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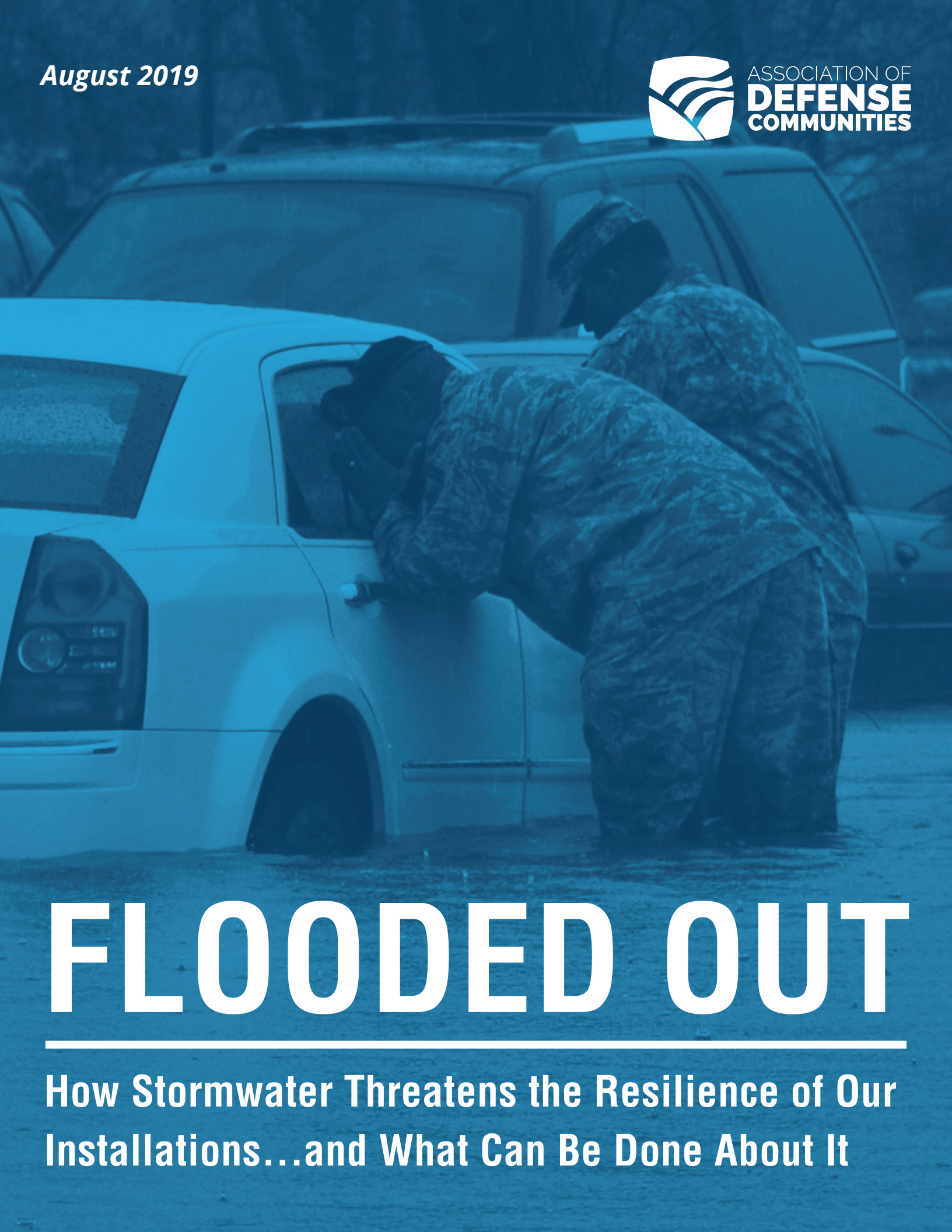

FLOODED OUT

How Stormwater Threatens the Resilience of Our Installations…and What Can Be Done About It

On April 18, 2013, Scott Air Force Base, Ill., endured a heavy storm that dropped five inches of rain in under six hours, resulting in widespread flash flooding and stormwater failures across the base. The deluge so overwhelmed the stormwater system at the time that parking lots flooded, personnel couldn't reach their cars, and several key facilities were damaged.

The rainfall at the base on that day was more than it had received in the preceding two months *combined*. By late that morning the heavy rain was causing significant problems with many parking lots submerged and water damaging vehicles. Some homes in base housing began experiencing flooding and streets became impassable.

As a result of the flooded base conditions that day, nonessential mission personnel were released from duty and installation security was forced to alter traffic patterns to get drivers off base safely. The base and its stressed stormwater system incurred extensive costs and long-term damage. The storm exposed the depth and breadth of risk that accumulates when stormwater systems are left to degrade over time; most of the resulting improvements never would have been addressed if not for the storm.

Scott Air Force Base is simply one example of these risks. In the past year, multiple military installations have faced catastrophic flooding causing damages that will require billions in federal dollars to repair. Although "hundred-year storms" caused some of this recent damage and operational disruption, recurrent flooding is the leading vulnerability for installations and poses an ongoing threat at 51 installations across the country[1].

This report was produced by the Association of Defense Communities in conjunction with its Energy and Water Council; Editor - Greg Traweek.

"Scott responds to flooded conditions"
Photo by U.S. Air Force Airman 1st Class Jaeda Waffer

Cover photo by U.S. Air Force Airman Megan Friedl

CASE STUDIES

Recurring system failures from even routine storms have caused major installation disruptions including washout damage to other utilities (water, wastewater, electricity), collapsed underground stormwater pipes that lead to sinkholes, road and sidewalk closures due to unsafe erosion, and recurrent roadway flooding that occurs with any storm resulting in placement of “high water” signs rather than full repair.

Systemic failure from multiple flooding events have caused major issues involving standing water, sinkholes and erosion due to deteriorated underground pipes, stormwater washout, and rooftop drainage flowing to underground stormwater pipes that connect to a sanitary sewage lift station where overflows occur during every heavy rain event.

Another example of commonly occurring standing stormwater due to system failure; sinkholes and soil erosion due to unmaintained below ground pipes; overgrowth allowed to flourish around a buckled and unmaintained storm drainage area; sidewalk and roadway collapses; and recurring damage to the interconnected stormwater and wastewater treatment system during heavy rainfall overflows.

An alarming example of stormwater drainage failure occurred when a 60-inch stormwater drain failed and the ensuing overflow and downstream runoff left a sewer main fully exposed and sagging over a 10-foot ravine that had been cut by stormwater sediment erosion. The potential hazardous sewage spill could have been much worse if the sewer main had not been recently reinforced with protective piping, providing some support before private utility partners made comprehensive repairs.

HOW STORMWATER IMPACTS HEALTH, SAFETY AND QUALITY OF LIFE

These flooding vulnerabilities and potential damages are not just limited to coastal locations facing sea-level rise from the impacts of climate change. The vulnerability to recurrent flooding is prevalent and is resulting in high risks to mission effectiveness and installation operations. Up to 60 military installations have potential vulnerability from the same issue.[2] Simply stated, more than two-thirds of DOD's most vulnerable installations are sites where recurrent flooding has been identified as a known operational risk.

This increasing threat has put growing pressure on the stormwater infrastructure at our military installations, which is often degraded or insufficiently maintained. Stormwater systems are under increased pressure, yet policy guidance (and associated military construction funds) to holistically address and resolve recurrent vulnerabilities continues to be lacking. Similar neglect of appropriate system maintenance and funding would never be acceptable to meet the reliability and resilience that is required of similar off-base utility systems. Civilian stormwater management codes and best practices, at the state and municipal level, would not permit stormwater utility systems to operate in such a degraded state.[3]

The risks associated with the stormwater challenge and system drainage failures include recurring and disruptive flooding, surface sinkholes, washout, erosion, runoff, and unmanaged sedimentation buildup. These results degrade the resiliency, readiness and overall quality of life on the nation's military installations. The common risks associated with stormwater drainage failures have become more than occasional events that create temporary installation hazards and disrupt routine activities; they occur with increasing regularity and intensity. In fact, stormwater risks and challenges are both foreseeable and predicted to increase as climate change becomes a threat to installation readiness.

Adding to these risks, the majority of installations still have legacy cross-connections

HOW IS STORMWATER CURRENTLY MANAGED ON BASES?

Stormwater drainage systems on installations are generally managed and operated on a reactive basis. Military construction contracts, or MILCONs, awarded at the base level for stormwater maintenance do not reflect a holistic approach to stormwater systems. The current approach fails to leverage system owner expertise and system flow modeling of the entire system. At the installation level, management of stormwater systems is often a patchwork of individual site repairs that do not fully address or resolve larger stormwater flow patterns and system failures. As a result, decrepit stormwater systems increasingly threaten even recapitalized drinking water and wastewater systems, particularly at vulnerable system interconnections.

In general, the military services do not provide proactive investment, management and operation of their installations' stormwater systems. Necessary funding for stormwater system operations is not routinely awarded through the roads and grounds program at the Department of Public Works or Civil Engineering Department for maintenance of the system, but only for reactive catastrophic failures that can overwhelm on-base water treatment facilities. Without proactive system management and maintenance, installations face risks of further disruption to water treatment facility sustainment models, and recurring flooding puts installation buildings and paved roadways at risk for quicker degradation to Q/F4 ratings. ■

(i.e., stormwater to sanitary sewer) which present several serious health and safety issues when overwhelmed. The contamination caused by bacteria in raw sewage overflows, for instance, threatens quality of life across the base. Legacy cross-connections also pose a serious environmental risk, as overflows can also end up in stormwater outlets and drainage areas leading to natural resource areas on base, and eventually flow into waters of the nearby community.

The additional stormwater flow into existing sanitary sewers across military installations places the sewer system in jeopardy of being overwhelmed. In severe cases, pipes back up, manholes flood, and system overflows occur. Major overflows often damage roads, buildings and related infrastructure, causing disruption to mission-related functions or overall access to the base.

THE COST OF DOING NOTHING — RISKS OF NOT MANAGING STORMWATER

Formation of Sinkholes from Collapsed Pipes – Visible sinkholes caused by stormwater system drainage failures are a recurring problem and growing hazard that impacts installation readiness and overall quality of life. These sinkholes are routinely caused by collapsed and failed underground stormwater pipes where washout then erodes the subsurface soil which sinks the surface. The result is surface level depressions, or sinkholes, that are both hazardous and unsightly, and can be an impediment to routine operations. The current solution – if any solution is pursued - is to routinely fill these sinkholes and surface depressions with topsoil, but it neglects addressing the underlying problem. The practice of filling sinkholes is a solution that can last a matter of days where a comprehensive repair will remedy drainage failures for years.

Compliance with State Laws – Stormwater systems that lapse into disrepair could fall below the standards required by state authorities. For instance, the Maryland Department of the Environment provides a standard of care for state and federal stormwater projects: "The Maryland Stormwater Management and Erosion & Sediment Control Guidelines for State and Federal Projects state that the owner of a best management practice (BMP), or agent in control of the BMP, must maintain in good condition and promptly repair and restore all stormwater management BMPs and appurtenances. Such repairs, restoration, and maintenance must be in accordance with the MDE approved plans."[5]

Impacts of Quality of Life and Military Housing – Installation stormwater drainage risks extend beyond visible failures near well-established drainage areas. An example is Fort Jackson, S.C., where an installation housing development has frequently suffered significant roadway flooding and surface damage due to underground stormwater drainage system failures. Within the development, open roadside ditches have formed where stormwater runoff has shifted from the collapse of a major underground drainage conduit preventing proper channeling of the stormwater flow into a culvert. As a result, the base has resorted to temporary erosion control and channeling measures to attempt to manage the stormwater flow.

Unnecessary Costs – Illicit connections and inactive/improperly abandoned sections can cause inflow and infiltration. Significant additional costs accrue to the installation for treating storm and ground water. Ad-hoc stormwater drainage system connections and inactive and improperly abandoned drainage sections also create stormwater system dysfunction. As illicit connections feed into the stormwater system, it generates significant costs to treat stormwater as installation wastewater. ■

HOW STORMWATER IMPACTS INSTALLATION RESILIENCE & GOVERNMENTAL RESOURCES

Diminished installation resilience and readiness are the ultimate risks associated with today's stormwater challenge. As these aging and failing stormwater systems become more stressed due to increasing storm intensity, installation resilience is surely to suffer worsening impacts that won't be easily or quickly overcome. While routine storm events are already overwhelming stormwater drainage systems and creating recurrent disruption and damage, future extreme weather events are certain to trigger greater risks and challenges that will require increasingly extensive and expensive repair and rehabilitation measures.

The degradation of stormwater systems is costing DOD money every time there is a significant storm event, and it is having a significant impact on the mission readiness of installations. As installations are increasingly reliant on reactive maintenance, more money is spent on short-term repairs while installations gain no assurance of increased resiliency and readiness. Patchwork maintenance solutions are not solving the larger drainage issues, and a major influx of installation-level military construction funding for proactive upgrades seems unlikely.

FINDING SOLUTIONS TO INSTALLATION STORMWATER CHALLENGES

Installation readiness and resiliency demands forward-looking solutions and expertise that will deliver real stability and reliable performance. Three general pathways could fund enhancements to the resilience and reliability of stormwater systems: (1) additional military construction (MILCON) dollars appropriated by Congress; (2) partnerships with a local government through the intergovernmental support agreement authority; or (3) utility privatization.

UTILITY PRIVATIZATION AND STORMWATER

The statutory authorization for Utility Privatization (UP) dates to the FY 1998 National Defense Authorization Act (NDAA), which added section 2688 to Title 10 of the U.S. Code. A concurrent Defense Reform Initiative Directive #9 (December 1997) directed military departments to privatize to the greatest extent possible, absent strong national security or economic reasons to retain government control. The UP program enhances energy supply, efficiency, reliability, and resilience – concerns are not limited to the electric grid, given the symbiotic relationship between electrons and gallons.

Some services have restricted the application of the statute as it relates to stormwater in contradiction to congressional authority. Although the statute does not use the word "stormwater" in the definition of "utility system" subject to privatization authority, subsequent legislation specifies that the term "wastewater" – which does appear in § 2688 – includes stormwater.[6]

In the absence of direction from the Office of the Secretary of Defense, the services have taken varying positions on stormwater UP. The Army has been leading the way; it privatized stormwater systems on Fort Knox pursuant to 10 U.S.C. § 2688 in 2004. By contrast, the Air Force has argued that it lacks the authority to privatize stormwater systems.

In 2018, the Senate Armed Services Committee reiterated its concern with stormwater management by DOD, and was "discouraged with DOD's failure to comply with section 2813 ... which stated that it was the sense of Congress that 'wastewater' captures stormwater within the definition of section 2688(i)." ■

Relying on annual MILCON appropriations represents a highly risky and uncertain approach. Competition for resources, even within funding streams as large as those in the Defense and MILCON/VA appropriations bills, and could perpetuate the vulnerability of installations to stormwater system failure. Military construction funds are often appropriated into relatively broad accounts where there is no certainty that the funding will be directed to comprehensive stormwater system resiliency. Moreover, any direct MILCON funds, by themselves, would still not leverage the available industry expertise to adequately resolve the problem.

Community partnerships are also unlikely to resolve the stormwater problem due to the uncertainty and inconsistency in community resources. In select cases partnerships may work if a community already has the appropriate stormwater infrastructure in place, but in many cases a community's infrastructure and an installation's stormwater solution will not align perfectly. Communities and installations often have too many inconsistencies for partnerships to work.

THE CASE FOR MANAGING STORMWATER THROUGH UTILITY PRIVATIZATION

Utility privatization (UP) of stormwater infrastructure is a forward-looking response to this growing threat to installation resiliency. Private partners have the expertise to address increasing threats and provide the resiliency that installations expect. Through such partnerships, which are already authorized in current law, lasting solutions can deliver the real resiliency and reliability that missions demand.

The Defense Department and the services should leverage existing legislative authorities, the value of competition, and the expertise of private sector partners to modernize stormwater infrastructure in a proactive approach. To be sure, a UP contract represents a long-term investment of time and resources, but the twenty-year experience with UP shows that an up-front investment in modernization can insure against significant threats to life and property. Moreover, the services can - and should - include stormwater systems under existing UP contracting activity.[4] Such a comprehensive approach to utilities management is consistent with the DOD's strategic objectives, represents a cost-effective approach to risk management, and enables the services to enhance energy and water resilience for installations and residents.

In this report, ADC seeks to explore how the stormwater challenge could be appropriately addressed through utility privatization solutions and how the existing UP authority provides a cost-effective, ready-to-go option for leveraging private investment.

Moreover, stormwater systems are typically integrated with installation water and wastewater treatment systems, many of which are already undergoing upgrades and repairs through smart business partnerships with private sector utility owners.

Approaching maintenance and infrastructure upgrades from a systemic viewpoint allows for the services to plan and construct effective utility infrastructure. When interconnected systems are constructed in absence of consideration for one another, complications, including improper sizing and alignment, are bound add vulnerabilities. Furthermore, when individual system investment does not address the system at large, as we have seen with current military construction awards, the effectiveness and ultimate protective purpose of the system construction is significantly undermined.

"Storm monitoring system keeps water pollutant-free"
Photo by Lance Cpl. Jason Jimenez
Marine Corps Air Station Cherry Point

CASE STUDIES

FORT BRAGG, N.C.: ROADWAY FLOODING IMPACTS INSTALLATION MOBILITY

At Fort Bragg, N.C., stormwater system failures are increasingly causing severe washouts, sinkholes, flooded roads and other disruptions during heavy rainfall. As the region faces more intense storms and stronger impacts from hurricane seasons, this damage is a growing threat to installation readiness. As failures increase, the installation's operations face disruption and potential health and safety risks.

A major contributor to Fort Bragg's increasing stormwater system failures involves its connection with the installation's wastewater treatment system. This flaw is most evident as rooftop rain drains down gutters to underground drainage pipes that directly connect to a wastewater treatment lift station. As increasingly heavy rainfall occurs, the added stormwater flow overwhelms the lift station, forcing surface-level flooding. As a result, in addition to the hazard of standing wastewater overflows, the installation pays excessively for wastewater treatment, even though the added stormwater does not require special treatment.

Two examples of major on base drainage failures:

Severe Washout - In Feb. 2016 a Knox Street stormwater washout caused road and sidewalk closures due to a severe overflow that cut a gaping ravine and created a public safety hazard. This overflow also caused serious damage to utilities including water, wastewater, electricity and other installation services. The utilities were ultimately restored, but the stormwater overflowed to the point that standing water posed a health hazard. Resolution required the installation's Department of Public Works (DPW) requesting the wastewater system owner to monitor the exposed water and utilities daily.

Clogged Stormwater Basins - Another example of the failed stormwater drainage system includes recurrent flooding at a key installation intersection. A sand-filled stormwater catch basin at the intersection has likely clogged due to an underground pipe collapse, resulting in recurring drainage backup. More than 24 hours after flooding events, the catch basin and street can remain flooded. Increasingly this major intersection and others on Fort Bragg are prone to flooding. Since funding is not dedicated to fully repair the intersection's drainage system, the installation simply posts "high water" signs for all four intersection approaches.

FORT JACKSON, S.C.: STORMWATER FAILURES DISRUPT OPERATIONS

At Fort Jackson, S.C., stormwater drainage system failures are increasingly disrupting normal base operations and causing public hazards. The installation's stormwater drainage failures include deep sinkholes and soil erosion due to poorly or unmaintained underground pipes, sidewalk and roadway collapses, and recurrent overflows into the interconnected stormwater and wastewater system during heavy rainfall.

Examples of drainage failures on Fort Jackson:

A highly visible on-installation site features the critical failure of a large storm drain box culvert that created a massive sinkhole, exposing both the pipe and storm drain box. This failure is due to underground stormwater pipes that collapsed and allowed extensive soil erosion around the drain box. This stormwater drainage failure, and others like it, pose a serious threat to the safety of the families of Fort Jackson and creates a significant environmental hazard.

Stormwater damage has also impacted the Pierce Terrace Housing Development where sidewalks have completely collapsed due to failed underground drainage. Other stormwater drainage failures near the housing development have created open roadside ditches that have shifted and collapsed due to failure of the drainage system to properly channel the stormwater flow into the culvert. The installation has installed temporary erosion control and channeling measures to try to manage the storm water flow, but these patches are short-term solutions to a long-term problem.

A dditionally, Fort Jackson's existing stormwater channels are often overgrown and not maintained, preventing proper flow. Failure of the stormwater drainage has caused widespread soil erosion, including creating a large rill of unmanaged sediment. These surface hazards, and others on Fort Jackson, can increase the installation's liability by creating an unnecessary injury risk for the men and women, and families, who live and work on the base.

JOINT BASE ANDREWS, MD.: WIDESPREAD STORMWATER CHALLENGES CREATE BASE OPERATION ISSUES

Joint Base Andrews, Md., home base of Air Force One, is a high-profile example where installation stormwater drainage system failures have caused base-wide operation problems and potential public health hazards. Even during normal rains, recurring stormwater flooding, sinkholes, washouts, surface depressions and other visible stormwater damage results in installation disruption and overall system drainage complications.

Examples of stormwater drainage failures at Joint Base Andrews:

Significant and problematic recurring drainage system failures includes ongoing stormwater flooding near the commanding general's house during heavy rain, which has required private utility personnel and equipment to respond and repair the malfunctioning stormwater drainage. In addition to being a high-profile stormwater drainage failure, the flooding also disrupts routine operations and impairs installation readiness.

Another on-installation site of the drainage system's failure is a stormwater inlet in a drainage field that has deteriorated and the outflow pipe has fully collapsed, causing major erosion and soil washout. The drainage field surface, once level, has completely washed away, creating a steep, elongated crater. The soil washout has been so severe it ultimately exposed the stormwater inlet's concrete casing and the downstream stormwater piping. The unmaintained stormwater washout has now existed long enough for vegetation to flourish.

FORT RUCKER, ALA.: STORMWATER DRAINAGE FAILURE CREATES POTENTIAL SEWAGE FLOW

At Fort Rucker, Ala., stormwater system drainage failure is a serious and growing problem arising from heavy rainfall events during increasingly intensifying hurricane seasons.

An alarming stormwater drainage failure at Fort Rucker included a fully exposed and suspended and sewer main that had serious damage after a 60-inch stormwater drain failed during heavy rains, resulting in a 10-foot ravine being cut downstream caused by excessive stormwater erosion that left the sewer main vulnerable and sagging over the ravine.

The exposed and suspended sewer main showed signs of potential rupture, but it could have been much worse if the sewer main had not been recently reinforced with vitrified clay (VC) piping, providing additional support and protection from the unexpected stormwater distress.

Though the VC piping was broken and the sewer main was clearly distressed, worse damage could have resulted in unknown quantities of sewage flowing into the ravine and downstream with the torrent of uncontrolled stormwater.

The drainage failure required quick response of private utility partners to permanently repair the damage. Failure of the exposed sewer main was imminent, so by-pass pumping was installed to protect the environment and prevent sewer overflows. The by-pass solution was also installed as a lift station with a mission alarm system to provide alerts in the event of potential overflow. The exposed sewer main was then ultimately removed to allow repair of the failed storm drain and relocate it downstream from the sewer main.

Final private utility response to the incident involved full repair of the failed storm drain and reinstatement to proper grade, and installation of a new 21-inch sewer pipe and a manhole in the eroded area. The private utility work to repair the failed storm drain and the eroded area was completed in approximately three weeks.

ENDNOTES

1 *Report on Effects of a Changing Climate to the Department of Defense*, January 2019; "Summary Table of Current & Potential Effects to 79 Installations"; Office of the Under Secretary of Defense for Acquisition and Sustainment

2 Ibid.

3 See, e.g., City of Seattle, *Stormwater Manual*, Appendix G, "Stormwater Control Operations and Maintenance Requirements" (May 2017), available at http://www.seattle.gov/Documents/Departments/SDCI/Codes/FinalStormwaterManualAppendixG.pdf (describing defects, associated maintenance requirements, and expected condition after maintenance); State of Florida, *Best Maintenance Practices for Stormwater Runoff*, *Designer And Review Manual* sec. 1.8 (Apr. 2015), available at https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/maintenance/maintenance/rdw/bestmaintpracticesswrunoff.pdf?sfvrsn=3e4e5e53_0 (summarizing Florida Administrative Codes and Statutes for regulating stormwater management).

4 Maryland Department of the Environment, Technical Memorandum #9, "Maintenance Schedules" (June 1, 2018), available at: https://mde.maryland.gov/programs/Water/StormwaterManagementProgram/Pages/PlanReviewforStateandFederalProjects.aspx.

5 Recent congressional action underscores the broad support for the policy behind privatizing stormwater systems. A straightforward clarification of this existing authority foundered in FY2018 when the CBO concluded that the proposed amendment would increase direct spending, and accordingly "scored" it at a cost of $10 million per year. This flawed conclusion flowed from the CBO's faulty premise that "[s]torm water systems are not eligible for privatization." They are eligible, as Congress has repeatedly explained in Sense of Congress provisions and Armed Services Committee report language.

6 FY 2017 NDAA, Section 2813.

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