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March 27, 2014

Congressional Committees

Defense Infrastructure: DOD's 2013 Facilities Corrosion Study Addressed Reporting Elements

In 2013, the Department of Defense (DOD) reported spending an estimated \$20.8 billion annually to prevent and mitigate corrosion of its assets, including military equipment, weapons, and facilities and other infrastructure.¹ While the vast majority of these costs are related to corrosion issues on military equipment and weapons, the cost of corrosion at DOD facilities and other infrastructure² was estimated to be about \$1.9 billion annually.³ Corrosion is defined in Section 2228 of Title 10 of the United States Code as the deterioration of a material or its properties due to a reaction of that material with its chemical environment. DOD manages more than 555,000 facilities—including barracks, commissaries, data centers, office buildings, laboratories, maintenance depots, storage tanks, and piers—and linear structures, such as pipelines, roads, and runways, at more than 5,000 sites that cover more than 28 million acres.

In its report accompanying HR 1540, a bill for the National Defense Authorization Act for Fiscal Year 2012,⁴ the House Armed Services Committee directed DOD's Director of the Office of Corrosion Policy and Oversight (hereafter referred to as the Corrosion Office) to conduct an evaluation of corrosion matters related to the department's facilities and infrastructure, specifying that the study should (1) identify the key cost drivers⁵ for corrosion associated with facilities and infrastructure and recommend strategies for reducing their effect; (2) review a sampling of facilities that are representative of facility type, military department, and facility age; (3) include an assessment of at least one planned facility construction program; and (4) include information obtained from site visits and the examination of program documentation, including maintenance and facility engineering processes.

In the same report, the House Armed Services Committee directed that we provide the congressional defense committees an assessment of DOD's facilities and infrastructure

¹This cost estimate, which was produced by a DOD contractor and is based on data from fiscal years 2006 through 2010, is the latest estimate available on DOD corrosion costs.

²Infrastructure is defined in Section 2228 of Title 10 of the United States Code as all buildings, structures, airfields, port facilities, surface and subterranean utility systems, heating and cooling systems, fuel tanks, pavements, and bridges.

³The estimate of the annual cost of corrosion for DOD facilities and other infrastructure was produced by a DOD contractor and is based on data from fiscal years 2007 and 2008. This is the latest estimate available on DOD corrosion costs for facilities and other infrastructure.

⁴H.R. Rep. No. 112-78.

⁵For the purposes of its study, DOD defines cost drivers as costs that have already been spent for corrosion-related maintenance, including labor, material, and preventive and corrective actions.

evaluation study.⁶ This report assesses whether DOD addressed the House committee's reporting elements.

Scope and Methodology

To conduct our review, two analysts independently reviewed and assessed DOD's report to determine whether it contained information on the four elements specified in the House committee report. The analysts did this by comparing the House committee report's elements to findings in DOD's report to determine whether the report addressed each of the four elements. The analysts agreed on whether or not the report addressed each of the elements. Additionally, we obtained and reviewed previous DOD studies on corrosion costs and other documents to understand the relevant issues regarding DOD's corrosion prevention and control program. We also interviewed officials from DOD's Corrosion Office, members of the Facilities and Infrastructure Corrosion Evaluation Study team,⁷ and Corrosion Control and Prevention Executives⁸ from the Army, the Navy, and the Air Force, to obtain further information about the evaluation and to clarify various aspects of the report. Our focus was not on evaluating the assumptions, methods, or data used in DOD's report but rather on whether or not DOD's report addressed the elements specified in the House report.

We conducted this performance audit from August 2013 through March 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Results in Brief

Our review found that DOD's July 2013 report addressed the four elements specified in the House report. Specifically, the report by the Director of DOD's Corrosion Office addressed the following elements related to corrosion of facilities and infrastructure: (1) identification of key drivers of corrosion costs and recommended strategies for reducing their effect; (2) review of a sampling of facilities that are representative of facility type, military department, and facility age; (3) assessment of at least one planned facility construction program; and (4) information from 30 locations (15 site visits and 15 teleconferences) and the examination of program documentation from all the locations, including maintenance and facility engineering processes.

Regarding the first element on key drivers of corrosion costs at facilities and infrastructure, DOD identified 36 objects on which corrosion-related maintenance costs had been expended. DOD referred to these 36 objects as cost drivers for corrosion, and among them were factors that

⁶Department of Defense, *Department of Defense Facilities and Infrastructure Corrosion Evaluation Study Final Report* (Washington, D.C.: July 11, 2013).

⁷At the direction of the Under Secretary of Defense for Acquisition, Technology and Logistics, the Director of the Corrosion Office assembled a study team of representatives from the Army, the Navy, and the Air Force, and subject-matter experts from other stakeholder organizations to evaluate the costs, technology, and sustainment issues associated with the corrosion of DOD facilities and infrastructure.

⁸Section 903 of the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 (Pub. L. No. 110-417) required the Departments of the Army, Navy, and Air Force to each designate a Corrosion Control and Prevention Executive to be the senior official in each military department with responsibility for coordinating department-level corrosion prevention and control program activities.

may influence or drive corrosion costs, such as facility age, as well as equipment, facilities, or other infrastructure with the highest corrosion costs, such as air conditioning units and bridges. Officials also described new technologies that helped develop strategies or solutions to address corrosion. For example, in 2006, DOD applied an epoxy coating system to a hangar and another structure at Rock Island Arsenal, Illinois, and monitored the coating system for over a year to determine whether the technology could be used across the department. DOD found that applying the coating system to metal structures helped prevent corrosion and provided resistance to fire. For the second element, to review a sampling of facilities, DOD selected 30 locations to examine site-specific corrosion issues and identify best practices, as appropriate. The locations DOD selected varied by type, military department, and facility age. Regarding the third element, to assess at least one planned construction program and determine whether corrosion prevention and control decisions were considered during the planning, design, and construction phases, DOD officials selected the Guam Naval Hospital and provided their rationale that the new facility is to be built in one of the harshest environments that can cause corrosion, including ocean spray and typhoons. The study team's assessment was that throughout each phase, corrosion prevention and control requirements were documented and included to address corrosion issues, such as the harsh tropical environment. For the fourth element, DOD officials included information obtained from site visits and teleconferences by surveying installation officials at the 30 selected locations about how they implemented corrosion prevention, control, and mitigation strategies in their facilities and infrastructure. In addition, they examined program documentation including maintenance and facility engineering processes related to corrosion prevention and mitigation.

Background

Congress has taken a series of legislative actions aimed at enhancing DOD's ability to effectively address corrosion prevention and mitigation and provide Congress with greater transparency over the department's efforts. In 2002, Congress passed legislation that required the creation of the Corrosion Office within the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics. The Corrosion Office is responsible for the prevention and mitigation of the corrosion of military equipment and infrastructure.⁹ Since then, the Corrosion Office has taken a number of actions to provide guidance for corrosion prevention and control within DOD. To accomplish its oversight and coordination responsibilities, the Corrosion Office (1) hosts triannual corrosion forums; (2) conducts cost-of-corrosion studies; (3) operates two corrosion websites; (4) publishes an electronic newsletter; (5) works with industry and academia to develop training courses and new corrosion technologies; and (6) provides funding for corrosion-control demonstration projects proposed and implemented by the military departments. Additionally, the statute requires the Secretary of Defense to annually submit, along with the defense budget materials, a report to Congress on corrosion funding, including funding requirements for the long-term strategy.

In the past decade, we issued a number of reports on DOD's corrosion-control program, including the department's actions to fund related efforts for facilities and other infrastructure. In

⁹The Bob Stump National Defense Authorization Act for Fiscal Year 2003 required the Secretary of Defense to designate an officer, employee, board, or committee as the individual or office with this responsibility. See Pub. L. No. 107-314, § 1067 (2002) (codified at 10 U.S.C. § 2228). The National Defense Authorization Act for Fiscal Year 2008 amended this requirement by designating the Director of Corrosion Policy and Oversight as the official with these responsibilities. See Pub. L. No. 110-181, § 371 (2008).

our most-recent report, issued in May 2013,¹⁰ we reported on DOD's need to improve the tracking, reporting, and communication strategies for corrosion projects related to facilities and other infrastructure. We recommended five actions. DOD partially concurred with three actions—to improve project reporting and tracking, the accuracy of DOD's return-on-investment data, and DOD's communication with stakeholders on corrosion-control activities for facilities and other infrastructure. DOD did not agree with our recommendations to implement possible options for addressing reasons cited by project-management offices for not meeting reporting milestones, and revising guidance to hold the departments' project-management offices accountable for submitting infrastructure-related reports in accordance with DOD's strategic plan. However, DOD plans to implement a web-based tracking tool to improve data timeliness and standardization, among other actions.

In July 2013, the Corrosion Office issued its report to Congress on its study about corrosion-related challenges for DOD facilities and infrastructure. The report evaluated challenges and described findings of a small sampling of DOD installations. The report also detailed the methods that the study team used to address the specific elements, as outlined in House Report 112-78.

DOD's 2013 Facilities and Infrastructure Corrosion Report Addressed the Elements Specified in the House Report

Our review found that DOD's July 2013 report addressed the elements specified in the House report. Specifically, the report by the Director of DOD's Corrosion Office provided information to address the following four elements:

1. *Identify key drivers of corrosion costs associated with facilities and infrastructure and recommend strategies for reducing their effect.* DOD's report listed objects it identified as key cost drivers and examples of new technologies and best practices that have helped develop strategies or solutions to address corrosion. Regarding cost drivers, DOD listed 36 objects¹¹ that are associated with facilities and infrastructure. The objects included bridges, generators, air conditioning units, pavements, plumbing, and water pipes. According to DOD's report, policymakers and installation officials can use these key cost drivers as reference points for improvements and sustainment of their installations.¹² To identify the cost drivers, DOD used the military services' maintenance data and confirmed the information with installation officials during selected site visits and teleconferences. DOD officials determined that these cost drivers accounted for more than 75 percent of the corrosion-related costs for facilities and infrastructure.

To address the recommended strategies that reduce the effect of corrosion costs, DOD described numerous examples of new technologies—as well as best practices—that may help develop strategies or solutions that can reduce maintenance costs, minimize life-cycle costs, and extend the life of facilities and

¹⁰GAO, *Defense Infrastructure: DOD Should Improve Reporting and Communication on Its Corrosion Prevention and Control Activities*, GAO-13-270 (Washington, D.C.: May 31, 2013).

¹¹DOD refers to the examples as “unique maintenance objects.”

¹²See enc. I for a list of the 36 objects that DOD identified as key cost drivers.

infrastructure. One example of a successful solution, the report noted, was to apply an epoxy coating system to metal structures to prevent corrosion and provide fire resistance. In 2006, DOD applied an epoxy coating system to a hangar and another structure at Rock Island Arsenal, Illinois, and monitored the coating system for over a year to determine whether the technology could be used across the department. DOD found that the epoxy coating required virtually no maintenance and could withstand extreme environmental conditions, such as high temperatures. Another example DOD described was the Navy's development of a tool that was first demonstrated in 2006 to detect and identify hidden corrosion on guy wires (tensioned cables designed to add stability to freestanding structures) for all large guy-supported structures. As noted in DOD's report, through demonstration and development of the system, DOD learned that visual inspection of the guy wires was not efficient nor did it guarantee that critical corrosion would be found. The report noted that the tool, once fully developed, will provide a repeatable and more-efficient way to identify corrosion, and the results from the inspection will help to develop a replacement schedule for the guy wires based upon corrosion and useful life of the guy wires. Additionally, DOD included in its report a list of best practices to prevent or control corrosion that were cited by surveyed installation officials, such as the practices of monitoring water usage to detect possible leaks and using deicing spray instead of salt. As another best practice, surveyed installation officials suggested using a community of practice to improve communications. A community of practice, the report stated, would improve the dissemination of best practices and accelerate acceptance and implementation of new technologies.

2. *Review a sampling of facilities that are representative of facility type, military department, and facility age.* For its study, DOD selected 30 locations to examine site-specific corrosion issues and demonstrate best practices, as appropriate. The locations DOD selected varied by type and included operating bases, depots, and regional commands of the Army, Navy, Air Force, and Marine Corps. The selected locations also varied by age, ranging in establishment from 1767 to 1961.¹³ DOD's approach for selecting its locations began with a universe of 5,211 DOD sites listed in the Facilities Asset Database.¹⁴ The study team then narrowed the list by excluding thousands of sites listed in the database that were not relevant or were not within the scope of the study because the sites either were parcels of raw land or were tenants of larger installations. Subsequently, DOD also decided to select only major installations that host numerous tenants. For example, the Army Reserve Center at Fort A.P. Hill was ruled out as a separate site of interest because it was a tenant to a major installation (Fort A.P. Hill) and therefore was included as part of that larger installation. Through this selection process, DOD reduced the universe of 5,211 sites to a list of 772. From the 772, DOD selected 30 major installations to sample for its study. In addition to selecting sites that varied by military department, type, and date of establishment, DOD explained in its report that the study team's selection of 30 sites aimed to emulate the distribution of environmental conditions of

¹³See enc. II for a map of 30 locations DOD selected for its facilities and infrastructure corrosion study.

¹⁴The Facilities Asset Database, also known as the Base Structure Report, is a consolidated summary of the military departments' annual real-property inventory data.

all DOD installations by using the environmental severity index zone.¹⁵ The Corrosion Office provided an environmental severity index zone for each installation and considered the index zone in selecting the 30 sites.¹⁶ However, the 30 sites DOD selected for its study are not statistically generalizable to all DOD sites.

3. *Include an assessment of at least one planned facility construction program.* For the report, DOD officials selected the Guam Naval Hospital as the planned facility construction program to assess and determine whether corrosion prevention and control decisions were considered during the planning, design, and construction phases. DOD officials explained to us that they chose the Guam Naval Hospital—estimated by DOD to cost \$446 million to replace—because the facility was the largest ongoing military construction project in one of the harshest environments that can cause corrosion. The naval hospital is exposed to corrosive elements, such as constant ocean spray, torrential rains, and typhoons. The study team evaluated the facility’s planning, design, and construction phases to assess the extent to which corrosion prevention and control considerations were documented throughout the phases of this project. The study team’s assessment was that throughout each phase, corrosion prevention and control requirements were documented and included to address corrosion issues, such as the harsh tropical environment.
4. *Include information obtained from site visits and from an examination of program documentation, including maintenance and facility engineering processes.* DOD’s report included information on guidance, strategies for corrosion prevention and control, and policies and procedures from visits to 15 of the 30 locations selected for the study and from teleconferences with installation officials at the other 15 locations.¹⁷ DOD officials conducted a survey at the 30 selected locations to obtain information from installation officials on how they implement corrosion prevention, control, and mitigation strategies in their facilities and infrastructure, and examined program documentation including maintenance and facility engineering processes related to corrosion prevention and mitigation. The report noted that while most survey responses were location-specific, the responses from installation officials were also indicative of the across-the-board issues that most installations experience regardless of service, installation mission, or geographic location, such as use of criteria, training, and communication. For example, installation officials stated that they use aggressive preventive maintenance programs to ensure early detection of deficiencies and reduce corrosion deterioration, and request engineering analysis and potential solutions to address any critical issues about the extent of corrosion at facilities and infrastructure. Regarding maintenance and facility engineering documentation and processes, the report noted maintenance-related corrosion

¹⁵The environmental severity index is derived from a database developed by the research firm Battelle with the corrosion rates of various metals exposed to different environmental conditions found at military bases throughout the world. The DOD Corrosion Office, for its fiscal year 2012 cost of corrosion study of DOD facilities and other infrastructure, used corrosion rates for steel and developed an environmental severity index on a scale of 1 through 20 to show the impact of corrosion in different locations, with 1 being least severe and 20 being the most severe environmental conditions.

¹⁶See enc. III for DOD’s 30 selected sites and their assigned Environmental Severity Index zone.

¹⁷According to DOD officials, they were able to visit only 15 of the 30 locations because of time and resource constraints.

policies issued by each military service, such as a Navy instruction that identifies operations and maintenance related to facilities and infrastructure; an Air Force instruction that assigns maintenance responsibilities and requirements for electrical grounding systems on Air Force installations; Army technical manuals that address a broad range of facilities and infrastructure–related design, engineering and problem solving related to corrosion issues; and a Marine Corps standard that focuses on engineering and construction requirements.

DOD also identified and reported installation officials' concerns, such as the need for additional training and communication, as well as funds to implement new technology. DOD noted that large numbers of facilities and infrastructure professionals, including those with corrosion expertise, are eligible to retire, leading to a need to address training and knowledge transfer before those professionals retire. DOD's report identified a lack of communication among facilities and infrastructure professionals.¹⁸ DOD also noted effective communication is necessary to assist with knowledge transfer, and to expand the use of best practices, latest technologies, and criteria. Additionally, DOD found that installation officials are reluctant to implement technologies, except for the most mature, because of the inherent risk of failure and fear of losing scarce resources.

Agency Comments

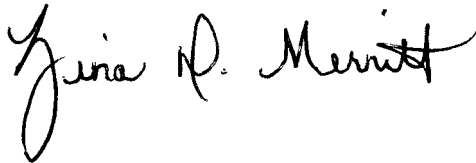
We are not making recommendations in this report. We provided a draft of this report to DOD for advance review and comment. DOD provided technical comments, which we incorporated as appropriate.

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We are sending copies of this report to the appropriate congressional committees and to the Secretary of Defense. Also, the report is available at no charge on the GAO website at <http://www.gao.gov>.

¹⁸In GAO-13-270, we found communication issues within the facilities and infrastructure community including that many relevant service officials did not receive key corrosion-control information because their Corrosion Control and Prevention Executives did not have targeted communication strategies and accompanying action plans.

Should you or your staff have questions concerning this report, please contact me at (202) 512-5257 or merrittz@gao.gov. Key contributors to this report were Carleen Bennett, Assistant Director; Mark Wielgoszynski, Assistant Director; Clarine Allen; Mark Dowling; Nicole Harris; Carol Petersen; Richard Powelson; Terry Richardson; and Amie Steele. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report.

A handwritten signature in black ink, reading "Zina D. Merritt". The signature is written in a cursive style with a large, stylized "Z" and "M".

Zina D. Merritt
Director
Defense Capabilities and Management

Enclosures (3)

List of Committees

The Honorable Carl Levin
Chairman
The Honorable James Inhofe
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Tim Johnson
Chairman
The Honorable Mark Kirk
Ranking Member
Subcommittee on Military Construction, Veterans Affairs and Related Agencies
Committee on Appropriations
United States Senate

The Honorable Howard P. "Buck" McKeon
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable John Culberson
Chairman
The Honorable Sanford D. Bishop, Jr.
Ranking Member
Subcommittee on Military Construction, Veterans Affairs, and Related Agencies
Committee on Appropriations
House of Representatives

Enclosure I: Department of Defense’s Cost Drivers of Corrosion Spending

To identify key cost drivers, the Department of Defense (DOD) sent questionnaires to installation officials at the 30 selected sites to obtain their perspectives on the root causes of corrosion spending. The responses identified 36 objects (DOD’s report refers to them as “unique maintenance objects”) that DOD identified as cost drivers for corrosion (see table 1).¹⁹

Table 1: List of Objects That the Department of Defense (DOD) Identified as Cost Drivers Related to Corrosion at Facilities and Infrastructure

♦ Boiler, heat exchange	♦ Fuel distribution	♦ Plumbing
♦ Bridge	♦ Fuel storage	♦ Roof
♦ Building exterior—paint	♦ Generator	♦ Signage
♦ Compressor	♦ Hot water tank	♦ Spillway
♦ Cooling, chiller	♦ HVAC ^a	♦ Staircase
♦ Culvert, ditch	♦ Hydrant	♦ Steam and distribution
♦ Electrical enclosure	♦ Insulation	♦ Swimming pool buildings
♦ Exterior electric	♦ Ladder	♦ Tank, tower
♦ External facilities, structure	♦ Lighting, etc.	♦ Valve
♦ Facility age ^b	♦ Mold	♦ Wash rack
♦ Fence	♦ Nonpotable water storage and distribution	♦ Water pipe
♦ Fire suppression	♦ Pavement, concrete	♦ Waterfront ^c

Source: DOD.

Notes: Data are from Department of Defense, *Department of Defense Facilities and Infrastructure Corrosion Evaluation Study Final Report* (Washington, D.C.: July 11, 2013).

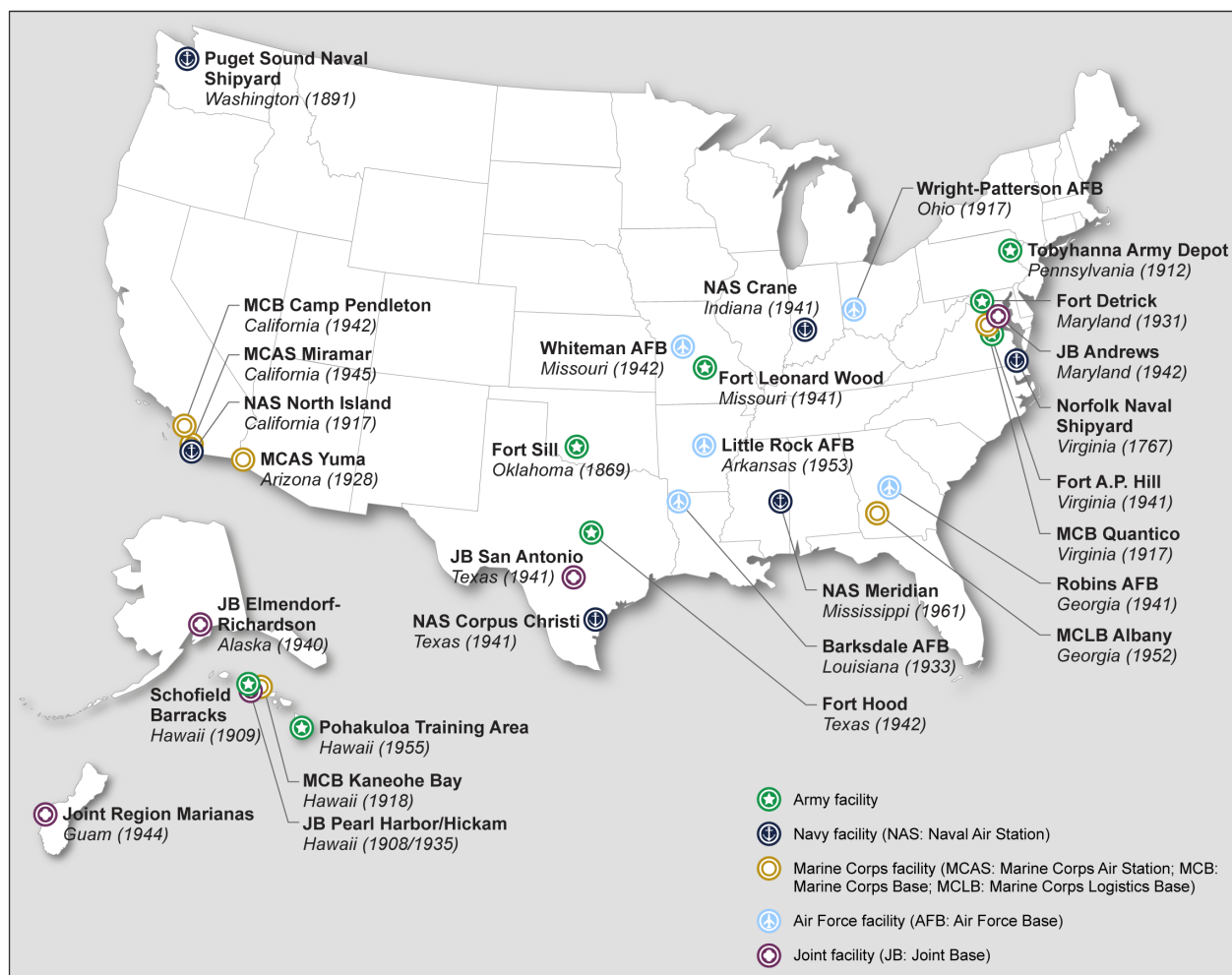
^aHVAC: heating, ventilation, and air conditioning.

^bDOD’s report notes that because age is not an object that can be maintained, age-related costs cannot be isolated from the other 35 objects. As such, DOD’s 36 objects include equipment, facilities and other infrastructure at which corrosion costs are occurring as well as factors that may influence (or drive) corrosion costs.

^cWaterfront includes dry docks, piers, and wharfs.

¹⁹DOD’s 36 objects include equipment, facilities, and other infrastructure at which corrosion costs are occurring as well as factors that may influence or drive corrosion costs.

Enclosure II: Locations Selected for the Department of Defense's Facilities and Infrastructure Corrosion Study, by Location, Military Department, and Date of Establishment



Source: GAO analysis of *Department of Defense Facilities and Infrastructure Corrosion Evaluation Study Final Report* (Washington, D.C.: July 11, 2013); Map Resources (map).

Note: Dates listed indicate the date that the installation was established.

Enclosure III: Sites Selected by the Department of Defense and their Assigned Environmental Severity Index Zone

Sites Selected for Department of Defense (DOD) Study	Assigned Environmental Severity Index (ESI) Zone ^a
Fort A.P. Hill, Virginia	8
Fort Detrick, Maryland	7
Fort Hood, Texas	6
Fort Leonard Wood, Missouri	5
Fort Sill, Oklahoma	5
Pohakuloa Training Area, Hawaii	2
Schofield Barracks, Hawaii	19
Tobyhanna Army Depot, Pennsylvania	6
Naval Air Station Corpus Christi, Texas	19
Naval Air Station Crane, Indiana	8
Naval Air Station Meridian, Mississippi	5
Naval Air Station North Island, California	14
Norfolk Naval Shipyard, Virginia	11
Puget Sound Naval Shipyard, Washington	18
Marine Corps Air Station Miramar, California	6
Marine Corps Air Station Yuma, Arizona	1
Marine Corps Base Camp Pendleton, California	14
Marine Corps Base Kaneohe Bay, Hawaii	19
Marine Corps Base Quantico, Virginia	8
Marine Corps Logistics Base Albany, Georgia	8
Barksdale Air Force Base, Louisiana	9
Little Rock Air Force Base, Arkansas	7
Robins Air Force Base, Georgia	10
Whiteman Air Force Base, Missouri	7
Wright-Patterson Air Force Base, Ohio	9
Joint Base Andrews (U.S. Air Force), Maryland	7
Joint Base Elmendorf-Richardson (U.S. Air Force), Alaska	2
Joint Region Marianas (U.S. Navy), Guam	19
Joint Base Pearl Harbor/Hickam (U.S. Navy), Hawaii	19
Joint Base San Antonio (U.S. Air Force), Texas	6

Source: DOD.

Note: Data are from Department of Defense, *Department of Defense Facilities and Infrastructure Corrosion Evaluation Study Final Report* (Washington, D.C.: July 11, 2013).

^a The Corrosion Office provided an environmental severity index zone for each installation. The environmental severity index is derived from a database developed by the research firm Battelle with the corrosion rates of various metals exposed to different environmental conditions found at military bases throughout the world. The DOD Corrosion Office, for its fiscal year 2012 cost of corrosion study of DOD facilities and other infrastructure, used corrosion rates for steel and developed an environmental severity index on a scale of 1 through 20 to show the impact of corrosion in different locations, with 1 being least severe and 20 being the most severe environmental conditions.

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