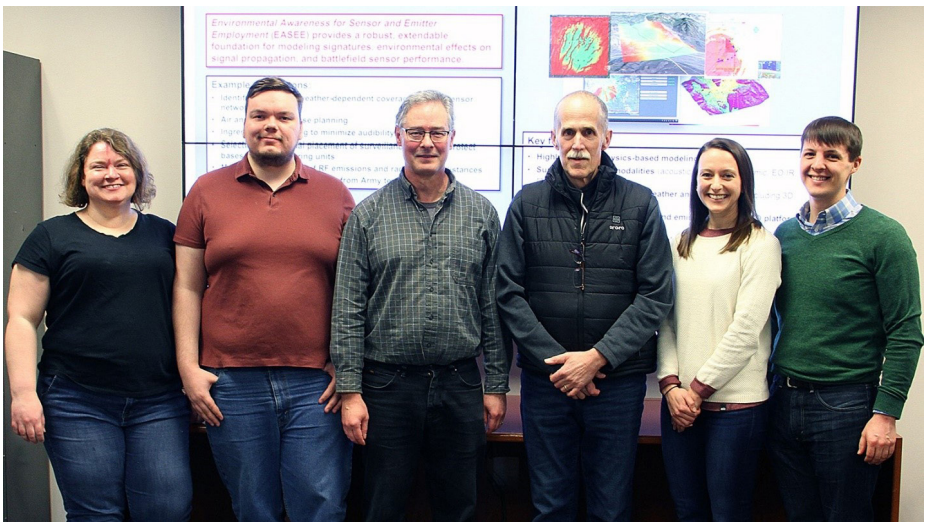
In all, this work took complicated issues and streamlined them, producing something usable, effective, and expandable. "I greatly enjoy the challenge of solving complex problems in and of itself—I'm very privileged to actually get paid to do it," Dr. Wilson added, "but it is even more rewarding when it connects with opportunities to develop products that benefit the nation." ☐

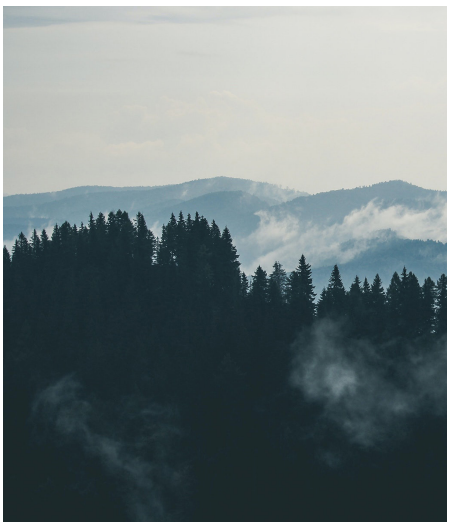
Article contributed by Emily B. Moynihan, writer-editor for the ITL Information Science and Knowledge Management Branch.

Opposite: Soldiers attending the US Army Mountain Warfare School in Jericho, VT. (US Air National Guard photo by Tech. Sgt. Sarah Mattison)

Bottom left: Dr. Wilson's team received a patent in 2019 for their "System for Modeling Intelligent Sensor Selection and Placement." Pictured are Rachel Romond, Jordan Bates, Dr. Keith Wilson, John Gagnon, Lauren Waldrop, and Matthew Kamrath. (Photo by Patrice Creel)

Bottom right: Mountainous terrain complicates signal predictability.





New from Engineering With Nature

With the top-three downloaded ERDC reports (thousands more downloads than any other), the Engineering With Nature (EWN) Initiative continues to unite researchers, organizations, and communities across the world looking for nature-based solutions to solve engineering challenges.

The team to create the *International Guidelines* document consisted of 150 people from 70 organizations across 10 countries—a huge logistical challenge. Additionally, the effort included seven in-person meetings over the five-year writing period. "There were times I wondered if I had missed my calling and perhaps could have made it as a cruise director for Carnival," joked Dr. Jeffery King, deputy lead for EWN.

"The collaborative aspect of the *International Guidelines* is what makes the document unique and significant," said Courtney Chambers, communications lead for EWN. "Many organizations have their own natural infrastructure documents; but in the *International Guidelines*, these organizations collectively shared agreed-upon best practices for nature-based features. The broad contributions result in greater buy-in or acceptance of the document regardless of sector or nation."

From the detailed and technical guidelines to the visually stunning *Atlas, Volume 2*, the EWN team has covered its bases and appealed to a broad readership. As King explains, "There is no doubt that all of these products will inspire others to engineer with nature and understand what is possible when leveraging nature to achieve a desired engineering outcome." ☐

Article contributed by Emily B. Moynihan, writer-editor for the ITL Information Science and Knowledge Management Branch.

ERDC SR-21-2

Engineering With Nature: An Atlas, Volume 2

By Todd S. Bridges, E. Michelle Bourne, Burton C. Suedel, Emily B. Moynihan, and Jeff K. King

http://dx.doi.org/10.21079/11681/40124

ERDC SR-21-5

Overview: International Guidelines on Natural and Nature-Based Features for Flood Risk Management

Edited by Todd S. Bridges, Jeffrey K. King, Jonathan D. Simm, Michael W. Beck, Georganna Collins, Quirijn Lodder, and Ram K. Mohan

http://dx.doi.org/10.21079/11681/41945

ERDC SR-21-6

International Guidelines on Natural and Nature-Based Features for Flood Risk Management

Edited by Todd S. Bridges, Jeffrey K. King, Jonathan D. Simm, Michael W. Beck, Georganna Collins, Quirijn Lodder, and Ram K. Mohan

http://dx.doi.org/10.21079/11681/41946

Opposite: The team visited Blackwater National Wildlife Refuge, Maryland, as part of a site visit during an in-person meeting for development of the International Guidelines on use of NNBF for Flood Risk Management. (Photo by Dr. Jeffrey King)

ERDC/GSL TR-21-2

Rapid Airfield Damage Recovery Next Generation Backfill Technologies Comparison Experiment: Technology Comparison Experiment

By Mariely Mejias-Santiago, Lyan Garcia, and Lulu Edwards

Abstract: The Rapid Airfield Damage Recovery (RADR) Next Generation Backfill Technology Comparison Experiment was conducted in July 2017 at the East Campus of the US Army Engineer Research and Development Center (ERDC), located in Vicksburg, MS. The experiment evaluated three different crater backfill technologies to compare their performance and develop a technology trade-off analysis. The RADR next generation backfill technologies were compared to the current RADR standard backfill method of flowable fill. Results from this experiment provided useful information on technology rankings and trade-offs. This effort resulted in successful crater backfill solutions that were recommended for further end user evaluation.

http://dx.doi.org/10.21079/11681/39661

Bottom left: Data collection during the demonstration.

Bottom right: ERDC team members make even data collection fun.

Opposite: Placing a foam backfill into the crater repair.

A quick fix . . .

Maintaining functioning airfields is critical to military operations. While difficult under normal circumstances, it becomes a greater challenge within hostile environments and when repairing damage from sabotage. The Rapid Airfield Damage Recovery (RADR) modernization program aimed to address this by establishing procedures to successfully expedite the project.

The team of Mariely Mejias-Santiago, Lyan Garcia, and Lulu Edwards took this guidance a step further in their follow-on project by comparing the performance of three proposed crater-repair backfill technologies. Edwards explained, "Finding alternatives to backfilling a crater is important to ensure that the military is able to adapt to any environment that they encounter. Knowing and applying the traditional methods are important, but having multiple options gives the military the ability to succeed anywhere in the world."

When asked her favorite part of this research, she exclaimed, "Working with a great team! I got to work with two engineers, Mariely Mejias and Lyan Garcia, and so many other engineers and technicians. While the research work was completed over time, we had a demonstration that lasted two intensive days. The technician team and engineers on the project came together and were able pull together a successful demonstration."

While this specific project is over, Edwards expects backfill and stabilization research will likely always be ongoing. "At least, I hope so!" she added. "We as researchers want to continuously improve the technology and methods." In the meantime, the lessons learned from this project are already being put into use for repairing military roads and for expedient and expeditionary airfield crater backfill technologies. Through these efforts, ERDC is continuing its mission of supporting our Soldiers around the world. ☐

Article contributed by Emily B. Moynihan, writer-editor for the ITL Information Science and Knowledge Management Branch.

ERDC TR-21-18

Optimizing the Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS)

By Martin Page, Bruce MacAllister, Marissa Campobasso, Angela Urban, Catherine Thomas, Clinton Cender, Clint Arnett, Craig White, Edith Martinez-Guerra, Ashley Boyd, Elizabeth Gao, Al Kennedy, Tom Biber, Kaytee Pokrzywinski, Chris Grasso, Briana Fernando, Chris Veinotte, Jim Riley, Ashley Gonzalez, Jay Miller, Kathryn Gunderson, Lance Schideman, Yuanhui Zhang, B. K. Sharma, Dan Levy, Bill Colona, David Pinelli, Tammy Karst-Riddoch, and Will Lovins

Abstract: Harmful algal blooms (HABs) continue to affect lakes and waterways across the nation, often resulting in environmental and economic damage at regional scales. The US Army Engineer Research and Development Center (ERDC) and collaborators have continued research on the Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS) project to develop a rapidly deployable and scalable system for mitigating large HABs. The second year of the project focused on optimization research, including (1) development of a new organic flocculant formulation for neutralization and flotation of algal cells; (2) testing and initial optimization of a new, high-throughput biomass dewatering system with low power requirements; (3) development, design, assembly, and initial testing of the first shipboard HABITATS prototype; (4) execution of two field pilot studies of interception and treatment systems in coordination with the Florida Department of Environmental Protection and New York State Department of Environmental Conservation; (5) conversion of algal biomass into biocrude fuel at pilot scale with a 33% increase in yield compared to the previous bench scale continuous-flow reactor studies; and (6) refinement of a scalability analysis and optimization model to guide the future development of full-scale prototypes.

http://dx.doi.org/10.21079/11681/42223

Opposite: Algal bloom formation along the shoreline near the Port Mayaca Lock and Dam (June 2021).

The right stuff . . .

Harmful algal blooms blanket swaths of water bodies choking aquatic life in a way akin to horror-movie ooze. A deep-bench research team from two ERDC labs, three USACE districts, the Illinois Sustainable Technology Center and University of Illinois, the Department of Energy's Pacific Northwest National Laboratory, and industry partners AECOM and Elastec spearheaded the second year of the Harmful Algal Bloom Interception, Treatment, and Transformation System (HABITATS). The team shares a crystal-clear purpose because, as researcher Martin Page explained, "Our whole team knows this is one of the greatest environmental challenges facing our nation, both technically and in terms of impact. HAB's threaten our water resources, recreational areas, and economy. The research is important not just because the problem is so impactful, but also because the problem is so difficult to solve. There are short-term approaches out there for inactivating algae with chemicals, but the root cause of the problem stays in the water. We're trying to get the algae out of the water, including the nutrients and potential toxins, in a sustainable and economically scalable manner."

The objectives, detailed in the report, included several pilot-scale demonstrations, which had several logistical challenges. Some of which were very welcomed, as when there was no algal bloom. "HABs are difficult to predict," Page explained. When the blooms do not materialize where they were predicted to occur, the team "in some cases [had] to move our entire demonstration within 48 hours." Few complain when HABs do not occur. "As one of our collaborators chided us in 2019, 'If you don't want it to rain, bring an umbrella. Thanks for being our umbrella.'"

Whatever the challenge, though, Page said, "Having a multi-disciplinary team of experts has been key to success. We've needed laboratory researchers and field engineers with expertise in microbiology, chemistry, environmental engineering, mechanical engineering, chemical engineering, and other fields to develop and assess a solution to this complex problem. Having perspectives from industry, academia, and government on the same team has also been a key enabler for the project."

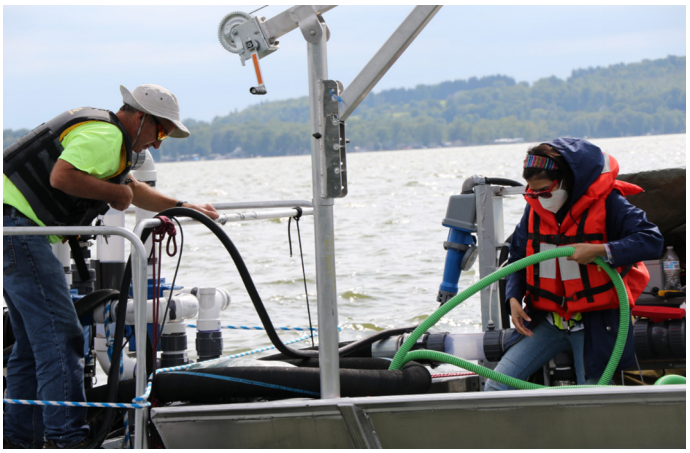
The deep network of motivated researchers and partners is looking to broaden its reach in the coming years. "We are planning a larger technology demonstration that will show the scalability of the technology. We have acquired a mobile system that can treat up to two million gallons of HAB-contaminated water per day. While this is still a pilot scale unit when considering the scale of HABs on large lakes, it is a significant step in the maturation of the technology and the development of large deployable water treatment systems for emergency response." In the future, Page "envision[s] a fleet of deployable water treatment systems" cleaning our canals, rivers, lakes, and coasts of the toxic algal cancers and in a way that produces as much fuel as it consumes. ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.

Bottom left: Algae harvested using a dissolved air flotation system falls into a storage tank prior to dewatering and biofuel conversion.

Bottom right: ERDC researchers setting up algae harvesting systems onboard the HABITATS mobile treatment prototype.

Opposite: Algae-laden water during a pilot-scale HABITATS test at one of ERDC's laboratories in Champaign, Illinois (August 2021).



ERDC TR-21-19

Accelerating the Tactical Decision Process with High-Performance Computing (HPC) on the Edge

Motivation, Framework, and Use Cases

By Alicia I. Ruvinsky, Timothy W. Garton, Daniel P. Chausse, Rajeev K. Agrawal, Harland F. Yu, and Ernest L. Miller

Abstract: Managing the ever-growing volume and velocity of data across the battlefield is a critical problem for warfighters. Solving this problem will require a fundamental change in how battlefield analyses are performed. A new approach to making decisions on the battlefield will eliminate data transport delays by moving the analytical capabilities closer to data sources. Decision cycles depend on the speed at which data can be captured and converted to actionable information for decision making. Real-time situational awareness is achieved by locating computational assets at the tactical edge. Accelerating the tactical decision process leverages capabilities in three technology areas: (1) High-Performance Computing (HPC), (2) Machine Learning (ML), and (3) Internet of Things (IoT). Exploiting these areas can reduce network traffic and shorten the time required to transform data into actionable information. Faster decision cycles may revolutionize battlefield operations. Presented is an overview of an artificial intelligence (AI) system design for near-real-time analytics in a tactical operational environment executing on co-located, mobile HPC hardware. The report contains the following sections, (1) an introduction describing motivation, background, and state of technology, (2) descriptions of tactical decision process leveraging HPC problem definition and use case, and (3) HPC tactical data analytics framework design enabling data to decisions.

http://dx.doi.org/10.21079/11681/42169

Opposite: Final Edge prototype consisting of Raspberry Pi and NVIDIA Jetson connected devices with integrated camera for collecting and syncing data. (Photo by Gary Haygood)

Tomorrow's battle decisions . . .

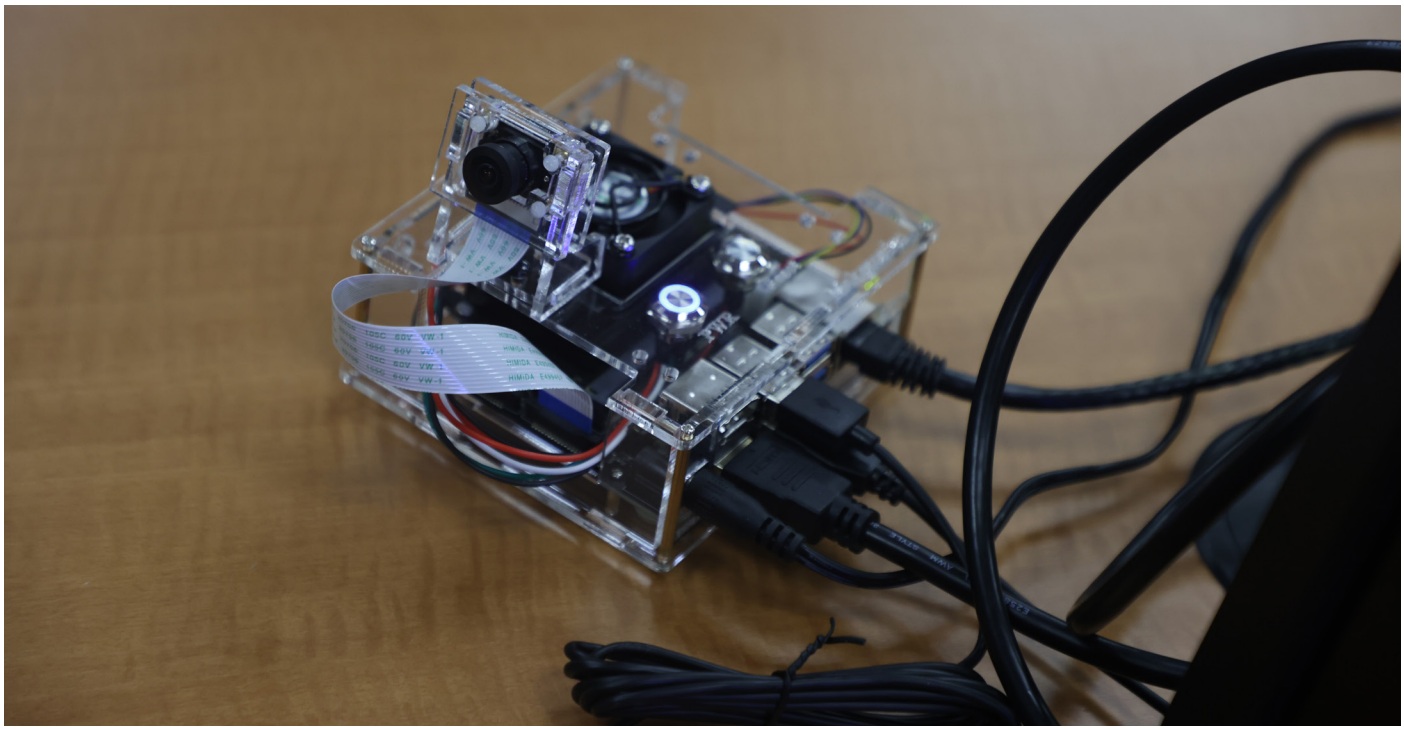
The tactical edge of any battle front is becoming more and more quantified, digitized, and analytically processed. Developments in artificial intelligence and high-performance computing inevitably mean "a major shift in how Soldiers will react in theater," said researcher Timothy Garton. Called edge computing, researchers at ITL and GRL theorized the best method to shift computational power from laboratories and data centers to the boots on the ground. "If we can better inform them of the surroundings, they can evade potentially harmful scenarios before they happen." The project team successfully tested a software suite "to prove the initial plans of interconnected edge devices using simple Raspberry Pi and NVIDIA Jetson devices to collect and sync data. This was a success and shows that there is potential in utilizing a true military network and specific need sensors to sync data" for the warfighter to make immediate and informed decisions.

That epochal shift is no easy feat as network infrastructures fail to meet the demands of high-performance computing on the edge. Garton explained, "Data must be synced, and devices must be interconnected in order for advanced edge analytics to be done. When it came time for demonstration of simple edge communication between devices, the mock network decided to fail, and we had to move to a shared cellular network to demonstrate as best as possible, but the entire demonstration could not go on. This showed the importance of the network structure that was discussed in the report."

The increasing velocity of change in edge computing was a further challenge to the team hustling to keep pace. "It was almost impossible to make a meaningful demo because before a device could be considered and specifications identified, someone else already was producing the next version or competitive device." But, Garton said, "Watching the rapid improvements in the hardware abilities inspires me to further research the theory because anything will be possible in the near future when you start today."

The project utilized a "don't get behind mentality" through a collaboration between two labs to "bring in the best and brightest of each area of expertise so that a complete solution could be developed." The initial meetings proved that ERDC works well on the edge. "Everyone could throw out their ideal problems and solutions, and the teamwork to identify what the greatest need for research in the field brought out the best of each team member. Everyone had a vision and could see just how much potential there is in this area." ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.



ERDC/CHL TR-21-7

Approaches for Assessing Riverine Scour

By Adam Howard, Jang Pak, David May, Stanford Gibson, Chris Haring, Brian Alberto, and Michael Snyder

Abstract: Calculating scour potential in a stream or river is as much a geomorphological art as it is an exact science. The complexity of stream hydraulics and heterogeneity of river-bed materials makes scour predictions in natural channels uncertain. Uncertain scour depths near high-hazard flood-risk zones and flood-risk management structures lead to over-designed projects and difficult flood-risk management decisions. This Regional Sediment Management technical report presents an approach for estimating scour by providing a decision framework that future practitioners can use to compute scour potential within a riverine environment. This methodology was developed through a partnership with the US Army Engineer Research and Development Center, Hydrologic Engineering Center, and St. Paul District in support of the Lower American River Contract 3 project in Sacramento, CA.

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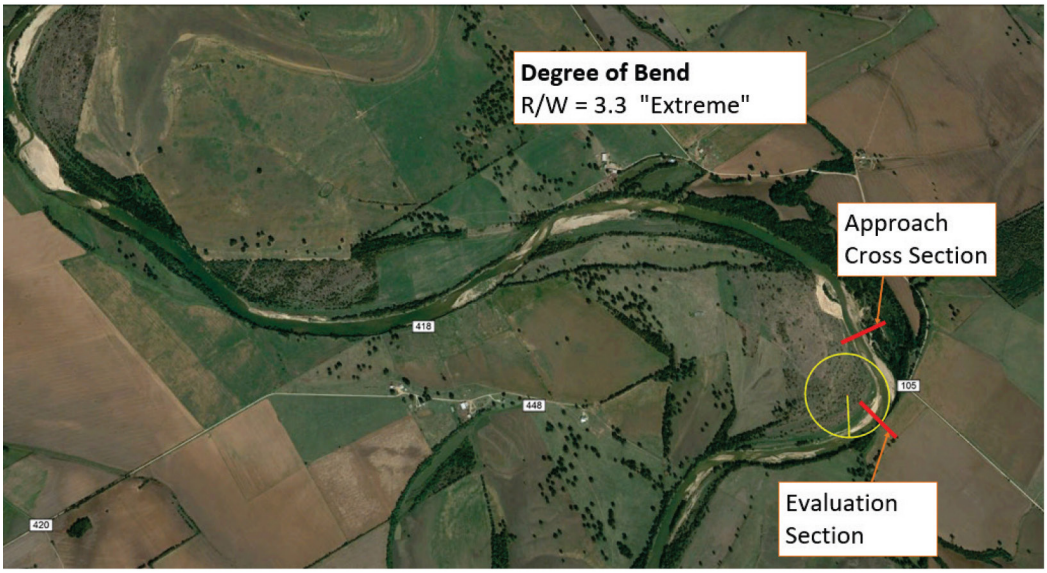
A river's toll . . .

Scour of river and stream beds mines the foundations of bridges, levees, and homes. Any human design on the water's edge or across its breadth must try to account for the hydraulic forces that threaten it. Yet, there persists a deep-seated uncertainty in predicting river or stream scour. As researcher Adam Howard explained, "Scour is a very important part of designing a flood risk management project; however, the science of calculating event-based scour is not exact. Similar to other sediment transport problems, the interactions between the river hydraulics and bed sediments make for a complex system that is hard to describe with a simple equation and leaves much to interpretation. Some of the scour equations owe their roots to research conducted as far back as the 1930s!"

The gnawing uncertainty attracted researchers across three USACE installations to attempt to compile a comprehensive approach to estimating scour and to clearly define scour equations. Scour equations, Howard said, "greatly influence a project's viability and cost. For instance, if you plan on using launchable riprap to protect against scour, if you overpredict the scour potential the amount of riprap required for project could end up very high. On the flip side, if you underpredict scour, it's possible the revetment design would be inadequate, potentially resulting in the project's failure during a critical design event." Assisting engineers and planners in threading that needle became the project team's goal. "Our goal wasn't necessarily to change or create new scour equations but rather to provide clear guidance to practitioners on the best approach to implement the equations. This process used input from all of our subject matter experts to discern the best approach that was justified by the literature and our team's field experience. We developed a scour working group that consisted of members from Hydrologic Engineering Center, ERDC, and the project team designing the Lower American River Contract 3 project. It was a great collaboration in a group with a wealth of knowledge in the area. The collaboration process was essential to the successful development of the scour guidance document. It did require some time to make sure we had accounted for everyone's thoughts, both during the initial review process and during the document drafting. Ultimately, that time we spent to collaborate was what made the research successful."

Still, even with that depth of knowledge and patient dialogue, a broader partnership with scour practitioners from outside of the USACE at the outset would have been helpful, the researchers found. "There is a wealth of knowledge available from private practitioners and would have been good to get their input before finalizing the report. We hope the current document can serve as a living document that can incorporate future knowledge gained from the dissemination of this report. The document is by no means a definitive answer to estimating scour in riverine systems. We are still collaborating as we work to incorporate additional guidance we receive from outside sources!" ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.



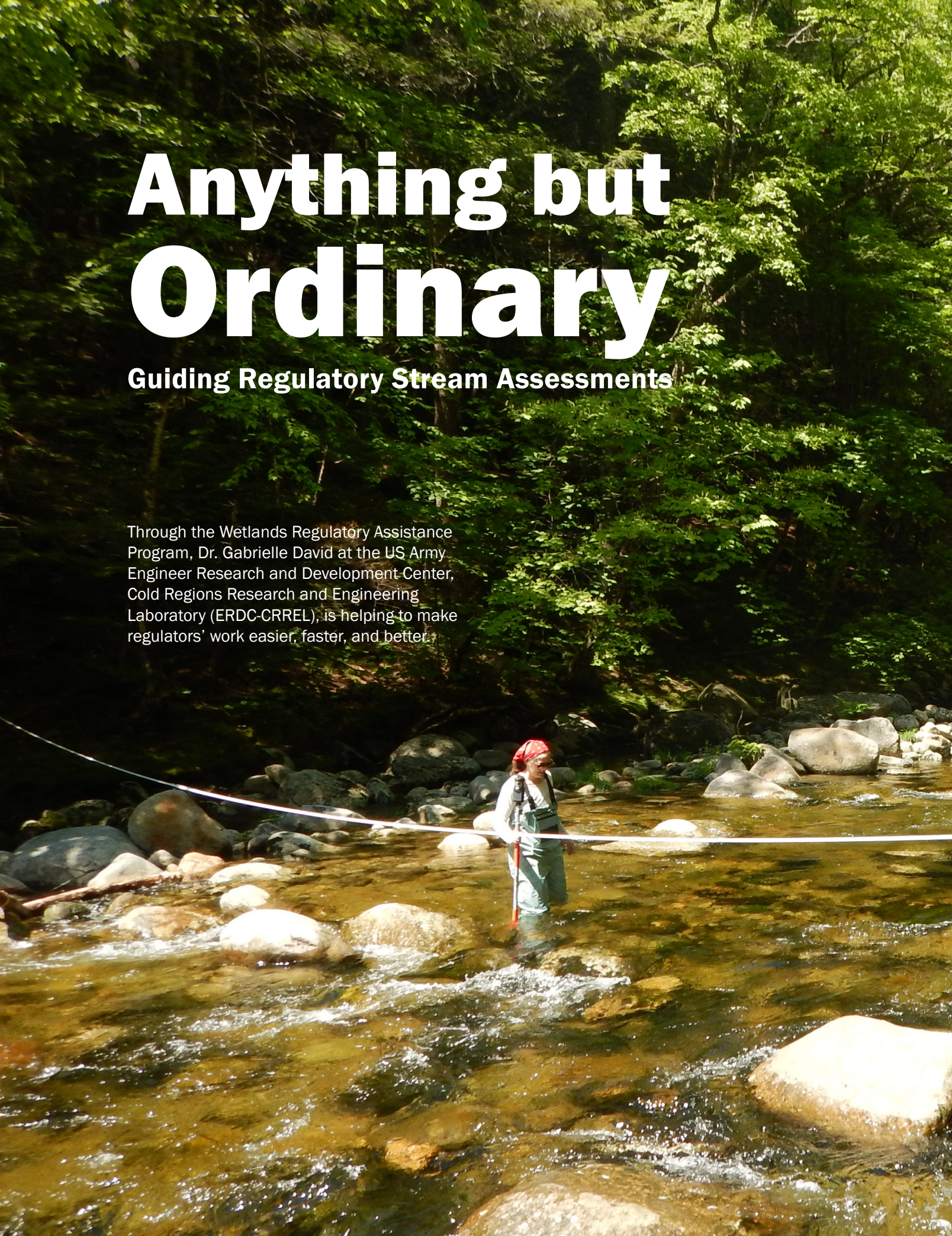
Opposite: The Lower American River in August 2021. (Photo by Adam Howard)

Left: A bend radius example for one location within a compound bend on the Brazos River in Texas. (Flow is from top left to bottom right.)

Anything but Ordinary

Guiding Regulatory Stream Assessments

Through the Wetlands Regulatory Assistance Program, Dr. Gabrielle David at the US Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL), is helping to make regulators' work easier, faster, and better.



ERDC/CRREL SR-21-2

Technical Guide for the Development, Evaluation, and Modification of Stream Assessment Methods for the Corps Regulatory Program

By Gabrielle C. L. David, D. Eric Somerville, Julia M. McCarthy, Spencer D. MacNeil, Faith Fitzpatrick, Ryan Evans, and David Wilson

Abstract: The US Army Corps Regulatory Program considers the loss (impacts) and gain (compensatory mitigation) of aquatic resource functions as part of Clean Water Act Section 404 permitting and compensatory mitigation decisions. To better inform this regulatory decision-making, the Regulatory Program needs transparent and objective approaches to assess the function and condition of aquatic resources, including streams.

Therefore, the Regulatory Program needs function-based stream assessments (1) to characterize a stream's condition or function, (2) to improve understanding of the impact of a proposed action on an aquatic resource, and/or (3) to inform the development of stream compensatory mitigation tools rooted in stream condition and/or function. A function-based stream assessment can provide regulatory decision makers with the resources to objectively consider alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of mitigation projects.

A multiagency National Committee on Stream Assessment (NCSA) convened to create these guidelines to inform the development of new methods and evaluation of both national-level and regional methods currently in use. The resulting guidelines present nine phases, including rationale and recommendations to facilitate work efforts. The NCSA hopes that this technical guide promotes transparency, technical defensibility, and consistent application of stream assessments in the Regulatory Program.

http://dx.doi.org/10.21079/11681/42182

ERDC/CRREL TR-21-9

Hydrologic Analysis of Field Delineated Ordinary High Water Marks for Rivers and Streams

By Daniel Hamill and Gabrielle C. L. David

Abstract: Streamflow influences the distribution and organization of high water marks along rivers and streams in a landscape. The federal definition of ordinary high water mark (OHWM) is defined by physical and vegetative field indicators that are used to identify inundation extents of ordinary high water levels without any reference to the relationship between streamflow and regulatory definition. Streamflow is the amount, or volume, of water that moves through a stream per unit time. This study explores regional characteristics and relationships between field-delineated OHWMs and frequency-magnitude streamflow metrics derived from a flood frequency analysis. The elevation of OHWM is related to representative constant-level discharge return periods with national average return periods of 6.9 years using partial duration series and 2.8 years using annual maximum flood frequency approaches. The range in OHWM return periods is 0.5 to 9.08, and 1.05 to 11.01 years for peaks-over-threshold and annual maximum flood frequency methods, respectively. The range of OHWM return periods is consistent with the range found in national studies of return periods related to bankfull streamflow. Hydraulic models produced a statistically significant relationship between OHWM and bankfull, which reinforces the close relationship between the scientific concept and OHWM in most stream systems.

http://dx.doi.org/10.21079/11681/41681

Wading deeper . . .

Water is essential to our everyday lives. We all know that, but how much do we think about it beyond that? For Dr. Gabrielle David at the US Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL), the answer is a lot. Her interest in how humans interact with the environment began in elementary school. By college, she knew she wanted to focus on rivers, in part because they are critical for clean drinking water.

However, it is because of water management and regulatory practices that the water is clean and able to meet our needs. To accomplish this, federal regulations established the ordinary high water mark (OHWM) to determine what falls under federal regulation. This allows regulators to assess what impacts a project may have on the waters of the US and to establish compensatory mitigation requirements. Yet, as Dr. David explained, "Despite the OHWM being part of the regulatory boundary of streams since the Rivers and Harbors Act of 1899, there has never been a national manual written on the topic." Therefore, these two reports address both the lack of official guidance for determining the OHWM and provide methods for assessing streams for the US Army Corps of Engineers (USACE) Regulatory Program.

In both leading the National Committee on the Ordinary High Water Mark (which includes members from the EPA, USACE, and academia) and working with regulators from across the country, Dr. David is "bringing the science of streams into the regulatory and management realm." She expressed how passionate but undervalued regulators are and so is excited to provide them with tools to make their work easier, faster, and better—without requiring any special equipment or scientific training. Further, "by providing improved tools and methods for rapidly assessing streams and identifying the OHWM, we can help accelerate and revolutionize civil works decision-making."

Dr. David is enthusiastic about what she does. "I like working on topics that are a bit of underdog in the research world. There's nothing particularly shiny or glamorous about studying a regulatory term, but it is something that is extremely important." She describes the Wetland Regulatory Assistance Program, which funds her work, as "where ERDC meets the American people." Through her ongoing diverse collaborations, Dr. David is ensuring that ERDC will continue to support the nation's regulators and the communities that depend on them. "I love being out in the field with people," Dr. David says. "A lot of that has been put on hold with Covid, but I look forward to getting back out there again." ☐

Article contributed by Emily B. Moynihan, writer-editor for the ITL Information Science and Knowledge Management Branch.

Opening: Dr. Gabrielle David crossing Hubbard Brook while surveying the stream as part of the OHWM project. (Photo by Brandon Booker)

Previous: Survey of Sweetbriar Creek in North Dakota as part of the OHWM project. Brandon Booker is pictured next to the total station. (Photo by Dr. Gabrielle David)

Opposite: Dr. David teaching the OHWM Field Delineation Training Course in Portland District. Dr. David is standing near the location of the OHWM on the Willamette River and discussing indicators of OHWM both up- and downstream of that location.

Left: Andrea Wagner, a regulatory detail from Portland District, and Rebecca Rossi assessing large wood content in the Nissitissit River in New Hampshire. (Photo by Dr. Gabrielle David)

ERDC/GSL TR-21-14

Development of CORPS-STIF 1.0 with Application to Ultra-High Performance Concrete (UHPC)

By Isaac L. Howard, Thomas Allard, Ashley Carey, Matthew Priddy, Alta Knizley, and Jameson D. Shannon

Abstract: This report introduces the first release of CORPS-STIF (Concrete Observations Repository and Predictive Software—Structural and Thermodynamical Integrated Framework). CORPS-STIF is envisioned to be used as a tool to optimize material constituents and geometries of mass concrete placements specifically for ultra-high performance concretes (UHPCs). An observations repository (OR) containing results of 649 mechanical property tests and 10 thermodynamical tests were recorded to be used as inputs for current and future releases. A thermodynamical integrated framework (TIF) was developed where the heat transfer coefficient was a function of temperature and determined at each time step. A structural integrated framework (SIF) modeled strength development in cylinders that underwent isothermal curing. CORPS-STIF represents a step toward understanding and predicting strength gain of UHPC for full-scale structures and specifically in mass concrete.

http://dx.doi.org/10.21079/11681/40440

Concrete improvements . . .

In an effort to optimize material components of concrete placements for ultra-high performance, researchers looked to produce a tool that could be used for understanding and predicting strength gain, specifically in mass concrete. This effort was a collaboration between ERDC's Geotechnical and Structures Laboratory and the Center for Advanced Vehicular Systems (CAVS) at Mississippi State University (MSU) that resulted in the launch of CORPS-STIF. CORPS-STIF is an acronym for Concrete Observations Repository and Predictive Software–Structural and Thermodynamical Integrated Framework. The tool evolved from a combination of mechanical and thermodynamical test recordings, strength-development models, and a thermodynamical integrated framework. Researchers are confident their initial representation can be used to improve the tool over time.

Dr. Isaac Howard, an MSU engineering professor who is familiar with multiple ERDC projects and has led numerous ERDC employees in their PhD efforts, developed the acronym specifically for this Corps effort. Howard worked closely on CORPS-STIF with Geotechnical and Structures Laboratory (GSL) researcher Dr. Jameson D. "Jay" Shannon, who said he enjoyed the opportunity to work professionally with Howard after having been connected with him through his own undergraduate studies at MSU.

"Throughout the project, we had near constant interaction with faculty and students at MSU," Shannon said. "Everything from shipping materials and specimens back and forth, to manufacturing of concrete with both groups present, to the MSU students casting specimens at Building 6000 in Vicksburg for analysis." According to Shannon, most materials were transported between Starkville and Vicksburg using a van and trailer. One of those exchanges, however, included an unexpected delay.

"On one trip," Shannon lamented, "after MSU students and faculty loaded up materials at ERDC to travel back to MSU, they had a flat tire in the Jackson area and had to unload thousands of pounds of materials on the side of the road to change the tire!"

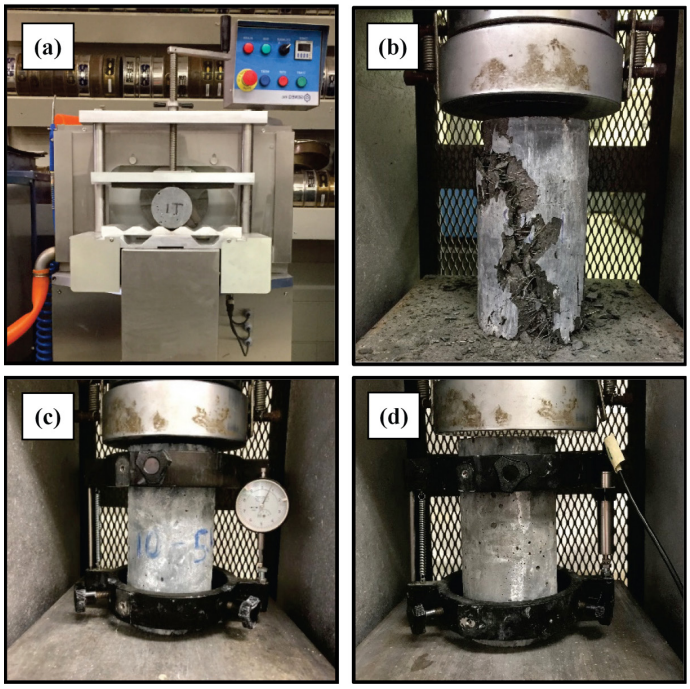
Some key components of CORPS-STIF include an observations repository containing experimental data; a 6-file software package of instructions and requirements; and an Abaqus file and Python files for developing functions and calculations. The research team determined in its composure of CORPS-STIF 1.0 that the tool is a feasible concept with the ability to improve over time toward better understanding of mass concrete. The future vision includes a more user-friendly version with an accompanying manual and the ability to carry out accompanying processes in a reasonably equipped laboratory.

"Working with CAVS is always a treat," Shannon said. "While the ERDC is an international organization and works with government, private industry, and academia from all over the world, it's always great to have a 'hometown' influence right here in Mississippi." ☐

Article contributed by Kathleen Miles, writer-editor for the ITL Information Science and Knowledge Management Branch.

Opposite: Dr. Jameson "Jay" Shannon with students who presented at the Internal Program Review (an annual review of work done by students on various projects) at CAVS.

Below: Specimen preparation and testing: (a) end grinder, (b) compression test, (c) elastic modulus (analog dial), and (d) elastic modulus (linearly variable displacement transducer).



ERDC/CHL TR-21-15

Sabine Pass to Galveston Bay, TX Pre-Construction, Engineering and Design (PED): Coastal Storm Surge and Wave Hazard Assessment

Report 1 – Background and Approach

By Jeffrey A. Melby, Thomas C. Massey, Abigail L. Stehno, Norberto C. Nadal-Caraballo, Shubhra Misra, and Victor Gonzalez

Abstract: The US Army Corps of Engineers, Galveston District, is executing the Sabine Pass to Galveston Bay Coastal Storm Risk Management (CSRM) project for Brazoria, Jefferson, and Orange Counties regions. The project is currently in the Pre-construction, Engineering, and Design phase. This report documents coastal storm water level and wave hazards for the Port Arthur CSRM structures. Coastal storm water level (SWL) and wave loading and overtopping are quantified using high-fidelity hydrodynamic modeling and stochastic simulations. The CSTORM coupled water level and wave modeling system simulated 195 synthetic tropical storms on three relative sea level change scenarios for with- and without-project meshes. Annual exceedance probability (AEP) mean values were reported for the range of 0.2 to 0.001 for peak SWL and wave height (Hm0) along with associated confidence limits. Wave period and mean wave direction associated with Hm0 were also computed. A response-based stochastic simulation approach is applied to compute AEP runup and overtopping for levees and overtopping, nappe geometry, and combined hydrostatic and hydrodynamic fluid pressures for floodwalls. CSRM structure crest design elevations are defined based on overtopping rates corresponding to incipient damage. Survivability and resilience are evaluated. A system-wide hazard level assessment was conducted to establish final recommended system-wide CSRM structure elevations.

http://dx.doi.org/10.21079/11681/41820

Opposite: A flooded portion of Galveston, Texas, after Hurricane Ike in September 2008. (Photo by Staff Sgt. James L. Harper Jr.)

The probability of safety . . .

Stretching from Galveston Bay to Sabine Pass, about seventy miles of the upper Texas coast, which encompasses the cities of Freeport, Galveston, Houston and Port Arthur, lies vulnerable to rising sea levels and hurricane storm surge. To better harbor life and property, the US Army Corps of Engineers (USACE), Galveston District (SWG), is executing the Sabine Pass to Galveston Bay (S2G), Coastal Storm Risk Management (CSRM) project. In an effort led by the CHL in the design phase, state-of-the-art hydrodynamic modeling and stochastic simulations predicted and quantified coastal storm surge, wave loading, and wave and surge overtopping. CHL's efforts were motivated by the pressing need to better plan and prepare for storm surge threats. As engineer Jeffrey Melby related, "It is heart wrenching to see hurricane catastrophes year after year. The changing climate will compound the risks and technical challenges going forward."

"This project was probably the best project I have worked on." These words, coming from a research engineer with a thirty-five-year career with USACE, convey the sense of a propitious moment for the taking in the ERDC's capabilities and partners. "Our understanding of hurricane hazards and our ability to model hurricane flood responses in high fidelity has leapt ahead in the last ten years. We are building complex multivariate probabilistic climate models to define the storm climatology over the entire probability space. We then use large-scale, high-fidelity numerical models to model thousands of storms on supercomputers. We then use these results to train metamodels, and this workflow feeds back to yield ever increasing definition of space, time and probabilistic spaces for storm hazards." Melby added, "To our knowledge, there has never been this level of fidelity applied to large regional flood risk reduction. We can now run a metamodel for an incoming hurricane in less than a minute that will give us detailed surge and waves responses over a region. The project had endless technical and schedule challenges. However, the timing was perfect because it evolved in near perfect synchrony" with ERDC's capabilities.

These advances were never certain. As Melby related, the revolutionary technology "was a hard sell to the sponsors at the beginning of the project." However, Melby added that, though skeptical, "the sponsors shared a major goal in this work to advance science." Collaboration with researchers through technology sharing workshops, the Galveston District, FEMA, the USGS, several universities, and the USACE Risk Management Center proved "critical to the success of the project." And according to Melby, they will prove critical in the future: "My sense is that NOAA, FEMA, and USACE are becoming better coordinated in advancing coastal storm modeling and flood risk technology. In addition, ERDC has several large programs that are joint with universities, including the compound flooding research. So, future work is likely to be even more collaborative, and products are more likely to be multi-agency going forward. I began my career in 1987, and there was far less collaboration then. Collaboration is much easier." A development that should prove timely as "still endless challenges" exist to motivate "the next generation of researchers." ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.

ERDC/GRL TR-21-3

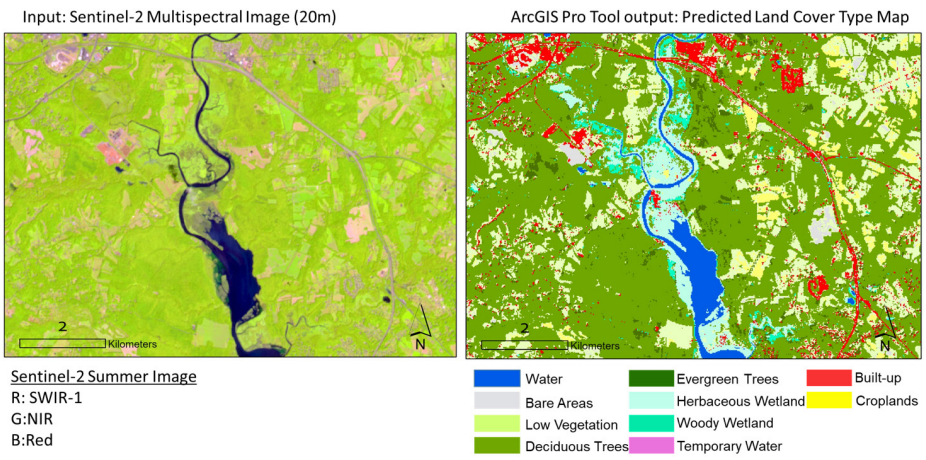
Monitoring Ecological Restoration with Imagery Tools (MERIT)

Python-Based Decision Support Tools Integrated into ArcGIS for Satellite and UAS Image Processing, Analysis, and Classification

By Kristofer D. Lasko and Sean P. Griffin

Abstract: Monitoring the impacts of ecosystem restoration strategies requires both short-term and long-term land surface monitoring. The combined use of unmanned aerial systems (UAS) and satellite imagery enable effective landscape and natural resource management. However, processing, analyzing, and creating derivative imagery products can be time consuming, manually intensive, and cost prohibitive. In order to provide fast, accurate, and standardized UAS and satellite imagery processing, we have developed a suite of easy-to-use tools integrated into the graphical user interface (GUI) of ArcMap and ArcGIS Pro as well as open-source solutions using NodeOpenDroneMap. We built the Monitoring Ecological Restoration with Imagery Tools (MERIT) using Python and leveraging third-party libraries and open-source software capabilities typically unavailable within ArcGIS. MERIT will save US Army Corps of Engineers (USACE) districts significant time in data acquisition, processing, and analysis by allowing a user to move from image acquisition and preprocessing to a final output for decision-making with one application. Although we designed MERIT for use in wetlands research, many tools have regional or global relevancy for a variety of environmental monitoring initiatives.

http://dx.doi.org/10.21079/11681/40262



Left: Two dates of Sentinel-2 imagery are input into the tool to create a wetland area land cover type map. An example output is shown on the right. The user need only input their imagery; no training data is required.

Opposite: Wetlands at Joint Base Langley-Eustis, Virginia. (Photo by Airman 1st Class Anthony Nin Leclerec, US Air Force)

Mapping worth mentioning . . .

Land surface monitoring is a critical component of measuring the effectiveness of ecosystem restoration strategies. The use of unmanned aerial systems (UAS) and satellite imagery enable timely, dynamic surveillance; but processing, analyzing, and creating derivative imagery products can be slow, arduous, and costly. ERDC Geospatial Research Laboratory researchers Kristofer Lasko and Sean Griffin—leveraging the subject matter expertise of Environmental Laboratory researchers—have addressed this opportunity by developing a suite of user-friendly tools for ArcMap and ArcGIS Pro and open-source options using NodeOpenDroneMap. The Monitoring Ecological Restoration with Imagery Tools (MERIT) save time and resources by allowing users to perform image acquisition, preprocessing, and final output within a single application.

But MERIT nearly never was; it could have been Supporting Wetlands Using Imagery and Mapping tools: SWUIM. "We had a few back and forth discussions trying to decide upon a name and acronym for the toolset," said Lasko. "[I] was a big fan of SWUIM because of the obvious pun connection to the wetlands. . . . It was difficult to have both a pun and a meaningfully named tool, so we decided on a more practical acronym suggested by Sean: MERIT."

MERIT is the first-known implementation within ERDC of Python-based decision support tools directly integrated into the ArcGIS Pro toolbox. It eliminates the need for advanced programming or remote-sensing experience for scientists and technicians, which saves serious time for the user. Research is ongoing. Said Lasko, "We have still provided occasional enhancements to the tools based on outcomes from other projects. For example, we updated the toolbox to include an automated surface water mapping tool. . . . MERIT provides broad utility for any geospatial application requiring UAS or other remotely sensed imagery."

Looking ahead, MERIT aims to be a jumping-off point for future innovation and improvement in the automated space. "Providing any automated method is of interest to most researchers, but automating land cover mapping is a problem set that remote-sensing practitioners have been trying to tackle for decades," said Lasko. "The innovative tools under this project provide a solid roadmap for other geospatial researchers to follow and improve." ☐

Article contributed by Dane Torbeck, writer-editor for the ITL Information Science and Knowledge Management Branch.

ERDC/ITL TR-21-4

USACE Advanced Modeling Object Standard

Release 1.0

By Andrew Ross, David Johnson, Hai Le, Danny Griffin, Carl Mudd, and David Dawson

Abstract: The US Army Corps of Engineers (USACE) Advanced Modeling Object Standard (AMOS) has been developed by the CAD/BIM Technology Center for Facilities, Infrastructure, and Environment to establish standards for support of the Advanced Modeling process within the Department of Defense (DoD) and the Federal Government. The critical component of Advanced Modeling is the objects themselves- and either make the modeling process more difficult or more successful. This manual is part of an initiative to develop a nonproprietary Advanced Modeling standard that incorporates both vertical construction and horizontal construction objects that will address the entire life cycle of facilities within the DoD. The material addressed in this USACE Advanced Modeling Object Standard includes a classification organization that is needed to identify models for specific use cases. Compliance with this standard will allow users to know whether the object model they are getting is graphically well developed but data poor or if it does have the data needed for creating contract documents. This capability will greatly reduce the designers' efforts to either build an object or search/find/edit an object necessary for the development of their project. Considering that an advanced model may contain hundreds of objects this would represent a huge time savings and improve the modeling process.

http://dx.doi.org/10.21079/11681/42152

Opposite: BIM views of the mechanical system for the new USACE Engineer Research and Development Center headquarters building.

Defining the language . . .

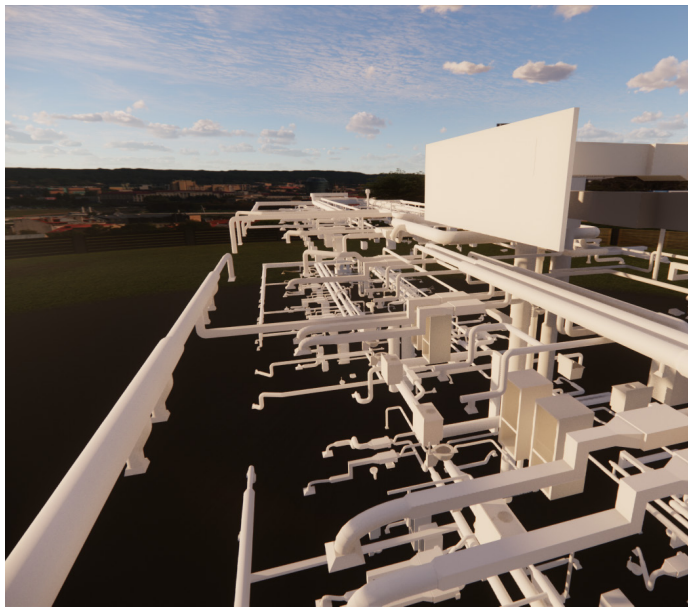
The effort to standardize modeling objects for Building Information Modeling (BIM) was scrapped, again and again. "Every time we would think we were done, there was a better approach of the standard that would emerge. It was like finding out that instead of reaching the top of the mountain, you had to descend into a valley again and back up the other side to the next peak." It was, finally, the fourth effort—after false summits, funding woes, and time crunches—that worked.

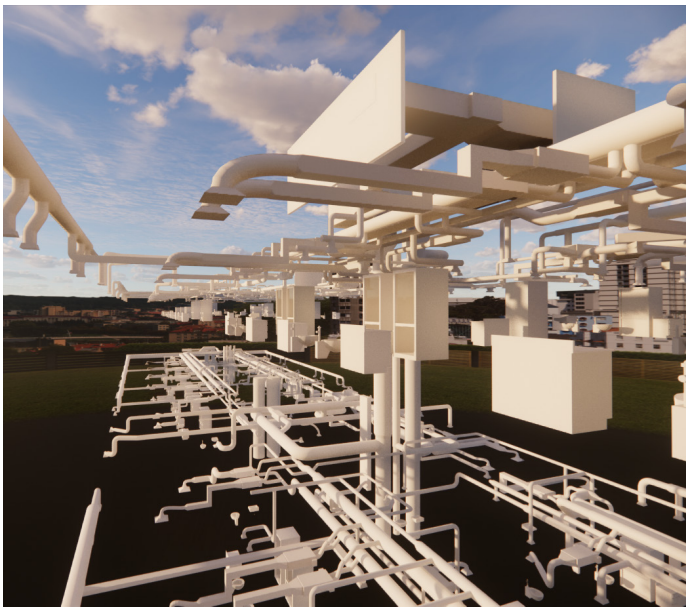
Previous to ITL and USACE's efforts, the typical modeling process frequently involved searching for specific objects and editing them for a particular project. The work not only required large amounts of time, but the results differed among districts and among individuals, effectively annulling efforts to share objects and data. "The use of data," according to David Johnson, "requires consistency and organization." An object standard enables the development of consistent objects and a common library. It enables the data to translate across individuals, districts, and industries for common goals, such as cost estimating and facilities management.

However, the problem facing the team was as broad as it was deep. "To reduce the standard down to a single document was difficult. [W]e had to develop and filter through many possibilities but develop something that allowed us to differentiate qualities of the objects—the graphics, the data, the functions and the external controls." Condensing the different possibilities and vocabularies into a single standard required fielding a team that could create a widely applicable standard. "The project involved personnel from several districts that were very experienced in the Building Information Modeling process and the BIM objects but had different perspectives. Getting field experience for various disciplines," Johnson said, "was critical for developing the breadth as well as the depth of the standard. The effort needed review from people with different professional skill sets—architectural, mechanical, structural, and electrical engineering. We needed to have designers reaching an agreement for BIM objects that had a broad range of types. Being able to include designers from various districts as well as all the disciplines gave us a broad case view of the objects."

For such an ambitious collaboration, "time was difficult to find," but "there were face-to face meetings at critical stages that were important for team building in the discussions and evaluations." Their success was "only the first step in a major effort to create advanced modeling standards for 'objects' used in the BIM process." Next, they hope to add Civil Information Modeling (CIM) objects to the standard. "Civil engineering objects (levee, channel, road sections) are similar but very different in composition and structure and will require adjustment to the existing standards." Indeed, the next step should, Johnson said, prove the "most difficult." ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.





ERDC/CHL TR-21-3

guiBathy

A Graphical User Interface to Estimate Nearshore Bathymetry from Hovering Unmanned Aerial System Imagery

By Brittany Bruder, Katherine Brodie, Tyler Hesser, Nicholas Spore, Matthew Farthing, Matthew Geheran, and Alexander Renaud

Abstract: This US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, technical report details guiBathy, a graphical user interface to estimate nearshore bathymetry from imagery collected via a hovering Unmanned Aerial System (UAS). guiBathy provides an end-to-end solution for non-subject-matter-experts to utilize commercial-off-the-shelf UAS to collect quantitative imagery of the nearshore by packaging robust photogrammetric and signal-processing algorithms into an easy-to-use software interface. This report begins by providing brief background on coastal imaging and the photogrammetry and bathymetric inversion algorithms guiBathy utilizes, as well as UAS data collection requirements. The report then describes guiBathy software specifications, features, and workflow. Example guiBathy applications conclude the report with UAS bathymetry measurements taken during the 2020 Atlantic Hurricane Season, which compare favorably (root mean square error = 0.44 to 0.72 m; bias = −0.35 to −0.11 m) with in situ survey measurements. guiBathy is a standalone executable software for Windows 10 platforms and will be freely available at www.github.com/erdc.

http://dx.doi.org/10.21079/11681/39700

A bird's-eye view . . .

Hovering sixty meters above the shoreline for ten minutes or longer, unmanned aerial systems now have the capability to estimate nearshore depths thanks to *guiBathy*, a software developed by researchers at the Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL). To get measurements prior to this, researchers typically piled into a boat. Now, "No one needs to get wet," assured coastal research engineer Brittany Bruder. Moreover, Bruder explained *guiBathy* "is significant because data analysis using quantitative coastal imagery has yet to be fully transitioned to districts; it still heavily relies on niche knowledge and experience of subject matter experts." The integration of *guiBathy* will mean USACE districts and stakeholders do not have to rely as much on subject matter experts but can now, with minimal equipment, personnel, and time commitment, "collect, process, and analyze coastal imagery independently in a standalone tool."

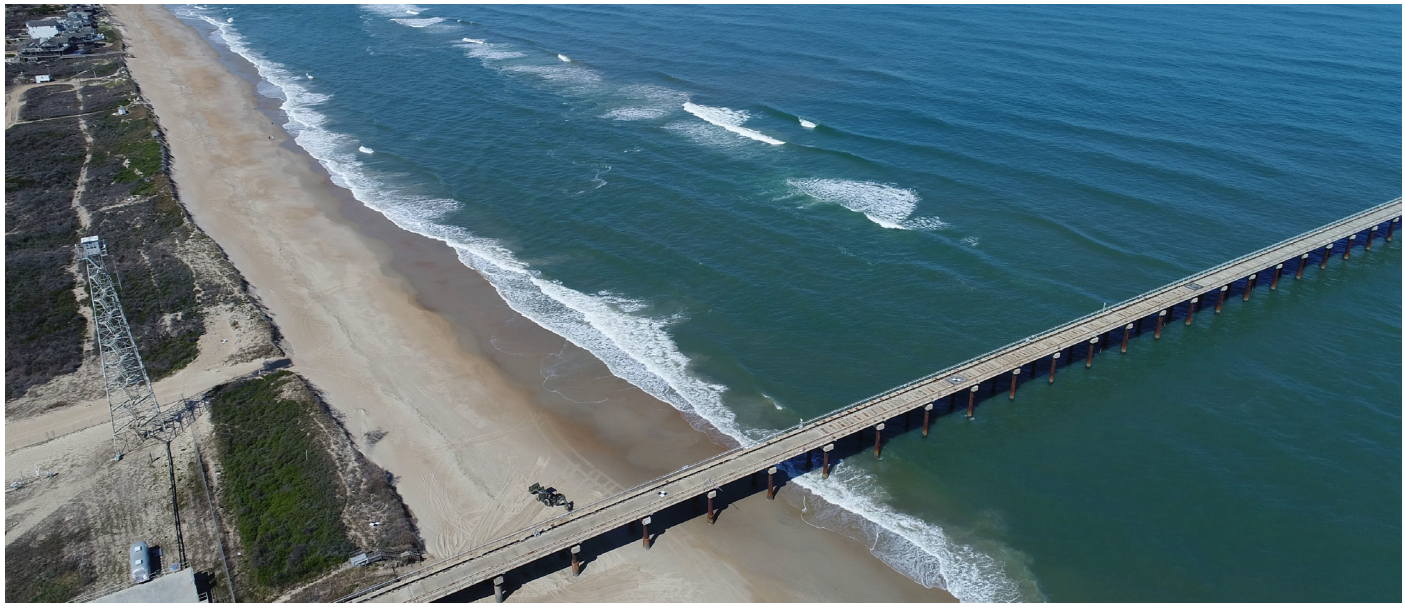
The benefits only compound, Bruder explained, "With low operational costs, in both finance and time, the Corps can respond and monitor more events in a more timely fashion. This allows for longer and more accurate prestorm assessments, observations during storms, and, thus, improved data for poststorm assessments and reconstruction. guiBathy has the potential to substantially alter the Corps' ability to collect coastal geospatial products for project monitoring and emergency preparation and response. USACE districts will have high-value coastal monitoring data that can be integrated into engineering decisions."

Despite being developed in house at CHL, Bruder related guiBathy actually relies on thirty years of collaborative effort first started at the University of Oregon. "The software uses algorithms that have been developed collaboratively over years through the Coastal Imaging Research Network (CIRN). CIRN is an international group of researchers from government agencies and laboratories, nonprofits, and universities focused on developing open-source code and technology for exploiting imagery of the coast for an increased understanding of coastal phenomenon. Because of this collaboration, we were able to leverage over 30 years of expertise and knowledge in the coastal imaging community." The next phase of the project deepens that collaborative effort by testing other districts' data. But even with a bright horizon, the project has already been one of joy and reward for Bruder: "This research embodied what I love most about my career path as a coastal research engineer at ERDC: (1) collecting field data; (2) computer programming for scientific analysis; and (3) transitioning research for applied use. Like any applied research, it is wonderful to see research being used in the real world where it can help practitioners and the public." ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.

Opposite: UAS monitoring active beach nourishment project and resultant shoreline change.

Below: The pier at ERDC's Field Research Facility in Duck, North Carolina; image taken by UAS.



ERDC TR-20-22

Microbiological Indicators Reflect Patterns of Life

By Alison K. Thurston, Andrew Hoisington, Andmorgan Fisher, Shelby A. Rosten, Elizabeth J. Corriveau, Robert M. Jones, and Robyn A. Barbato

Abstract: Resolving patterns of human movement, specifically for actors of interest, in an urban environment is an extremely challenging problem because of the dynamic nature of human movement. This research effort explores a highly unconventional approach, addressing residual or lingering signatures of interest to the Army in an urban operation. Research suggests that unconventional signatures commonly associated with human presence or prior occupation of a space, such as microbes attached to skin cells or in the gut, may linger for an extended amount of time. In this scoping study, our objectives were to detect microbial communities in the built environment, to examine microbial community composition, and to investigate the longevity of a microbial signature. To do so, we conducted a controlled study to obtain a mechanistic understanding of the fidelity of the biological signatures in the built environment, with a particular focus on their longevity and stability.

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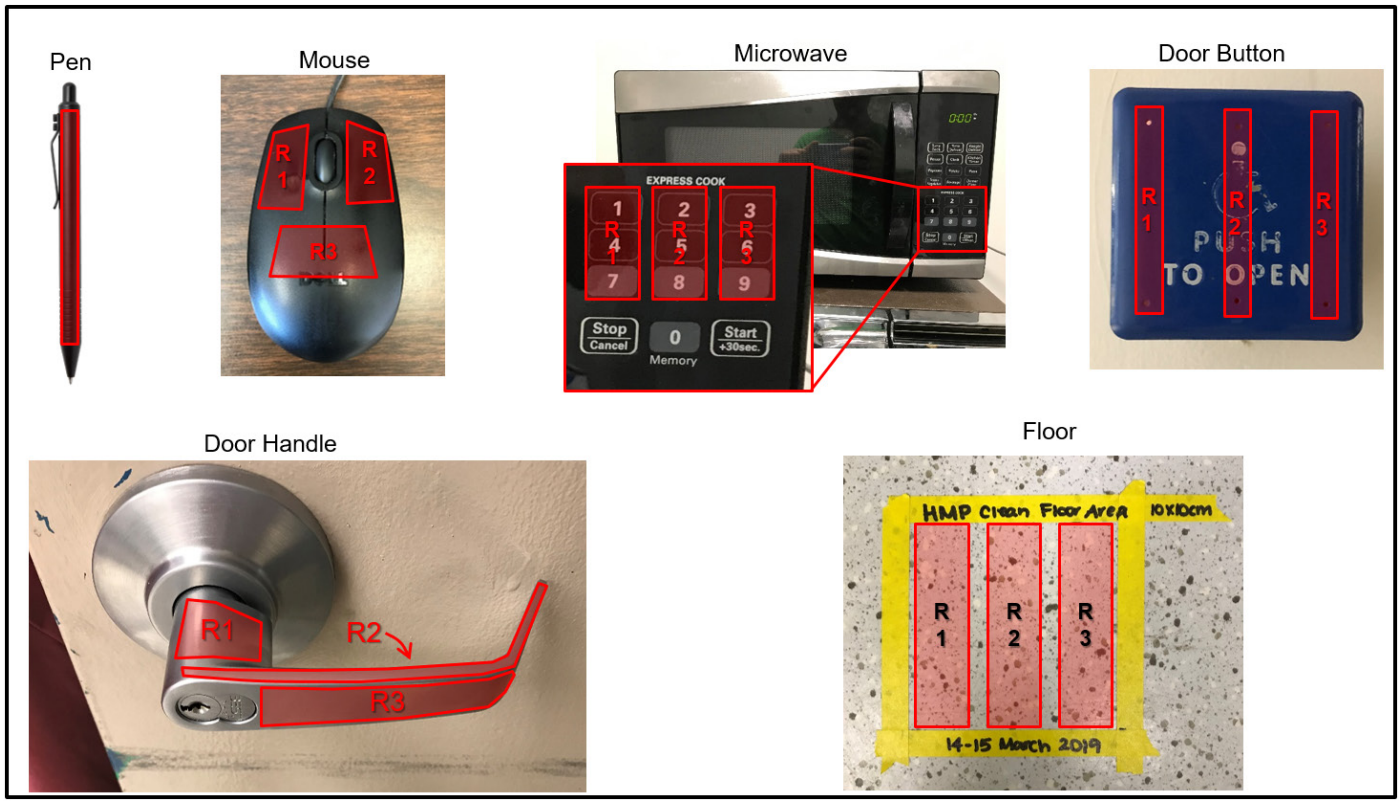


Microbial "fingerprints" . . .

If you saw someone working in the breakroom in a full-body clean suit like you might see on *CSI*, what would be your first thought? Or better yet, what if they came into your office?

A human body has more microbes on it than human cells; and as we move through the day and interact with our environment, we leave some of these microbes behind. But how distinct is our microbial signature, and is it possible to track someone's movements based on microbes alone? That was in part what the CRREL, GRL, and Air Force team aimed to explore in this one-year basic research project. Hence the clean suits so team members would not contaminate the samples. The team swabbed various surfaces around CRREL to see what signatures they could find and how these signatures changed over time. "One of the funniest things," Dr. Robyn Barbato, lead PI for the project, explained, "was showing three small squares on the floor to guests entering the labs and saying, 'Hey, you're in our study now.'" Lead author Alison Thurston added, "To this day, the squares are still on the floor in the lab."

And what did they find? Dr. Barbato was enthusiastic. "You want to know which person touched the microwave—we could tell you! I need to repeat this—we could tell you which person touched an object like the microwave without assessing their skin microbiome. Maybe we'll see this on the next episode of *CSI*!" Team member Robert Jones continued, "I think part of what makes me passionate about certain research endeavors is how relatable I can make it to nonscientists. . . . Being able to engage people in our science is what I'm passionate about, and I think other researchers as well have a passion for science communication." The reactions to this project are far from glazed eyes. "Everyone has seen or at least heard of *CSI*, so they can get on board with what we are talking about and why we might do it."

The collaboration between laboratories and with the Air Force Institute of Technology allowed the team to draw on both ERDC's knowledge of microbial ecology and their Air Force colleague's experience with the human microbiome and the built environment. When asked what about the collaboration worked, Dr. Barbato exclaimed, "Everything! Working across the services improves the final outcome of the research."

Overall, this study sets the stage for future research into skin microbes and their interaction with the environment and even with those on other people. "Capturing microbial signatures is a growing area of research that will enable us to detect things with better fidelity," explained Dr. Barbato. With any luck, the team will be able to continue this research themselves. As Jones concluded, "I personally love the almost surreal moments when I or one of my colleagues is doing something undeniably strange and it hits us that this weird thing we're doing is our job." ☐

Article contributed by Emily B. Moynihan, writer-editor for the ITL Information Science and Knowledge Management Branch.

Top: Swabs for testing. (Photo by Shelby Rosten)

Left: Swab design for various objects. Red boxes indicate the area swabbed for that object. (Image by Shelby Rosten)

ERDC/CERL TR-21-19

Integration of Autonomous Electric Transport Vehicles into a Tactical Microgrid

Final Report

By Angela Rolufs, Amelia Trout, Kevin Palmer, Clark Boriack, Bryan Brilhart, and Annette L. Stumpf

Abstract: The objective of the Autonomous Transport Innovation (ATI) technical research program is to investigate current gaps and challenges and develop solutions to integrate emerging electric transport vehicles, vehicle autonomy, vehicle-to-grid (V2G) charging and microgrid technologies with military legacy equipment. The ATI research area objectives are to identify unique military requirements for autonomous transportation technologies; identify currently available technologies that can be adopted for military applications and validate the suitability of these technologies to close need gaps; identify research and operational tests for autonomous transport vehicles; investigate requirements for testing and demonstrating of bidirectional-vehicle charging within a tactical environment; develop requirements for a sensored, living laboratory that will be used to assess the performance of autonomous innovations; and integrate open standards to promote interoperability and broad-platform compatibility. This final report summarizes the team's research, which resulted in an approach to develop a sensored, living laboratory with operational testing capability to assess the safety, utility, interoperability, and resiliency of autonomous electric transport and V2G technologies in a tactical microgrid. The living laboratory will support research and assessment of emerging technologies and determine the prospect for implementation in defense transport operations and contingency base energy resilience.

http://dx.doi.org/10.21079/11681/42007

A battlefield charge . . .

Autonomous electric vehicles promise to alter the built environment of Army installations. Their integration into installations' transportation networks and power microgrids, the report argues, is needed to increase resiliency and to ensure electric vehicle mobility is possible outside the wire. A stunningly broad research partnership developed a "living laboratory" on Fort Leonard Wood to demonstrate the near-at-hand possibilities of autonomous electric vehicles. The base was a perfect fit in more ways than one, as home to both a DoD driving school, CERL's Contingency Basing Integration Training and Evaluation Center (CBITEC), and the Prime Power School. Lead researcher Annette Stumpf explained, "I could see that being an area where they could experiment and see how [autonomous electric vehicles] work and then understand them so they could train on them or adopt them. There has to be that proving ground."

One of the primary objectives of the team was to prove that bidirectional charging—where a charge can go from the vehicle back to the grid—was possible with a tactical microgrid. Having an architect brain meant Stumpf had to become familiar with the concept herself. "This was really awesome, cutting-edge research. And it is kind of an accident of mine, misunderstanding how easy it would be to do it. I thought you could just plug a charger in. The bidirectional charging on a tactical microgrid was a lot harder than we thought." Her networking with researchers and Fort Leonard Wood, however, meant her team had already bought in. "I'd go around, and I'd find researchers, and I'd talk to them about what the needs are at the post. You have to get a commitment from a researcher that whatever the effort is, it is important to them, that they are going to do it. It is harder to come up with the ideas and then get somebody to do it later that wasn't bought in on the idea. There's no way I would have gotten this done the way we did if I hadn't been doing that. We had to work together and research and talk together to shape it. We had to think of what are we going to do that is different than what is commercially available. What can we do that will help the Army?"

A capability Stumpf homed in on was the tactical microgrid standard, a standardization meant to ensure microgrids used by deployed warfighters are interoperable, modular, and adaptable. The team began working on "trying to figure out how to charge [autonomous electric vehicles] at the tactical microgrid and have energy resiliency where you could get power back from a vehicle to share when you need it. The Army cannot use our tactical electric vehicles until we can charge them out in the field. This was really a turning point to prove that that can be done, that you could charge a vehicle. I think it was groundbreaking. Everyone that was part of the team contributed. I think it all really went well together in the end." ☐

Article contributed by James O'Donoghue, writer-editor for the ITL Information Science and Knowledge Management Branch.

Opposite: The Bidirectional V2G Charger being demonstrated at ERDC-CERL CBITEC Field Office. (Photo by Annette Stumpf)

Bottom: Clark Boriack explaining the operation of the V2G Bidirectional Charging Station, which is charging an electric vehicle off the tactical microgrid. (Photo by Annette Stumpf)

Hosting Datasets

Preserving and Transferring Critical Information

When Engineer Research and Development Center (ERDC) researchers work on their various projects, they generally create scientific datasets as part of that work. Historically, technical publications related to these projects referenced these datasets, but the entire dataset was not always made available as part of these publications. Many datasets were available to other researchers only upon request.

In recent years, publishers in peer-reviewed science and engineering journals have been promoting the importance of making the full datasets generated during the research process available to the public alongside the relevant publications. Further, some of these publishers require as part of the publication process that researchers host their relevant datasets on a reputable digital repository with a persistent link. In many cases, it is up to the researcher to find a place to host the dataset that meets the publisher's requirements. If they are unable to meet publisher's requirements, publishing in the journal becomes impossible. This threatens to make it difficult for ERDC researchers to publish in some of the high-impact journals in their fields of research.

In response to these developments, the ERDC Library has created processes for uploading ERDC datasets onto ERDC Knowledge Core so that researchers have the option of hosting and sharing their datasets on a secure, ERDC-sponsored platform for free. ERDC Knowledge Core already hosts several datasets successfully, and the ERDC Library is ready to accommodate more requests from our researchers going forward. While submissions of datasets over 1 GB will require special attention, ERDC librarians are eager to work with researchers to find ways to get the data online. Contact the ERDC Library for more info and to get started! ☐

Article contributed by Jered Lambiotte, librarian for the ITL Information Science and Knowledge Management Branch.

Why Should I Publish a Miscellaneous Paper, and Is It Worth the Undertaking?

So glad you asked! The Information Science and Knowledge Management Branch (ISKM) has been actively promoting the publication of Miscellaneous Papers (MPs) since 2019 when ERDC issued updated technical reporting requirements. These MPs provide a process to aid in capturing, reporting, and transferring ERDC's Army Research, Development, Test, and Evaluation (RDT&E) technologies and data.

Why should I publish an MP?

1. It is free! There is no cost to authors to publish an MP.
2. Your journal article or conference paper is added to DTIC as an official ERDC publication where it is available to the DTIC community along with other important research reports and results, all in the same location. This will increase the visibility of ERDC authors and their research. This also allows more accurate records for data calls and tracking of publication statistics.
3. Your work will also be added to the ERDC Digital Repository where it can readily be found and is available to R&D-loving colleagues who may be looking for a partner with great ideas to consult or collaborate on a project or added as a reference.
4. Keywords are always added to the MP by an ERDC librarian before publication, making your work easier to find online.
5. One more reason—by sending your articles and papers to be published as MPs, you are also following the updated technical reporting requirements from ERDC (issued 1 May 2019) for Army-sponsored RDT&E 6.1–6.3 projects to provide technical reporting and transfer of RDT&E technologies and data. This does not mean only RDT&E 6.1–6.3 projects should be sent for MP publishing. All ERDC authored articles and papers are welcome!

Is it worth the undertaking?

It is like free advertising for you and your research. Further, the process is uncomplicated. You will need to send your MP publication request with the following items to ISKM Editing:

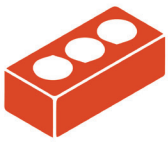
1. A digital copy of the final accepted manuscript or a PDF copy of the article
2. A completed and signed ERDC Form 7
3. The journal citation metadata or conference information and DOI

In FY21, ISKM published 85 MPs. Totals by Lab were CRREL 24, EL 17, ITL 13, GSL 6, CHL 5, CERL 3, GRL 1, and ERDC 16.

Contact me so we can help you publish! Vicki Reinhart, MP POC, at Vicki.A.Reinhart@usace.army.mil. ☐

Article contributed by Vicki Reinhart, editorial assistant for the ITL Information Science and Knowledge Management Branch.

Left: ISKM provides expert assistance in research, writing, publishing, and organizing, preserving and increasing the visibility of ERDC research.



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14. ABSTRACT

As the main research and development organization for the US Army Corps of Engineers (USACE), the Engineer Research and Development Center (ERDC) helps solve our nation's most challenging problems. With seven laboratories under the ERDC umbrella, ERDC expertise spans a wide range of disciplines. This provides researchers an amazing network of collaborators both within labs and across them.

Many of the publications produced by ERDC through the Information Technology Laboratory's Information Science and Knowledge Management Branch (ISKM), the publishing authority for ERDC, are a testament to the power of these partnerships. Therefore, in this issue of *The Forefront*, we wanted to highlight some of those collaborations, across ERDC and beyond. Colored flags at the top of each page indicate the laboratories involved in each report (see the end of this issue for a full list of the laboratories and their lab colors), in addition to USACE red for district collaborators and gray for others. Through these collaborations, ERDC is continuing to demonstrate its value nationally and internationally.

Questions about the reports highlighted in *The Forefront* or others published by ERDC? Contact the ISKM virtual reference desk at erdclibrary@ask-a-librarian.info or visit ERDC Knowledge Core, ISKM's online repository, at https://erdc-library.erdc.dren.mil/. For general questions about editing and publishing at ERDC, you are also welcome to reach out to me at Emily.B.Moynihan@usace.army.mil. We look forward to continuing to be a resource for ERDC and seeing all the remarkable research that is yet to come.

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The reports highlighted here are just a few of the 200+ publications that the ERDC Information Technology Laboratory's Information Science and Knowledge Management (ISKM) Branch publishes for ERDC, USACE, Army, and DoD communities each year.

For more information, contact ISKM at erdclibrary@ask-a-librarian.info.

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