



US Army Corps
of Engineers®



Installation Technology Transfer Program

Deployable Resilient Installation Water Purification and Treatment System (DRIPS)

Geoenabled Water Production and Disinfection Systems for Installations

Clint B. Smith, Damarys Acevedo-Acevedo, Fahmi M. Atwain,
Ilea A. Diaz Lluberres, Osman A. Tirmizi, Ziyad F. Atwain, and
Jason C. Smith

April 2024



The US Army Engineer Research and Development Center (ERDC) solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, the Department of Defense, civilian agencies, and our nation's public good. Find out more at www.erdclibrary.on.worldcat.org/discovery.

To search for other technical reports published by ERDC, visit the ERDC online library at <http://www.erdclibrary.on.worldcat.org/discovery>.

Deployable Resilient Installation Water Purification and Treatment System (DRIPS)

Geoenabled Water Production and Disinfection Systems for Installations

Clint B. Smith, Fahmi M. Atwain, Ilea A. Diaz Lluberres, Osman A. Tirmizi, Ziyad F. Atwain,
and Jason C. Smith

*US Army Engineer Research and Development Center (ERDC)
Geospatial Research Laboratory (GRL)
7701 Telegraph Road
Alexandria, VA 22315-3864*

Damarys Acevedo-Acevedo

*US Army Engineer Research and Development Center (ERDC)
Environmental Laboratory (EL)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199*

Final Technical Report (TR)

Distribution Statement A. Approved for public release: distribution is unlimited.

Prepared for Headquarters, Department of the Army, G-9
Washington, DC 20310

Under MIPR 11830817

Abstract

The Deployable Resilient Installation water Purification and treatment System (DRIPS) was delivered to aid an Organic Industrial Base in increasing their Installation Status Report–Mission Capacity (ISR-MC) score from black to green as part of a Course of Action (COA) within their Installation Energy and Water Plan (IEWP). DRIPS was also intended to help them be better prepared for the future in meeting their water and energy requirement goals for sustainment of critical missions. The IEWP ISR-MC requirements were met upon implementation of this project. Overall, the purpose of the DRIPS is to be a critical asset in disaster response and military operations, providing a reliable and effective means of producing potable water and disinfection in challenging and unpredictable environments. Its adaptability, mobility, and comprehensive water treatment capabilities make it an invaluable resource for addressing water-related emergencies and water disruptions and for sustaining critical missions. It also addresses a point of need by improving the ability to meet demands, reducing convoy requirements and the logistical footprint, facilitating the endurance of expeditionary forces, and ensuring the well-being of affected installations during times of disaster response, training operations, normal water disruptions, and emergency preparation.

DISCLAIMER: The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

DESTROY THIS REPORT WHEN NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.

Contents

| | |
|---|-----------|
| Abstract | ii |
| Figures | iv |
| Preface..... | v |
| 1 Introduction..... | 1 |
| 1.1 Background..... | 1 |
| 1.2 Objective..... | 6 |
| 1.3 Approach | 7 |
| 2 Challenges..... | 8 |
| 3 Method | 11 |
| 4 Results | 14 |
| 4.1 User Jury Feedback | 16 |
| 4.1.1 Topics That Were Most and Least Valued | 19 |
| 4.1.2 Topics That Were Not Covered or Were Still Unclear | 20 |
| 4.1.3 What was Liked, and What was Identified for Change | 21 |
| 4.1.4 Additional Feedback | 21 |
| 4.2 Summary | 22 |
| 5 Conclusions and Next Steps | 24 |
| Bibliography | 27 |
| Appendix: Additional Deployable Resilient Installation Water Purification and Treatment System (DRIPS) Documentation | 30 |
| A.1 Situational Report for NATO Norway Meeting in April 2023 | 30 |
| A.2 DRIPS Unit Factsheets | 32 |
| A.3 DRIPS Logo..... | 36 |
| Abbreviations..... | 37 |
| Report Documentation Page (SF 298)..... | 41 |

Figures

| | | |
|----|--|----|
| 1. | The ruggedized Water on Wheels (WOW) mobile emergency water treatment system, now called the Deployable Resilient Installation water Purification and treatment System (DRIPS) unit, set up for the user jury at Fort Leonard Wood (FLW) in June 2023..... | 5 |
| 2. | The DRIPS delivery and training team at an Organic Industrial Base (OIB) in July 2023. (Photograph shows, <i>left to right</i> , Mr. Osvaldo Alomar, Mr. Osman Tirmizi, Mr. Jason Smith, Dr. Clint Smith, Mr. Johnny Brown, Mr. Kurtis Daniels, Mr. Jeffrey Ott, SSG Sherndale Hinton, Mr. Tony Zollo, Ms. Ilea Diaz Lluberres, Mr. Joshua Sweat, and Mr. Ziyad Atwain)..... | 5 |
| 3. | DRIPS unit in the bed of a pickup truck at an OIB for transport to the training location..... | 10 |
| 4. | The DRIPS unit’s integrated electrochlorinator from WaterStep. The M100 supplies the gas infusion of chlorination into the water treatment train, providing rapid disinfection to the source-water treatment..... | 12 |
| 5. | DRIPS unit user jury setup, training, and demonstration at FLW in June 2023..... | 17 |
| 6. | User jury survey for the DRIPS unit..... | 18 |
| 7. | User jury survey responses from FLW and the OIB in June and July 2023..... | 19 |
| 8. | The user jury and training team (<i>top</i>), which included (<i>left to right</i>) Mr. Osvaldo Alomar, MAJ Maurice Pritchett, Mr. Christopher High, Mr. Fahmi Atwain, Mr. Ziyad Atwain, Dr. Clint Smith, Mr. Kurtis Daniels, Dr. Jim Allen, LTC John Decker, Dr. Jim Goodrich, Dr. Chris Griggs, Mr. Osman Tirmizi, and Ms. Ilea Diaz Lluberres. The user jury setup (<i>bottom left</i>) and the finished chlorination-gas-infused product water output (<i>bottom right</i>)..... | 23 |

Preface

This study was conducted for Headquarters, Department of the Army, G-9, for Project 474139, “Deployable Resilient Installation water Purification and treatment System,” MIPR 11830817.

This work was performed by the Geospatial Applications Branch of the Research Division, US Army Engineer Research and Development Center, Geospatial Research Laboratory (ERDC-GRL). At the time of publication, Mr. Fahmi Atwain was chief, Geospatial Applications Branch; Mr. Jeffrey Murphy was chief, Topography, Imagery, and Geospatial Research Division; and Dr. Austin Davis was the lead technical director for Geospatial Research and Engineering. The deputy director of ERDC-GRL was Ms. Valerie Carney, and the interim director was Mr. Vijay Acharya. The work was also performed by the Environmental Engineering Branch of the Environmental Processes and Engineering Division, Environmental Laboratory (EL) at ERDC. Dr. Michael Rowland was chief, Environmental Engineering Branch; Mr. Warren Lorentz was chief, Environmental Processes and Engineering Division; and Dr. Pat Deliman was lead technical director for the Applied Research Planning Support Center (ARPSC) and Installation Energy and Water Plan (IEWP) programs. The deputy director of ERDC-EL was Dr. Brandon Lafferty, and the director was Dr. Edmond Russo, Jr.

Because this work involved operational water, Mr. James Allen, the lead technical director for Operational Science and Engineering, ERDC, Construction Engineering Research Laboratory (ERDC-CERL), served as the technical director for this research. He did a phenomenal job at supporting this effort and marketing it to others.

Portions of the Background were reproduced with permission, under Creative Commons License CC BY-NC-ND 4.0 Deed, from “Developing Water Resiliency Solutions at Military Installations,” by Smith et al. (2022).

COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

This page intentionally left blank.

1 Introduction

The purpose of this report is to capture an innovative technology that can be transferred to Army installations to improve their resiliency and security. Though there are systems that are capable of chemical weapons agent (CWA) filtering and can produce potable water that meets Tri-Service standards, the Army Futures Command (AFC) highlighted the size and weight of these systems, their fuel requirements, and their overall logistical burdens as areas for improvement.

1.1 Background

The Deployable Resilient Installation water Purification and treatment System (DRIPS) is an innovative technology aimed at reducing the overall logistical burden of providing potable water. It is a small, mobile system that is lighter than its predecessors and offers decentralized fuel options. It reduces the overall logistical burden by reducing the resupply demand signature for sustainment of Multidomain Operations (MDO) and increasing the disaster operational reach, maneuverability, and bottled water resupply while reducing bottled water waste supply logistics (Quinn 2023). The DRIPS unit is a small, mobile, state-of-the-art drinkable water supply unit with an infused disinfection capability for watercraft-functional mission operations (Headquarters, Department of the Army 2023a). The DRIPS unit provides a reliable, versatile, and low-maintenance solution for generating potable water and providing disinfection for preventative medicine applications, in various training operations, in disaster responses, and in emergency preparation situations. The DRIPS unit was delivered to aid an Organic Industrial Base (OIB) in increasing their Installation Status Report–Mission Capacity (ISR-MC) Critical Mission Sustainment (CMS) attribute score and changing their color rating from black to green (discussed next) as part of a project solution Course of Action (COA) within their Installation Energy and Water Plan (IEWP). This COA helps the installation be better prepared for the future by meeting their water and energy resiliency and security goals.

As previously noted in Smith et al. (2022), the Installation Management Command (IMCOM) requires Army installations to submit the ISR-MC annually by the end of the second quarter. The ISR-MC is a questionnaire that installations are required to provide responses to every year and is used to assess the capability of an installation to support its current and

future mission requirements, readiness, and sustainment with priority water resources.

COAs are developed based on current deficiencies, which are provided by an installation's stakeholder team. They are also proposed to maintain a certain color rating due to the risk of their current status declining and turning into a deficiency in the future. For the color rating, the following scoring pattern is used:

- Green: Greater than or equal to 90% of the critical demands are captured in the prioritized, up-to-date list of critical missions and supporting infrastructure used for Mission Sustainment (MS) calculations.
- Amber: Less than 90% and greater than or equal to 75% of the critical demands are captured in the prioritized, up-to-date list of critical missions and supporting infrastructure used for MS calculations.
- Red: Less than 75% and greater than or equal to 40% of the critical demands are captured in the prioritized, up-to-date list of critical missions and supporting infrastructure used for MS calculations.
- Black: Less than 40% of the critical demands are captured in the prioritized, up-to-date list of critical missions and supporting infrastructure used for MS calculations (ISR-MC Appendix A, unpublished internal document).

Overall, the purpose of the DRIPS unit is to be a critical asset in humanitarian assistance and disaster response for military and civil operations, providing a reliable and effective means of producing potable water and disinfection in challenging and unpredictable environments. Its adaptability, mobility, and comprehensive water treatment capabilities make it an invaluable resource for addressing water-related emergencies and ensuring the well-being of affected installations during disaster responses, training operations, normal water disruptions, and emergency preparation. It also addresses a point of need by improving the ability to meet potable water and disinfection demands, reducing convoy requirements and the logistical footprint, and facilitating the endurance of expeditionary forces (Headquarters, Department of the Army 2023a). The DRIPS unit supports Army Directive 2020-08 (*US Army Installation Policy To Address Threats Caused by Changing Climate and Extreme Weather*; Secretary of the Army 2020b) and Army Directive 2020-03 (*Installation Energy and Water Resilience Policy*; Secretary of the Army 2020a). It also supports DoD Directive 4705.1E, *Management of Land-Based Water Resources in*

Support of Contingency Operations (DoD 2015b); ATP 3-35.1, *Army Pre-Positioned Operations* (Headquarters, Department of the Army 2022a); AR 30-22, *Army Food Program* (Headquarters, Department of the Army 2019a); AR 70-38, *Research, Development, Test and Evaluation of Materiel for Worldwide Use* (Headquarters, Department of the Army 2020); and AR 700-136, *Tactical Land-Based Water Resources Management* (Headquarters, Department of the Army 2009).

The current DRIPS unit is at Technical Readiness Level (TRL) 7 or 8 and supports installations by improving their water resiliency and security, thus increasing their ISR-MC, specifically the CMS MS320-3 (Water Sustainment Requirements) and Assured Access (AA) MS321-4b (Emergency-Response/Management) requirements for water resiliency and sustainment efforts and the Systems Operation (SO) MS323-5 for installation annual exercises (for emergency preparation and restoration). TRLs are

a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest. (Manning 2023, para. 1)

CMS measure MS320-3 is used to determine what percentage of an installation (including subinstallations and all tenant units) has the ability, technology, equipment, and energy available on-site to supply the potable and nonpotable water needed to support critical missions for the duration determined by Senior Command. A deficient score is anything less than green, and for the installations to have a green color rating, the percentage of the critical demands met with on-site supply must be greater than or equal to 90%.

AA measure MS321-4b indicates if an installation has documented access to contingency potable water supplies with permanent connection(s) to the installation's distribution system(s) or has in-house access, equipment, and capability to treat alternative water supplies. Anything rated less than green indicates a deficiency in this measure. To achieve a green or green+ color rating, an installation must meet at least 90% of daily water demands or 100% of all daily water demands, respectively.

SO measure MS323-5 indicates if installations have emergency water and wastewater preparedness plans that mitigate risks from water disruption and if these plans are exercised annually to mitigate risk during a prolonged water and wastewater utility outage, to maintain emergency water and wastewater requirements, and to look at vulnerabilities, requirements, and potential improvements. To achieve a score that is not deficient, meaning green or green+, the installation must have annual full-scale functional exercises of the emergency water and wastewater preparedness plans completed for either the critical water and wastewater requirements of the installation or for the entire installation.

The capability of the DRIPS unit has a current focus on the *F* in DOT-MLPF-P, which stands for Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities–Policy. The acronym is used by the US DoD and is defined in the Joint Capabilities Integration Development System (JCIDS) process as the framework to design what administrative changes or acquisition efforts would fill a capability need required to accomplish a mission (DAU 2014; DoD 2015a; Perkins 2015). In addition, the focus is not just on facilities; it is being sought for inclusion into acquisitional pathways for programs of record, as appropriate. This effort has developed a partnership among the US Army Corps of Engineers (USACE), US Army Engineer Research and Development Center (ERDC), US Environmental Protection Agency (EPA), and industry partner WaterStep to ruggedize the Federal Emergency Use System called the Water on Wheels (WOW) Cart. ERDC refers to the newly ruggedized system as the DRIPS unit and is working toward improved compliance so the unit will meet military standards and address the critical installation needs for having potable water available during disaster-response operations and normal disruptions.

Figure 1 shows the ruggedized WOW mobile emergency water treatment system, or DRIPS unit, which was demonstrated for a user jury at Fort Leonard Wood (FLW) in June of 2023. Figure 2 shows representatives from ERDC, the US Army Quartermaster, the OIB, and the WaterStep Organization delivering and training on DRIPS at an OIB in July 2023.

Figure 1. The ruggedized Water on Wheels (WOW) mobile emergency water treatment system, now called the Deployable Resilient Installation water Purification and treatment System (DRIPS) unit, set up for the user jury at Fort Leonard Wood (FLW) in June 2023.



Figure 2. The DRIPS delivery and training team at an Organic Industrial Base (OIB) in July 2023. (Photograph shows, *left to right*, Mr. Osvaldo Alomar, Mr. Osman Tirmizi, Mr. Jason Smith, Dr. Clint Smith, Mr. Johnny Brown, Mr. Kurtis Daniels, Mr. Jeffrey Ott, SSG Sherndale Hinton, Mr. Tony Zollo, Ms. Ilea Diaz Lluberres, Mr. Joshua Sweat, and Mr. Ziyad Atwain).



The IEWP is a process that was launched in response to the Army Net Zero initiatives in the early 2000s and to meet strategic goals, including the Energy Policy Act of 2005. The first step established in the IEWP process is to determine the baseline condition of the installations and to provide a roadmap to improve energy and water (E&W) security to achieve resiliency. The IEWP is developed using a data-driven approach and through collaboration with all mission owners, tenant organizations, and relevant stakeholders. This information is obtained through data requests, biweekly virtual meetings, and workshops. It is then analyzed to determine existing water and energy resources, infrastructure uses and conditions, existing deficiencies, and installation needs to establish a baseline condition.

Any gaps identified in the baseline condition are addressed in a series of COAs. These COAs include capital improvement projects to reduce E&W consumption, improve installation resource resiliency and security, and ensure that there are reliable infrastructure conditions and E&W resources and effective SOs. COAs can also focus on policy changes or conservation projects. These COAs can be created to fit each installation's needs or taken from a database or tool that is continuously updated. The COAs drive improvements for Army installations to develop their capability to respond to their challenging deficiencies and augment each installation's capability to understand the long-term effects of COAs and reducing risks. Installation stakeholders and planners have been receptive to solutions that mitigate risks and hazards identified in the IEWPs and provide environmental, social, and economic benefits for installation occupants and the Army.

1.2 Objective

The objectives of this project were to ruggedize the DRIPS, to demonstrate the unit to obtain end-user feedback for improvement by planning a user jury that occurred at FLW prior to delivering the DRIPS unit to an OIB, and then to deliver the unit to aid an OIB. To meet the second objective, the team coordinated with FLW for the first demonstration and user jury. As part of the third objective, the DRIPS unit was intended to help the OIB to be better prepared for the future by meeting their water and energy requirement goals for sustainment of critical missions. Overall, the purpose of the DRIPS is to be a critical asset in disaster response and military operations, providing a reliable and effective means of producing potable water and disinfection in challenging and unpredictable environments.

1.3 Approach

First, the ERDC team coordinated with the US EPA and WaterStep for the initial design and development of the DRIPS unit, which included ruggedizing the federal unit for military use. The team used components of the federal unit, called the WOW Cart, so it would meet Military Standard (MIL-STD)-810 requirements with the funding provided for the project and so it would have the required National Science Foundation (NSF) graded-steel frame and Chemical Agent Resistant Coating (CARC) paint for protection against chemical and corrosive materials. The number of operational valves was reduced from 20 to 10 for ease of use and training, and an optional telemetry package for geospatial networked sensing was added to also include flow and chlorine sensors linked to a data logger.

Once designed and manufactured, the unit was shipped to FLW for the user jury demonstration to gain feedback from end users. The end users were from FLW, the 75th Innovation Command, and the Department of Public Works (DPW) from the OIB. Their feedback was solicited on the use of the system, training on the system, and technological needs and gaps that the DRIPS unit might address in future iterations. After the user jury and demonstration at FLW, the DRIPS unit was transported to the OIB to aid the OIB in meeting its goals for IEWP improvements and use.

2 Challenges

Installations face water and energy sourcing and infrastructure challenges. Climate change and rising human water demands are projected to raise the vulnerability of available water resources and pose further risks to global water security. From a military perspective, innovative technology will be necessary for developing enhanced sustainment solutions for water resiliency and for improving water management, resiliency, and security at installations.

Climate change is predicted to increase the vulnerability of global water resources (Vörösmarty et al. 2000). One of the greatest challenges of this century will be to secure enough fresh water for the world's increasing population (Harlan et al. 2009), 55% of whom live in urban areas (United Nations 2018). New studies seek to address current knowledge gaps for effective water management and solutions (Bafarasat 2021). There are many uncertainties in global decision-making associated with water sustainability; however, tools and efficient planning can be utilized to collect and compare overarching socio-environmental systems.

Water sustainability is linked to water resiliency. Resilience is defined as “an ability to recover from or adjust easily to misfortune or change” (Merriam-Webster, n.d.). The idea of resilience or resiliency is increasingly applied to the context of water systems and water governance in response to climate change effects, hydrologic variability, and the uncertainty associated with various dimensions of global environmental change. However, the meanings, applications, and implications of resiliency related to water governance are still poorly understood, and the resiliency informed water governance literature remains fragmented and predominantly centered on conventional approaches and framings of water planning, particularly on engineering resiliency in water supply infrastructure (Rodina 2019). Resiliency informed water governance is important for developing tools that can help to measure or change the strain to the environment and the water supply over an area of designated land. Generally, the land also comprises human-made structures, other supportive infrastructure, and supportive environmental features for proper management of the local ecosystem (Da Silva et al. 2020). These tools can be used to analyze different scenarios that can greatly enhance operations of planned communities, military installations, or small cities. Additionally, these tools could be utilized as lessons learned from military installations that could be applied to planned

communities and cities. The DRIPS unit is innovative in its ability to hold its treatment trains, including chlorination, UVC, and various pre- and in-line-filtration components for water production and disinfection, in a tight, small, mobile form factor. It is designed to function as a mini water treatment plant on wheels.

US Army installations provide critical support to Army's mission. Army facilities face many risks that must be overcome to ensure that vital missions continue. IEWPs are a pivotal effort to ensure that facilities maintain access to the resources they need and can obtain resilient solutions to maintain water supplies to sustain people and the environment. An essential component of the IEWP is the development of potential solutions, or COAs, to address deficiencies that can improve an installation's baseline condition, ensuring E&W security and resiliency. The undertaking seeks to improve security and resiliency by considering the varied threats of water disruption within installations and providing measures for adaptable recovery. These disruptions may be caused by adverse events, including environmental events, droughts and climatic events, spills, and water security threats, that affect water quality and quantity. Increasing E&W resiliency increases the likelihood that the Army's mission will be successful, even if water resources are reduced, cut off, or compromised. Innovative technologies that improve water and energy infrastructure at installations are sought. The DRIPS unit is ruggedized to ensure access to safe and drinkable water in any climate condition. Disasters such as hurricanes, earthquakes, floods, and other natural or human-made disasters can severely disrupt water supplies and lead to contaminated water sources. In these scenarios, access to clean water becomes essential for the survival and well-being of affected populations. The DRIPS unit steps in to bridge this gap and offers a reliable water purification system that can be rapidly deployed to affected areas.

The system's foundation, the WOW Cart, plays a crucial role in the DRIPS functionality. This mobile system can produce a substantial amount of drinkable water per minute (i.e., 10 gal. per minute [GPM]) and provides an infused chlorine gas solution for disinfection and cleaning purposes.* The DRIPS unit is designed with mobility in mind, making it easily

* For a full list of the spelled-out forms of the units of measure used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–252, <https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf>.

transportable to different locations and ensuring that critical water needs can be met in a timely manner, even in remote or hard-to-reach areas. Figure 3 shows the DRIPS unit in the back of a pickup truck, after it was loaded using a forklift. The system was then transported to the demonstration location for training and operation at the OIB, which took place in July 2023.

Figure 3. DRIPS unit in the bed of a pickup truck at an OIB for transport to the training location.



3 Method

Currently, Installations and Convoy Support Centers (CSCs) produce or procure water from a source and then distribute it via 2,000 gal. capacity water tank racks (i.e., Hippos) that are compatible with Load Handling System (LHS) tanker trucks (ATP-44; Headquarters, Department of the Army, and Marine Corps Engineer School Camp 2015). Warfighters with Military Occupational Specialties (MOS)–specific training encompassing 92W are the water treatment specialists who supervise or operate an installation’s water purification equipment, water storage and distribution operations, and activities. The 68S are the preventive medicine specialists who conduct or assist with preventive medicine inspections, surveys, control operations, and preventive medicine laboratory procedures to assess the water quality. The DRIPS unit is designed to be non-MOS-specific so that any MOS can operate the unit.

Installations will face increased resiliency threats that may limit water resupply frequency. Installations that do not meet the water requirements for critical mission sustainment might be at risk. Installation water source scarcity makes production from contracted sources of water difficult after natural or human-made disaster events. Our approach aims to combine water production, storage, reuse, and hygiene capabilities into a single compatible mobile platform to help mitigate water resupply related risks. The DRIPS unit is non-MOS-specific and leverages decentralized power sources to offset energy requirements. Upon receiving the approved system Safety Release from the Army Test and Evaluation Command–Aberdeen Proving Grounds (ATEC-APG) for the ruggedized DRIPS unit (Appendix), the team provided an adaptable and flexible plan for DoD to retrieve sourced water supplies to produce potable water and, in tandem, to generate sodium hypochlorite “bleach” gas infused (using electrochlorination) with 6 oz of table salt (Figure 4).

Water treatment is a key purpose of the DRIPS unit. The system incorporates various water treatment components, including prefiltration processes, media filtration and adsorption tanks for targeted contaminant removal, and the use of UV-LED technology for additional microbial inactivation. This multistep treatment process ensures that water from various freshwater sources can be purified and made safe for consumption. The unit was demonstrated at the FLW user jury and training on 25 June and 25 July with the 75th Innovation Command, members of the FLW

Garrison, the Petroleum and Water Department (PWD) from Quartermaster School Fort Gregg-Adams, and the OIB.

Figure 4. The DRIPS unit's integrated electrochlorinator from WaterStep. The M100 supplies the gas infusion of chlorination into the water treatment train, providing rapid disinfection to the source-water treatment.



Using the DRIPS unit reduces resupply demand signature for MDO and increases disaster operational reach and maneuverability, thus reducing the need for appropriated fund requests (TRADOC 2018). Resilient, mobile, integrated, and survivable ground forces will offer the Joint Force Commander an array of asymmetric options for deterring and defeating adversaries in all domains. For sustainment of distributed operations and survivability, the Army (in concert with partners) seeks to establish and sustain a dynamic forward presence, reduce demand, augment mobility with small platforms for distributed operations, protect lines of communication, rapidly recover, and move (Headquarters, Department of the Army 2021). In 2020, the federal version of the DRIPS unit, called the WOW Cart, was used by Humanitarian Assistance and Disaster Relief (HA/DR) as part of the federal response to Hurricane Laura in Lake Charles, Louisiana. Use of the unit saved the federal system on requests for over 800,000 bottled water resupplies by the community in the disaster area and was used for an 18-day sustainment period. It saved \$182K and was used successfully in six training hand-off operations by first responders (personal communication, WaterStep and EPA, 2022). The training hand-off means that the initial team of first responders were trained to operate the system

by the main industry and federal government delivery team, and then five additional teams of first responders trained each other as each passed along operation to the next team with little to no disruption in operation of the unit during the 18-day period. Training is an important part of the project, particularly for the teams demonstrations at FLW and for the OIB teams. The feedback from the user jury provided important information that will help improve the training process for operation of the DRIPS unit so that initial and continual operation has less impact on providing potable product water when the unit is needed at actual events.

4 Results

The DRIPS unit is a versatile backup water generation system that produces potable water and bleach for disinfection in all climate conditions. The system, which was created in partnership with ERDC, US EPA Center for Environmental Solutions and Emergency Response (CESER), and WaterStep, complies with military standards and can be integrated with microgrid modular components. The reinforced WOW Cart, which is heavily utilized in federal emergency response scenarios, is the foundation of DRIPS' fundamental capability. For emergency operations, this mobile system can produce 10 GPM of drinkable water. The cart also has five 1 L containers that produce 1.25 gal. of bleach (5,000 ppm) every hour for cleaning. Notably, the treatment train on the cart has a daily production capacity of 50,000 gal. The treatment train of the DRIPS incorporates various components to ensure water quality and disinfection. This includes prefiltration processes to reduce turbidity and enhance disinfection and two media filtration and adsorption tanks designed for targeted removal of chemical or radiological contaminants using methods such as granulated activated carbon (GAC) or ion exchange. Furthermore, UV-LED technology, specifically using UVC light, is utilized for additional microbial inactivation. The system offers flexibility in the field, allowing treatment processes to be added or subtracted as needed, along with the ability to recirculate treated water to increase disinfection efficacy. For ruggedization, CARC paint was applied to the unit for corrosion and chemical warfare protection. The NSF-grade steel frame was MIL-STD-810G compliant. The valves on the unit were reduced from 20 to 10 for improved ease of use.

The DRIPS power supplies are diverse and can meet various operational scenarios. The energy sources are also variable, allowing Soldiers in the field to use generators to operate the unit on diesel, gas, natural gas, propane, or jet-propulsion fuel 8 (JP-8) or to use a 12V vehicle DC battery, building electrical 110V or 220V AC, and microgrid solar options. The output valves are compliant for adaptable fixtures from 1 in. to 2 in. or for 3 in. piping and hosing apparatuses with other operations gear that meets military specifications.

In terms of mobility, the DRIPS was designed with practicality in mind. It weighs less than 750 lb (less than 550 lb without the ruggedized wheel frame), making it transportable and capable of fitting in the back of a pickup truck. The system is specifically designed for two-person transport

to facilitate its deployment in different locations and scenarios. The ruggedized unit is liftable by forklift, and without the ruggedized attached wheel frame and trailer, the unit can fit through doorways and be operated inside a building.

The development and deployment of the DRIPS unit involved collaboration with multiple entities, including the following:

- ERDC, US Army Garrison (USAG) FLW, and ERDC's Contingency Basing Integration Training and Evaluation Center (CBITEC)
- US OIB, Pennsylvania
- Headquarters (HQ) IMCOM, IEWP
- US Army Combat Capabilities Development Command (DEVCOM), Ground Vehicle Systems Center (GVSC), Fuel and Water Equipment Branch (FWEB)
- Product Manager Petroleum and Water Systems (PdM PAWS)
- DEVCOM Soldier Center (SC) and the Combat Field Service Equipment Team (CFSET) Force Provider (FP)
- Product Manager Force Sustainment Systems (PdM FSS)
- Futures and Concepts Center (FCC)
- Sustainment-Capability Development Integration Directorate (S-CDID)
- AFC-Combined Arms Support Command (CASCOM)
- Defense Public Health-Army (DPH-A)
- Medical Command (MEDCOM)
- Army Materiel Command (AMC) Combined Force Integration (CFI)
- HQAMC, Army Operations (G3) and Army Logistics (G4)
- US EPA

To be more specific, ERDC collaborated with the federal US EPA and industry partners on the ruggedization of the DRIPS. The USAG was the receiving Army entity for the DRIPS. ERDC's CBITEC (at FLW) provided a venue for the user jury and first demonstration. The remaining entities participated in a working group that tracked the project's progress and knowledge of the system. The US Army G9's Installation Technology Transfer Program (ITTP) funded the project. Additionally, collaboration with the USACE Districts-Civil Works WG (Water Working Group), JWRMAG (Joint Water Readiness and Management Action Group), Federal WaTr WG (Water Treatment Working Group), Water Sensors COP (Community of Practice), and International Cooperative Engagement

Program for Polar Research (ICE-PPR) Water and Wastewater WG (Infrastructure Capability Enhancement–Preparedness and Response) played a vital role in the project’s success.

4.1 User Jury Feedback

The user jury was surveyed to provide feedback on the DRIPS unit. Feedback comments included, “More demonstrations with first responders / emergency management and or a ‘line unit’ should be encouraged for more feedback opportunities,” “seeing the unit in action was liked,” “the tutorial was helpful,” and “the system is a step-by-step operation and can be used in a practical exercise.” The July training at the OIB included their DPW E&W managers and Department of Emergency Services (DES) leaders, who engaged stakeholders to train the operational users and discuss integration of the unit into their strategic initiatives for their IEWP. The user jury, training, and demonstrations involved a collaborative team effort with representatives from ERDC (from the Geospatial Research Laboratory [GRL], Environmental Laboratory [EL], and Construction Engineering Research Laboratory [CERL]), WaterStep, and the USEPA-CESER, FLW, and the OIB to deliver the system. Figure 5 shows the DRIPS unit user jury setup, training, and demonstration at FLW in Missouri in June 2023. Figure 6 shows a sample survey that was provided to participants from the user jury, demonstration, and training at FLW and at the OIB locations. Figure 7 shows the user jury survey responses displayed as a bar graph for all surveys collected at FLW and the OIB in June and July of 2023.

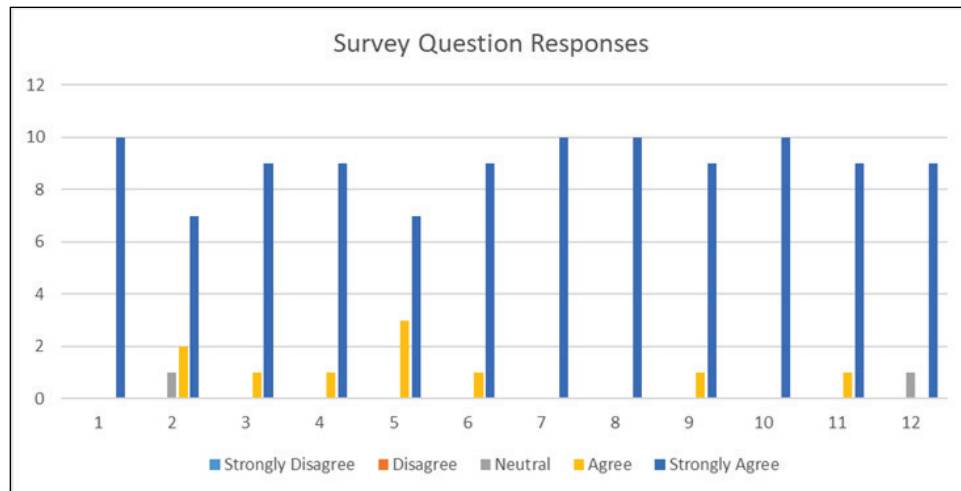
Figure 5. DRIPS unit user jury setup, training, and demonstration at FLW in June 2023.



Figure 6. User jury survey for the DRIPS unit.

| User Jury 2023—Survey Sample Deployable Resilient Installation Water Purification System (DRIPS) | | | | | | | | |
|---|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Name: _____ (Last Name, First Initial) | | | | | | | | |
| Instructions: Mark the response that most accurately describes your opinion of using the system capabilities to perform your job. Provide one answer per question. Short comments for response questions. | | | | | | | | |
| Question | | Strongly Disagree | | Neutral | | Strongly Agree | | NA |
| 1 | Overall training achieved its stated objectives and was informative. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 2 | The pace and allocation of time for the training were appropriate. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 3 | The overall safety briefing was understandable in preparing for operating the system. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 4 | Each component of the setup was explained clearly. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 5 | I understand all 3 parts of the "Treatment Train," including the "Pretreatment Train." | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 6 | The concepts taught were understandable even if I am not a water operator. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 7 | I understand how to use the power to run the DRIPS. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 8 | This training method aids in passing operational knowledge of the system to the next user so that they can successfully use the system. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 9 | Watching a video, having a manual, and/or having an in-person training was sufficient for learning the material needed to successfully operate the system. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 10 | I understand the process to test the water's chlorine/pH levels. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 11 | I understand how to start distributing the treated water to other water required systems. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 12 | The session objectives were clear. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 13 | What topics within this session were most valuable? | | | | | | | |
| 14 | What topics within this session were least valuable? | | | | | | | |
| 15 | What topics were not covered or unclear that you would like to learn more about? | | | | | | | |
| 16 | What was most relevant about the session (discussions, tutorials, activities, etc.)? | | | | | | | |
| 17 | If you could change anything about the session, what would it be? | | | | | | | |
| 18 | Please provide any additional comments/feedback. Back of survey can be used | | | | | | | |

Figure 7. User jury survey responses from FLW and the OIB in June and July 2023.



As part of the survey, participants were asked to provide comments and to identify the most valued topic. Comments received included the DRIPS units' components were desired for incorporation for water treatment. The training included a nice explanation for use of the treatment trains. The training covered daily use and maintenance for day-to-day operations and storage. The training and manuals were understandable and explained how to operate and utilize the system. The treatment train for chlorine generation was clear and valued. There was a request for ERDC to work toward establishing an Agency Location Code (ALC) and a National Stock Number (NSN) so the equipment could be sought for purchase. The pre-operational setup instruction and training were valued. No one selected disagree or strongly disagree for any of the survey questions.

4.1.1 Topics That Were Most and Least Valued

Survey participants identified the following as the most valuable topics:

- DRIPS unit components
- Explanation of treatment trains
- DRIPS unit use on a day-to-day basis
- Understanding how to operate/utilize the system
- Chlorine generation
- ALC; need for NSN
- Preoperational setup

No comments were listed in the section of the survey that asked participants to identify the least valued topics.

4.1.2 Topics That Were Not Covered or Were Still Unclear

The topics that follow were identified as either not covered or still unclear:

- What to do with the waste process by chlorine generate
- The difference between the DRIPS unit and boiling water after rock filtration
- Chemical/radiological risks
- What the system can filter for brackish or saltwater concentrations (DRIPS is currently only used for fresh water)

The survey questions involving topics not covered or still unclear had comments involving what to do with the waste process by chlorine generation. This was covered in the training, where each side of the electrochlorinator is shown to have a byproduct of sodium hypochlorite formation. When sodium hypochlorite dissolves in water, two substances are formed that play a role in oxidation and the disinfection processes. These are hypochlorous acid and the less active hypochlorite ion. After using the system, the two solutions are mixed into a bucket again, and when the two are reintroduced to react, the by-product forms a nontoxic solution that can then be discarded safely. The chlorine gas produced is minimal and does not persist in the atmosphere. Electrochlorination is the process of producing hypochlorite by passing electric current through salt water. This disinfects the water and makes it safe for human use, such as for drinking water.

Another comment related to the difference between using the DRIPS unit and boiling water after rock filtration. The DRIPS unit has more treatment trains than just rock or sand filtration. DRIPS offers particle filtration; chlorination; options for recirculation of chlorination; UVC treatment; GAC filtration for removal of odors, taste, and (to a point) radiation; and further polishing of the potable water. The treatment train is intricate and in a small form factor that allows it to be mobile and to operate in various scenarios and locations. Chemical and radiological risks are present when using the system. The system has some level of reduction and depends on the chemical concentration, chemicals, and type of radiation for system reduction. The US EPA has conducted tests of the initial chemical and radiological risks. Additional treatment trains are being studied by the US EPA, as are ways to attach additional treatment trains to the unit. This is still under research and development for the DRIPS unit and WOW Cart. The system is currently used for freshwater sources. Additional add-ons, such as desalination units, are also being investigated for use with the unit.

4.1.3 What was Liked, and What was Identified for Change

The user jury liked the following:

- Seeing the unit in action
- The tutorial being helpful
- In-person explanations
- Use of the machine
- Practical exercise
- Step-by-step operation

The user jury suggested making the changes that follow:

- Use dirtier water during the demonstration to help observers gain confidence in the system.
- Have a shorter prebrief.
- Bring additional cover to reduce sun exposure during training.

The suggestion to use dirtier water can be implemented in a future demonstration. A shorter prebrief can be considered, depending on the audience and on who is being trained. The team can investigate making the prebrief shorter. Depending on the training locations and sun, the team can bring more covers to support less sun exposure.

4.1.4 Additional Feedback

Additional feedback from the user jury survey included that it would be helpful to demonstrate the system with first responders / emergency management or a line unit and to collect their feedback. The team is looking into this for the next year, and there have been requests for HA/DR efforts and exercises with federal entities and military-associated entities.

The team will continue efforts to achieve military certification and meet ruggedization standards. This will be conducted with newly proposed efforts in collaboration with the DPH-A at APG and with Naval Facilities (NAVFAC) Engineering and Expeditionary Warfare Center, Port Hueneme. The demonstrations confirmed the ability of the DRIPS unit to quickly configure multiple water treatment processes to treat sufficient quantities of contaminated water. Full-scale testing at a lake during the OIB demonstration allowed for a real-source water supply scenario that provided an impressive field deployment of the DRIPS unit and showcased

its ease of transportation and positioning, making it a valuable asset for training, emergency preparation, and disaster response planning.

4.2 Summary

Based on our experiences and evaluations, the DRIPS unit successfully provided sediment and surface algae filtration and gas-infused electro-chlorination and disinfection of the source water, rendering the water safe to drink within a matter of hours. However, it was noted that extremely dirty water with high turbidity levels could prematurely foul the prefiltration and, if chemicals were in the water, the chemical water treatment process, leading to reduced supplies of treated water.

The objectives of this research were met. The first objective was accomplished by ruggedizing the Water Cart to create the DRIPS unit. The second objective was met by completing the user jury and delivering the unit to the OIB. The third objective was met because the DRIPS unit increased the OIB ISR-MC score from black to green within their IEWP. The IEWP ISR-MC requirements for a measure associated with MS320-3, MS321-4b, and MS323-5 were also met upon implementation of this project. Future research activities for the DRIPS will focus on meeting specific requirements under the federal Safe Drinking Water Act and Clean Water Act (TB MED 577 [Headquarters, Department of the Army, Navy, and Air Force 2010] and TB MED 576 [Headquarters, Department of the Army 2023b]) and pursuing standards such as MIL-STD-810G (DoD 2008) for DoD installations. Efforts will continue to integrate additional prefiltration technologies to effectively treat extremely contaminated water. Evaluation and integration of innovative future treatment technologies, such as desalinization, heavy metal contamination removal, and graywater polishing, will be explored to enhance the system's capabilities.

The DRIPS unit implemented a near real-time and remote operating and reporting capability to enable efficient monitoring and control of the system during emergency operations. The system's potential applications to medical triage in the field and at more forward installations will be studied to assess its utility in supporting medical personnel during emergencies. Figure 8 shows the user jury setup and the finished chlorination-gas-infused product water output. It also shows the user jury and training team, which was made up of members from OIB; ERDC-

CERL, ERDC-EL, and ERDC-GRL; the 75th Innovation Command; the EPA; and the WaterStep organization.

Figure 8. The user jury and training team (*top*), which included (*left to right*) Mr. Osvaldo Alomar, MAJ Maurice Pritchett, Mr. Christopher High, Mr. Fahmi Atwain, Mr. Ziyad Atwain, Dr. Clint Smith, Mr. Kurtis Daniels, Dr. Jim Allen, LTC John Decker, Dr. Jim Goodrich, Dr. Chris Griggs, Mr. Osman Tirmizi, and Ms. Ilea Diaz Lluberes. The user jury setup (*bottom left*) and the finished chlorination-gas-infused product water output (*bottom right*).



5 Conclusions and Next Steps

When there are natural disasters or water treatment facility failures, access to clean water is crucial for both DoD installations and surrounding communities. This need extends beyond drinking water; it includes water for cooking, cleaning, and medical triage. Water treatment becomes essential if the water system is contaminated. Similarly, human-made incidents or accidents may also require water treatment for mitigation and recovery efforts. The DRIPS was developed to address such challenges. This project allowed for the first transfer of the DRIPS technology to an OIB. The team will utilize a leveraged unit from ERDC to participate in contested logistics displays and sustainment-battle laboratory demonstrations and will seek more opportunities to conduct further ruggedization, MIL-STD assessments, and policy and program integration into more routine Army installation management operations and modernization program efforts. The team will continue partnerships with WaterStep and others in industry, such as Mid-South Chemical Company, and participate in cooperative research and development agreement opportunities to pursue scale-up and additional treatment train expansion of the technology, as evident in proposed projects with a target capacity of 100,000 gal./day.

WaterStep has coordinated with the government of the state of Kentucky and the Department of Health and Corrections to preposition as many as 20 WOW Carts throughout the state. This placement creates a “lily pad” perspective from a map view of the state containing the WOW Carts, so when a natural disaster occurs, there will be units ready for use. Dr. Smith (ERDC-GRL) is seeking to build momentum on the federal and military fronts to develop a National Lily Pad concept that will be explored to strategically deploy the DRIPS units to designated locations, including ERDC, districts, and installations, and to Civil Affairs Emergency Response–National Guard and Reserve (NG&R). This strategic deployment approach will ensure readiness and rapid response in critical areas, strengthening the nation’s capacity to effectively address emergency water needs.

The DRIPS has undergone significant research, development, and evaluation through this collaborative effort. The system’s capabilities have been demonstrated in challenging environments and disaster scenarios, showcasing its potential as a vital asset for disaster-incident response and humanitarian relief efforts. Ongoing research and future developments will further enhance the system’s performance, making it a reliable and

effective solution for ensuring access to clean water during disasters in the Arctic regions. With the next project planned, the system will undergo integration into a solar-powered microgrid to operate in subarctic and arctic temperatures. The microgrid is planned to provide the power as well as the insulated infrastructure needed in the extreme cold environment for water production to occur. The DRIPS unit provides an adaptable and flexible option for the DoD that can be utilized for retrieving source water supplies to produce potable water in times of need and to reduce the need for appropriated funds for bottled water. Furthermore, the DRIPS is a testament to the Army's commitment to innovation and preparedness in the face of evolving challenges.

In line with the Army's goals, the DRIPS supports efforts to unplug from the grid and to identify capability gaps related to infrastructure, operations, and maintenance. The integration of the DRIPS at an OIB through the IEWP program is a significant step toward achieving the Army's objectives. The DRIPS represents an ongoing endeavor to create, develop, modernize, and reimagine new solutions.

Exercises performed by the DoD play a crucial role in this process because they provide valuable insights and identify potential solutions to ensure the uninterrupted functioning of critical loads in installations. The Army recognizes that securing enough fresh water for the world's increasing population is a challenge of this century. Therefore, continuous efforts are being made to create, develop, modernize, and reimagine new solutions to effectively address this challenge.

In this context, the successful transition of the first ruggedized WOW Cart, or DRIPS, to the OIB via the IEWP program showcased the Army's commitment to sustainable and resilient infrastructure. In June of 2023, ERDC updated the OIB's five-year IEWP using the ISR-MC and Mission Readiness / Installation Resiliency documentation tools. These tools enabled the OIB to assess its capability to support current and future mission requirements, ensure readiness, and maintain critical resources such as air, land, water, and energy.

As the Army continues its pursuit of sustainable and resilient solutions, the DRIPS represents a critical asset that ensures access to potable water and disinfection capabilities during disaster situations. Its integration into mobile and modular setups provides a valuable response tool for disaster

incidents, addressing diverse environmental conditions and meeting the needs of military operations. With its adaptable features and comprehensive treatment train, the DRIPS stands as a testament to the Army's commitment to innovation and preparedness in the face of evolving challenges.

Bibliography

- Bafarasat, A. Z. 2021. "Is Our Urban System Still Sustainable? A Simple Statistical Test with Complexity Science Insight." *Journal of Environmental Management* 280: 111748. <https://doi.org/10.1016/j.jenvman.2020.111748>.
- Da Silva, J., V. Fernandes, M. Limont, M. Dziedzic, C. V. Andreoli, and W. B. Rauen. 2020. "Water Sustainability Assessment from the Perspective of Sustainable Development Capitals: Conceptual Model and Index Based on Literature Review." *Journal of Environmental Management* 254 (15): 109750. <https://doi.org/10.1016/j.jenvman.2019.109750>.
- DAU (Defense Acquisition University). 2014. "Joint Capabilities Integration and Development System (JCIDS) Documentation." <https://www.dau.edu/acquimedia-article/joint-capabilities-integration-and-development-system-jcids-documentation>.
- DoD. 2008. *Environmental Engineering Considerations and Laboratory Tests*. MIL-STD-810G. Washington, DC: US Department of Defense. <https://www.atec.army.mil/publications/Mil-Std-810G/Mil-Std-810G.pdf>.
- DoD. 2009. *Installation Energy Management*. DoD Instruction 4170.11. Washington, DC: US Department of Defense. <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/417011p.pdf>.
- DoD. 2015a. *Department of Defense Dictionary of Military and Associated Terms*. Joint Publication (JP) 1-02 (As Amended Through 15 March 2015). Washington, DC: US Department of Defense.
- DoD. 2015b. *Management of Land-Based Water Resources in Support of Contingency Operations*. Department of Defense Directive 4705.01E. Washington, DC: US Department of Defense. <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/470501Ep.pdf?ver=2020-01-02-131411-810>.
- Harlan, S. L., S. T. Yabiku, L. Larsen, and A. J. Brazel. 2009. "Household Water Consumption in an Arid City: Affluence, Affordance, and Attitudes." *Society and Natural Resources* 22 (8): 691–709. <https://doi.org/10.1080/08941920802064679>.
- Headquarters, Department of the Army. 1988. *Combat Service Support*. Field Manual (FM) 100-10. Washington, DC: Department of the Army.
- Headquarters, Department of the Army. 2009. *Tactical Land-Based Water Resources Management*. Army Regulation (AR) 700-136. Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/r700_136.pdf.
- Headquarters, Department of the Army. 2019a. *Army Food Program*. AR 30-22. Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN7458_R30_22_FINAL.pdf.

- Headquarters, Department of the Army. 2019b. *Sustainment Operations*. Field Manual (FM) 4-0. Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN19602_FM%204-0%20FINAL%20WEB%20v2.pdf.
- Headquarters, Department of the Army. 2021. *Army Multi-Domain Transformation: Ready to Win in Competition and Conflict*. Chief of Staff Paper 1, Unclassified Version. Washington, DC: Department of the Army. <https://api.army.mil/e2/c/downloads/2021/03/23/eeac3d01/20210319-csa-paper-1-signed-print-version.pdf>.
- Headquarters, Department of the Army. 2022a. *Army Pre-Positioned Operations*. Army Techniques Publication (ATP) 3-35.1. Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN36912-ATP_3-35.1-001-WEB-2.pdf.
- Headquarters, Department of the Army. 2022b. *Research, Development, Test and Evaluation of Materiel for Worldwide Use*. AR 70-38. Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN30017-AR_70-38-000-WEB-1.pdf.
- Headquarters, Department of the Army. 2023a. *Army Water Planning Guide*. Washington, DC: Department of the Army, Office of the Deputy Chief of Staff. https://cascom.army.mil/g_staff/g3/TTD/Products/QM-How-to-Handbook/AWPG_approved_20Mar23.pdf.
- Headquarters, Department of the Army. 2023b. *Sanitary Control and Surveillance of Water Supplies at Fixed Installations*. TB MED 576. Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN39860-TB_MED_576-000-WEB-1.pdf.
- Headquarters, Department of the Army and Marine Corps Engineer School Camp. 2015. *Water Support Operations*. ATP 4-44/MCRP 3-40D.14. Washington, DC: Department of the Army and Lejeune, NC: Marine Corps Engineering School. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN37080-ATP_4-44-000-WEB-1.pdf.
- Headquarters, Departments of the Army, Navy, and Air Force. 2010. *Sanitary Control and Surveillance of Field Water Supplies*. TB MED 577/NAVMED P-5010-10/AFMAN 48-138_IP. Washington, DC: Departments of the Army, Navy, and Air Force. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/tbmed577.pdf.
- Manning, C. G. 2023. "Technology Readiness Levels." NASA. https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level.
- Perkins, D. 2015. "Perkins Discusses Operationalizing the Army Operating Concept" [YouTube video]. US Army TRADOC, September 16, 2015. <https://www.youtube.com/watch?v=-46HlgVPYDQ>.
- Quinn, B. J. 2023. "Sustaining Multidomain Operations: The Logistical Challenge Facing the Army's Operational Concept." *Military Review* March-April: 128–137. <https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/MA-23/Multidomain-Operations/Sustaining-Multidomain-Operations.pdf>.

- Resilience. n.d. Merriam-Webster online dictionary. Accessed February 15, 2024. <https://www.merriam-webster.com/dictionary/resilience>.
- Rodina, L. 2019. "Defining 'Water Resilience': Debates, Concepts, Approaches, and Gaps." *WIREs WATER Journal* 6 (2): e1334. <https://doi.org/10.1002/wat2.1334>.
- Secretary of the Army. 2020a. *Installation Energy and Water Resilience Policy*. Army Directive 2020-03. Washington, DC: US Department of Defense. https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/ARN21689_AD2020_03_FINAL_Revised.pdf.
- Secretary of the Army. 2020b. *U.S. Army Installation Policy To Address Threats Caused by Changing Climate and Extreme Weather*. Army Directive 2020-08. Washington, DC: US Department of Defense. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN30836-ARMY_DIR_2020-08-000-WEB-1.pdf.
- Smith, C. B., D. Acevedo, P. E. Martinez-Guerra, V. F. Medina, M. P. Duczynski, S. R. Wolters, N. Garfinkle, L. Melendez, and L. Feliciano. 2022. "Developing Water Resiliency Solutions at Military Installations." *Climate Risk Management* 37 (8): 100451. <http://dx.doi.org/10.1016/j.crm.2022.100451>.
- TRADOC (US Army Training and Doctrine Command). 2018. *The U.S. Army in Multi-Domain Operations 2028*. TRADOC Pamphlet 525-3-1. Fort Eustis, VA: TRADOC. <https://adminpubs.tradoc.army.mil/pamphlets/TP525-3-1.pdf>.
- United Nations. 2018. *World Urbanization Prospects: the 2018 Revision*. ST/ESA/SER.A/420. New York, NY: United Nations, Department of Economic and Social Affairs, Population Division. <https://population.un.org/wup/publications/Files/WUP2018-Report.pdf>.
- US Army and US Marine Corps. 2022. *Water Support Operations*. ATP 4-44/MCRP 3-40D.14 (MCRP 3-17.7Q). Washington, DC: Department of the Army. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN37080-ATP_4-44-000-WEB-1.pdf.
- US Army Maneuver Center of Excellence. n.d. "Learning Adaptation and Innovation." *Maneuver Self Study Program*. Last updated December 18, 2018. <https://www.moore.army.mil/mssp/Learning%20Adaptation/>.
- Vörösmarty, C. J., P. Green, J. Salisbury, and R. B. Lammers. 2000. "Global Water Resources: Vulnerability from Climate Change and Population Growth." *Science* 289 (5477): 284–288. <https://doi.org/10.1126/science.289.5477.284>.

Appendix: Additional Deployable Resilient Installation Water Purification and Treatment System (DRIPS) Documentation

This appendix contains additional DRIPS documentation. The safety release for the DRIPS unit (formerly named WASP 2.0) is available by request.

A.1 Situational Report for NATO Norway Meeting in April 2023



International Cooperative Engagement Program for Polar Research (ICE-PPR) Polar Water and Wastewater Group (PWWG) Norway Meeting Summary



The Installation Technology Transfer Program (ITTP) provided support for the DRIPS unit to be presented at and shared with the International Cooperative Engagement Program for Polar Research (ICE-PPR) Polar Water and Wastewater Group (PWWG), and other water and wastewater technologies, by the Army, Joint Department of Defense (DoD), and International PWWG Spring Meeting, which was held in Elverum, Norway, on 18–20 April 2023 at the NATO Centre of Excellence (COE) Cold Weather Operations (CWO) facility. The meeting aimed to develop a Water and Wastewater Project Arrangement (PA) to enable collaboration between the water and wastewater defense communities from countries that are party to the ICE-PPR Memorandum of Understanding, including Norway, Denmark, and the US. Attendees from the US included representatives from four (4) US Army Engineer Research and Development Center (ERDC) laboratories (Geospatial Research Laboratory, Environmental Laboratory, Construction Engineering Research Laboratory, and Cold Regions Research and Engineering Laboratory) and branches of the US military (Space Force, Army, and Navy), who shared their knowledge and expertise on the technologies and research areas that the US DoD will provide as part of the PA. The meeting featured plenary sessions and presentations that elaborated on the PA objectives and scope of work. Participants also visited two locations identified as potential test sites for equipment demonstration and validation. The meeting was a great success, with plenary sessions, presentations, and site visits that helped elaborate on the PA objectives and scope of work. The PWWG continues to develop the PA through monthly standing meetings online.



POC: Dr. Clint Smith
Clint.B.Smith@usace.army.mil

PWWG Norway Meeting participants outside the CWO facility where the meeting was held in Elverum, Norway.



PWWG Norway Meeting participants on a site visit to view a pond that is used for fire suppression on Norwegian army training lands just outside Elverum, Norway.



ERDC Contingent at site visit to Rena Camp (Leir), Glomma River Dam, and Løpsjøen-Lake

A.2 DRIPS Unit Factsheets



Building Strong
DISCOVER | DEVELOP | DELIVER

Deployable Resilient Installation water Purification and treatment System 'DRIPS'

An affordable and easy-to-operate water decontamination system

Background

Following a natural disaster or loss of secondary or tertiary treatment functions at a water treatment facility, DoD Installations and surrounding communities need access to clean water not only for drinking but also for cooking, cleaning, and medical triage. If the water system is contaminated, water treatment will be needed. Similarly, mitigation and recovery following a man-made incident, or an accident could require water treatment.

Not all the water being treated needs to be drinking water quality. In some longer-term recovery efforts, contaminated stormwater or wash water from building decontamination activities only need to be treated to levels safe for disposal to the wastewater treatment plants or back to the environment. Mobile treatment of the highly contaminated water can significantly reduce the volume of water to be transported and reduce the liability and cost of transporting and disposing of a hazardous waste on DoD installations.

Most emergency water treatment systems for the Army and the DoD are large and expensive tractor-trailer mounted systems. They can be complicated to operate and maintain (high pressures and concentrated wastes) given their use of reverse osmosis water treatment technology. An emergency water treatment system could be designed and built so the sequence of treatments can be configured on-site to treat a broad spectrum of contaminants without using unnecessary and costly unit processes, and without producing large amounts of contaminated waste. The broad spectrum of potential contaminants includes chemical, biological and radionuclide contaminants. Rather than a treatment system, bottled water is typically the first responder's choice when responding to an incident. However, long-term dependence on bottled water creates a large solid waste disposal problem and,



Figure 1. Foreground (a): Final version of the water on wheels (WOW) mobile emergency water treatment system cart at the DRIPS Demonstration Ft. Leonard Wood 2023: Deployable Resilient Installation water Purification and treatment System (DRIPS).

often large vehicles transporting bottled water are unable to get to affected locations because of road debris and damage. In large or extended recoveries, bottled water use for bathing, sanitation, and other non-potable purposes is impractical. However, bottled water could be used in conjunction with an inexpensive and versatile mobile emergency water treatment system providing water for non-potable water applications such as toilet flushing.

Based on these considerations, through each organization cooperative research agreements from the ERDC and the EPA with industry partners, a list of capabilities needed for a mobile emergency water system was developed. The research and testing that produced the EPA system (Figure 1) is described. The military certification and meeting the MIL 810G Standard for ruggedization is being pursued. Coupling of the ERDC DRIPS would enable water quality reporting, bleach generation, and additional filtration options when coupled with the EPA system.

The U.S. Army Engineer Research and Development Center (ERDC) solves the nation's toughest engineering and environmental challenges. ERDC develops innovative solutions in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, DOD, civilian agencies, and our Nation's public good. Find out more on our website: www.erd.usace.army.mil. Approved for public release; distribution is unlimited. June 2018.

EPA INNOVATIVE RESEARCH FOR A SUSTAINABLE FUTURE <https://www.epa.gov/emergency-response-research/water-wheels-mobile-water-treatment-system-wow-cart>

U.S. Environmental Protection Agency

Capabilities Treatment Train

- Currently: Up to 10 gallons per minute or 38 liters per minute
- Pre-filtration to reduce turbidity and improve disinfection
- Two media filtration/adsorption tanks for targeted chemical or radiological contaminant removal (e.g. Granular Activated Carbon or Ion Exchange)
- UV LED for additional microbial inactivation
- On-site chlorine gas & bleach generation for disinfection
- Ability to add or subtract treatment processes in the Field and ability to re-circulate treated water to increase disinfection

Power Supplies

- Dual Fuel Generator (propane, gas)
- 110v AC
- 12v DC deep cell marine battery w/solar panel recharge

Mobility

- Weighs less than 550 pounds (Ruggedized for the Army will weigh about 750 pounds)
- Fits in back of pick-up truck
- 2-4-person transport

Communication (adding Telemetry)

- Wired output: Ethernet /USB
- Wireless Output: Bluetooth WIFI (802.11 b/g)-Cellular 5G
- Protocol: Mesh nodes – Dynamic routing –Peer 2 Peer



Figure 2: DRIPS mobile emergency water treatment system cart
Organic Industrial Base 2023.

Research Approach

Cooperative Research and Development Agreements

Utilizing a Cooperative Research and Development Agreement (CRADA) with the non-profit humanitarian relief organization WaterStep, a prototype mobile emergency water treatment system was first fabricated and evaluated at the Environmental Protection Agency (EPA) Test & Evaluation Facility located in Cincinnati, Ohio. The mobile emergency water treatment system was then challenged at the EPA Water Security Test Bed, located near Idaho Falls, Idaho, replicating a field scale emergency response. Components of the mobile system were then deployed to Puerto Rico in response to Hurricane Maria. The mobile emergency water treatment system was modified and expanded based upon the field results and challenged once again at the Water Security Test Bed. The ERDC's WaterDOG was tested with the Army Quartermaster Liquid Logistics Exercise (QLLEX), Effective Energy for Expeditionary Operations-Limited Objective Experiment (EX2-LOE),

Networked Integration Exercise (NIE) 16.1, & the Army Expeditionary Warrior Experiments (AEWE) Ft. Benning, GA. The ERDC formed a CRADA with Newcomer Arms LLC to develop the earlier version of the DRIPS that were sent to Africa for conservation efforts.

Prototype Test Evaluations

Pilot testing at the Test & Evaluation Facility for the WOW Cart confirmed the ability of multiple water treatment process to be quickly configured to treat sufficient quantities of contaminated water. Initial full-scale testing at the Water Security Test Bed demonstrated greater than 7 log reduction of *Bacillus globigii*, an anthrax surrogate, recirculating in batch mode. Field deployment also demonstrated that the mobile framework was capable of being easily transported via pick-up truck and rolled into position by two people.

Hurricane Maria Deployment

Shortly thereafter, Hurricane Maria made landfall in Puerto Rico on Wednesday, September 20, 2017.

Within just three weeks, WaterStep's team was on the ground training emergency workers and distributing kits with components of the 2nd generation WOW Cart. In addition to providing drinking water, in parallel, an added feature to the kits were 1-liter containers that produced a 1% solution of liquid bleach, to be used for general cleaning and for support of medical triage by medical personnel. Over 100 kits were deployed, and hundreds of people trained in the proper use of the equipment. Though some kits are still being used there, many are now positioned and poised to be used during the next disaster.

Evaluations to Date

Learning from both the field challenge and Hurricane Maria experience, the final version of the WOW Cart was challenged at the Test & Evaluation Facility with secondary wastewater and subsequently tested again at the Water Security Test Bed against lagoon water contaminated with diesel fuel and *Escherichia coli*. The WOW Cart successfully removed 4 to 6 logs of *E. coli* and total coliforms, respectively, to non-detection levels from the contaminated lagoon simultaneously with diesel fuel components. Diesel fuel components were removed to below detection levels, which made the water safe to drink. Results did reveal that extremely dirty water (turbidity >120 NTU) could foul the chemical water treatment process prematurely and prevent adequate supplies of treated water from being available.

Future Research Activities

This research is driven by requirements under the federal Safe Drinking Water Act and Clean Water Act. For DoD Installations TB-MED 576-Surveillance of Water Supplies at Fixed Installations; TB-MED 577 Sanitary Control and Surveillance of Field Water Supplies, and meeting MIL 810G Standard will be pursued. Other supporting documentation includes ASA(IE&E) Strategy 2025. Tri-Service publications include the TB MED 530/ NAVMED P-5010-1/AFMAN 48-147_IP and Joint Publication 4-02 for related Joint Health Services. It also responds to part of the National Response Framework developed by the Federal Emergency

Contacts: ERDC Technical Contacts: Dr. Clint B. Smith* (703) 428-6789, clint.b.smith@usace.army.mil
EPA Technical Contacts: Dr. Jim Goodrich, goodrich.james@epa.gov

Management Agency (FEMA). The EPA will continue to partner with drinking water and storm water utilities, disaster relief organizations, FEMA and other state and federal agencies, such as USACE ERDC, as well as private companies to protect public health and the environment. Technology development and integration will continue including:

- Additional pre-filtration technologies to treat extremely contaminated water
- Evaluation/integration of innovative future treatment technologies
- Real-time and remote operating and reporting capabilities
- Applications to medical triage in the field and at forward operating bases
- Case study field evaluations
- Industry CRADA: DRIPS scale up: 100,000GPD/17HRS
- National Lilly Pad: WOW Carts/ DRIPS deployed to strategically designated locations: ERDC, Districts, Installations, Civil Affairs Emergency Response-NG&R
- GLADIATOR: Graywater Logistics Assured Defense Installation Advance Technology for Operational Resilience system (ERDCs GRTS+ DRIPS)
- Arctic DRIPS w/ modular force sustainment unit Alaska

ADDITIONAL DRIPS KNOWLEDGE

The DRIPS has a small footprint (size of a shopping cart that fits through doors-non-ruggedized), can be stored with a low profile until needed and can, at a minimum, provide 10 gallons per minute (or 38 liters per minute) or roughly 7,200 gallons over a 12-hour period or above 14,400 GPD in 24 hrs. of potable water for contingency operations, disaster response, training, and austere water supply globally. Proposed future scale up to 100,000 GPD / (17-hour time frame).

The dual fuel 4550W portable generator comes with an electrical start 120V (Firman power equipment) that comes with the DRIPS holds 5 Gallons of gas and last for 14 hours. With a 10 GPM rate, a full tank will generate on average 8,400 gallons over a 14-hour period without having to be refilled. *Assuming a 50% load of the generator for estimate pulls of power from the DRIPS unit.

The DRIPS unit provides an adaptable and flexible option for the DoD in retrieving source water supplies to produce potable water and in tandem bleach generation using table salt in times of need and reduce the need for appropriated fund requests for bottled water by installations. The unit supports the Installation Energy and Water Plan (IEWP) program for requirements: Critical Mission Sustainment and Assured Access measures of the Installation Status Report Mission Capacity (ISR-MC) and is funded from the Installation Technology Transfer Program (ITTP). For Civil Works, the development and demonstration of the RWS Cart Unit is supported by the USACE Flood and Coastal Systems R&D (funded through GI R&D) in response to SoN 1636, to treat biofouling in relief wells.

USE CASE

As a use case scenario from the Lake Charles emergency use response, the use of just one system on the ground could save the military and estimated 20 C-130 flights (man-power, equipment, and fuel consumption savings), 16 tractor trailer truck shipments of bottle water (man-power, equipment, and fuel consumption savings) holding an estimated 800,000 water bottles or 416 pallets with an estimation of \$439 per pallet or \$182K savings for water and transportation per event. The DRIPS would reduce the logistics of bottled water waste build up and removal as well. The DRIPS aims to improve installation emergency response for water production technology to meet infrastructure readiness needs by providing an estimated over 1.8 million gallons of water treated for potable use over an 18-day period (Future GLADIATOR). Currently, one DRIPS unit has shown a capability to provide 100,000 gallons of water treated for potable use over an 18 day period to over 800 responders on-site, with food preparation and clean-up for 16,000 meals/per day prepared for responders and a community, water for laundry and showers, polished city water when re-distribution starts back up, 50 gallons of bleach solution prepared using 50 lbs of salt, and an ability for ease of training with training hand off with 6 cycles of new trained relief teams/responders. In addition to the ruggedization of the system the team aims to improve with integrating the system with geo-enabled sensors to monitor and report the system production parameters.

Deployable Installation Resilient Water Purification and Treatment System 'DRIPS'

Clint B. Smith¹, Ilea A. Diaz-Llubes², Fahmi M. Atwain¹, James Goodrich², Joshua Steenbock², Kurtis Daniels³

WHY: U.S. Army Corps of Engineers Engineer Research and Development Center Geospatial Research Laboratory¹; U.S. Environmental Protection Agency²; WaterStep Org³

BLUF: To Meet Installation Water Requirements for Critical Mission Sustainment and Assured Access

The Army seeks to unplug from the grid to identify capability gaps related to infrastructure, operations and maintenance. Exercises performed by DoD are invaluable, identifying potential solutions to maintain installations' critical loads. A challenge of this century will be to secure enough fresh water for the world's increasing population. New solutions are still being created, developed, modernized, & re-imagined.

The first ruggedized Water On Wheels (WOW) cart or DRIPS transitioned to the Organic Industrial Base via the Installation Energy and Water Plan (IEWP) program. On June 2023 ERDC updated the Organic Industrial Base's 5 Year IEWP utilizing the Installation Status Report-Mission Capacity (ISR-MC) and Mission Readiness/Installation Resiliency documentation tools to meet their installation improvement goals. The ISR-MC component assesses the capability of an organization to support its current and future mission requirements, readiness, & its sustainment with critical resources such as air, land, water, and energy.



The first User Jury of the DRIPS held at FLW-CBITEC 27 June in coordination with the Organic Industrial Base, Quartermaster PWD, & 75th Innovation CMD.

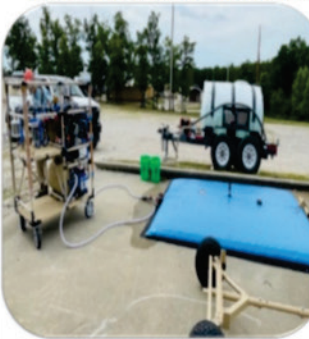
The DRIPS is a back-up water generation system that produces potable water and bleach for disinfection in times of need with a focus on all climate conditions. This includes temperate and extreme cold temperatures with integration into microgrid modular units.

The system provides a mobile water production & disinfection that provides 10 GPM potable water for contingency operations and (5) one-liter containers on the cart for 1.25 gallons per hour of bleach generation (5000 ppm). In addition, the carts treatment train, without filtration, can produce 50,000 gallons per day of treated water from Chlorine gas injection/recirculation for bleach generation. The system overall has an initial training that takes a few hours and there is an ease of training hand off to new users.

'DRIPS'

*CLINT.B.SMITH@USACE.ARMY.MIL

WHERE: Installations, Training Areas, Ranges, Response Areas



Current Capabilities

Treatment Train

- Up to 10 Gallons Per Minute (GPM) Flow Rate
- Pre-filtration to reduce turbidity and improve disinfection
- Two media filtration/adsorption tanks—targeted chemical or radiological contaminant removal (e.g. Granular Activated Carbon or Ion Exchange)
- UV LED for additional microbial inactivation (UV-C)
- On-site chlorine gas & bleach generation for disinfection
- Ability to add or subtract treatment processes in field & ability to re-circulate treated water to increase disinfection

Power Supplies

- Dual Fuel Generator (propane/gasoline) (Future:JP8/MIL SPEC'd)
 - 110v AC (Microgrid-capable-solar integration)
 - 12v DC deep cell marine battery w/solar panel recharge
- ##### Mobility
- Weights less than 500-700 pounds
 - Fits in back of pick-up truck
 - 2-person transport

WHAT: Water Analytics & Production/ Disinfection Systems

The WOW cart is used in Federal emergency use response & was sought out by US Army ERDC in collaboration with US EPA & WaterStep to meet military requirements. The mobile DRIPS is geared for water production & disinfection using various decentralized energy sources. The system is currently used for disaster response & experimentally treating relief well biofouling in dams & levees infrastructure.



WHO: US Army Cohort:

US Army ERDC, OIB, FTW-ERDC ESAPT, HQIMCOM, IEWP, DEVCOM GVSC WEB, PdM PAWS, SC CFSET FP, PdM FSS, FCFC-CS CDID AFC-CASCOM, DPH-A, MEDCOM and AMC CFI HQAMC G3/G4 and Federal US EPA, USACE Districts-Civil Works WG: JWRMAG) Water WG, WaTr WG, Water Sensors CoP, ICE-PPR Water & Wastewater WG

Strategic Placement for Disaster Response National Lily Pad Model



Polar Field Test Location Fox, Alaska Ft. Wainwright (FTW) US Army ERDC CRREL Expedient Structures Array Permafrost Tunnel (ESAPT) Facility

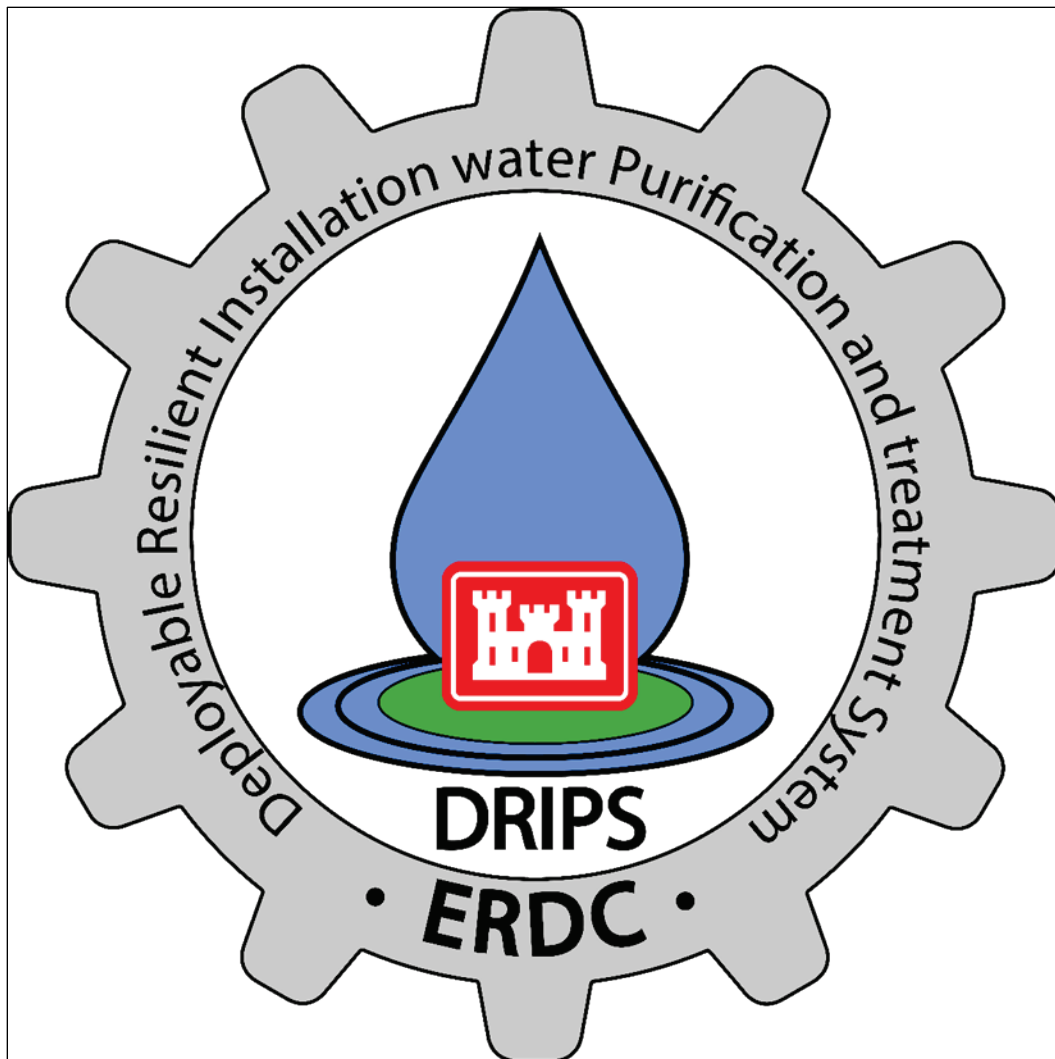


WHAT'S NEXT

- CRADA: US Army ERDC, US EPA, WaterStep: DRIPS scale up: 100,000GPD/17HRS
 - National Lily Pad: WOW Carts/DRIPS deployed to strategically designated locations: Installations, associated public response near bases; such as fire departments, police stations, community centers, hospitals, nursing homes, or jails across a community or state. Multiple locations across an area could be likened to that of lily pads spread across the surface of a pond for USACE ERDC, Districts, Installations, Civil Affairs Emergency Response-National Guard & Reserve
 - GLADIATOR: Graywater Logistics Assured Defense Installation Advance Technology for Operational Resilience system (ERDCs GRTS+DRIPS)
 - Arctic DRIPS within modular force sustainment unit Fox, Alaska: alternative water supply technology for water assurance during Army emergency preparation, response, and training operations using decentralized energy sources in the extreme polar environment. Sustainment during disaster response and recovery operations would be possible. Placement of system aids future validation with Arctic Army Test Centers (ATCs) aimed to improve energy and water resiliency for critical missions at Polar based military installations with a goal of sustaining critical missions—minimum of 14 days in event of water or energy disruption.
 - Provides drinkable water, improved reportability of water production & on-site disinfection for water security. Geo-enabled & capabilities for communication & sensor integration.
 - Additional use cases: forest firefighting, austere water sources, decontamination, added treatment trains, training, hospitals, clinics, & operation in Temperate/Sub-Arctic/Polar environments (ICE PPR Water and Wastewater PA FY25-29).
 - Recent Army Resilience Related Directives for IEWPs:
 - Army Directive 2020-08 (U.S. Army Installation Policy To Address Threats Caused by Changing Climate and Extreme Weather)
 - Army Directive 2020-03 (Installation Energy and Water Resilience Policy)
- This project was funded by the ITTP Program.



A.3 DRIPS Logo



The ERDC logo created for the Deployable Resilient Installation water Purification and treatment System (DRIPS) unit. The input for the logo was designed by the DRIPS team: Dr. Clint Smith, Ms. Ilea Diaz Lluberres, Mr. Fahmi Atwain, Dr. Edith Martinez-Guerra, and Mr. Osman Tirmizi. Mr. Osman Tirmizi provided the graphical software toolset to make the logo. The USACE Castle is embedded on an island surrounded by water and a large drop of water, symbolizing clean drinkable water. The drop of water and blue and green color schema encompass and symbolize the partnership and aspects from ERDC, the industry partner WaterStep, and the US EPA. The logo is surrounded by an engineer cog to symbolize the US Army ERDC and the drive to innovate!

Abbreviations

| | |
|----------|---|
| AA | Assured Access |
| AFC | Army Futures Command |
| ALC | Agency Location Code |
| AMC | Army Materiel Command |
| APG | Aberdeen Proving Grounds |
| ATEC-APG | Army Test and Evaluation Command–Aberdeen Proving Grounds |
| CARC | Chemical Agent Resistant Coating |
| CASCOM | Combined Arms Support Command |
| CBITEC | Contingency Basing Integration Training and Evaluation Center |
| CERL | Construction Engineering Research Laboratory |
| CESER | Center for Environmental Solutions and Emergency Response |
| CFI | Combined Force Integration |
| CFSET | Combat Field Service Equipment Team |
| CMS | Critical Mission Sustainment |
| COA | Course of Action |
| COE | Centre of Excellence |
| COP | Community of Practice |
| CSC | Convoy Support Centers |
| CWA | Chemical weapons agent |
| CWO | Cold Weather Operations |

| | |
|-----------|---|
| DAU | Defense Acquisition University |
| DES | Department of Emergency Services |
| DEVCOM | US Army Combat Capabilities Development Command |
| DOTMLPF-P | Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities–Policy |
| DPH-A | Defense Public Health–Army |
| DPW | Department of Public Works |
| DRIPS | Deployable Resilient Installation water Purification and treatment System |
| E&W | Energy and water |
| EL | Environmental Laboratory |
| EPA | Environmental Protection Agency |
| ERDC | US Army Engineer Research and Development Center |
| FCC | Futures and Concepts Center |
| FLW | Fort Leonard Wood |
| FP | Force Provider |
| FWEB | Fuel and Water Equipment Branch |
| GAC | Granulated activated carbon |
| G4 | Army Logistics |
| GPM | Gallons per minute |
| GRL | Geospatial Research Laboratory |
| G3 | Army Operations |
| GVSC | Ground Vehicle Systems Center |

| | |
|---------|---|
| HA/DR | Humanitarian Assistance and Disaster Relief |
| HQ | Headquarters |
| ICE-PPR | International Cooperative Engagement Program for Polar Research |
| IEWP | Installation Energy and Water Plan |
| IMCOM | Installation Management Command |
| ISR-MC | Installation Status Report–Mission Capacity |
| ITTP | Installation Technology Transfer Program |
| JCIDS | Joint Capabilities Integration Development System |
| JP-8 | Jet-propulsion fuel 8 |
| JWRMAG | Joint Water Readiness and Management Action Group |
| LHS | Load Handling System |
| MDO | Multidomain Operations |
| MEDCOM | Medical Command |
| MIL-STD | Military Standard |
| MOS | Military Occupational Specialties |
| MS | Mission Sustainment |
| NAVFAC | Naval Facilities |
| NG&R | National Guard and Reserve |
| NSF | National Science Foundation |
| NSN | National Stock Number |
| OIB | Organic Industrial Base |
| PA | Project Arrangement |

| | |
|----------|---|
| PdM FSS | Product Manager Force Sustainment Systems |
| PdM PAWS | Product Manager Petroleum and Water Systems |
| PWD | Petroleum and Water Department |
| PWWG | Polar Water and Wastewater Group |
| SC | Soldier Center |
| S-CDID | Sustainment-Capability Development Integration Directorate |
| SO | Systems Operation |
| TRADOC | US Army Training and Doctrine Command |
| TRL | Technical Readiness Level |
| USACE | US Army Corps of Engineers |
| USAG | US Army Garrison |
| WaTr WG | Water Treatment Working Group |
| WG | Water Working Group |
| WOW | Water on Wheels |

REPORT DOCUMENTATION PAGE

| | | | | | |
|--|------------------------------------|--|---|---|---|
| 1. REPORT DATE April 2024 | | 2. REPORT TYPE Final Technical Report (TR) | | 3. DATES COVERED | |
| | | | | START DATE FY22 | END DATE FY24 |
| 4. TITLE AND SUBTITLE Deployable Resilient Installation Water Purification and Treatment System (DRIPS): Geoenabled Water Production and Disinfection Systems for Installations | | | | | |
| 5a. CONTRACT NUMBER | | 5b. GRANT NUMBER | | 5c. PROGRAM ELEMENT | |
| 5d. PROJECT NUMBER | | 5e. TASK NUMBER | | 5f. WORK UNIT NUMBER | |
| 6. AUTHOR(S) Clint B. Smith, Damarys Acevedo-Acevedo, Fahmi M. Atwain, Ilea A. Diaz Lluberer, Osman A. Tirmizi, Ziyad F. Atwain, and Jason C. Smith | | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) See reverse. | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER ERDC TR-24-8 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Headquarters, Department of the Army, G-9 Washington, DC 20310 | | | 10. SPONSOR/MONITOR'S ACRONYM(S) HQDA | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Distribution Statement A. Approved for public release: distribution is unlimited. | | | | | |
| 13. SUPPLEMENTARY NOTES MIPR 11830817 | | | | | |
| 14. ABSTRACT The Deployable Resilient Installation water Purification and treatment System (DRIPS) was delivered to aid an Organic Industrial Base in increasing their Installation Status Report–Mission Capacity (ISR-MC) score from black to green as part of a Course of Action (COA) within their Installation Energy and Water Plan (IEWP). DRIPS was also intended to help them be better prepared for the future in meeting their water and energy requirement goals for sustainment of critical missions. The IEWP ISR-MC requirements were met upon implementation of this project. Overall, the purpose of the DRIPS is to be a critical asset in disaster response and military operations, providing a reliable and effective means of producing potable water and disinfection in challenging and unpredictable environments. Its adaptability, mobility, and comprehensive water treatment capabilities make it an invaluable resource for addressing water-related emergencies and water disruptions and for sustaining critical missions. It also addresses a point of need by improving the ability to meet demands, reducing convoy requirements and the logistical footprint, facilitating the endurance of expeditionary forces, and ensuring the well-being of affected installations during times of disaster response, training operations, normal water disruptions, and emergency preparation. | | | | | |
| 15. SUBJECT TERMS Military bases; Logistics; Sustainability; Water--Purification; Water--Supply | | | | | |
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | | 18. NUMBER OF PAGES |
| a. REPORT Unclassified | b. ABSTRACT Unclassified | c. THIS PAGE Unclassified | SAR | | 50 |
| 19a. NAME OF RESPONSIBLE PERSON | | | 19b. TELEPHONE NUMBER (include area code) | | |

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) (concluded)

US Army Engineer Research and Development Center (ERDC)
Geospatial Research Laboratory (GRL)
7701 Telegraph Road
Alexandria, VA 22315-3864

US Army Engineer Research and Development Center (ERDC)
Environmental Laboratory (EL)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199