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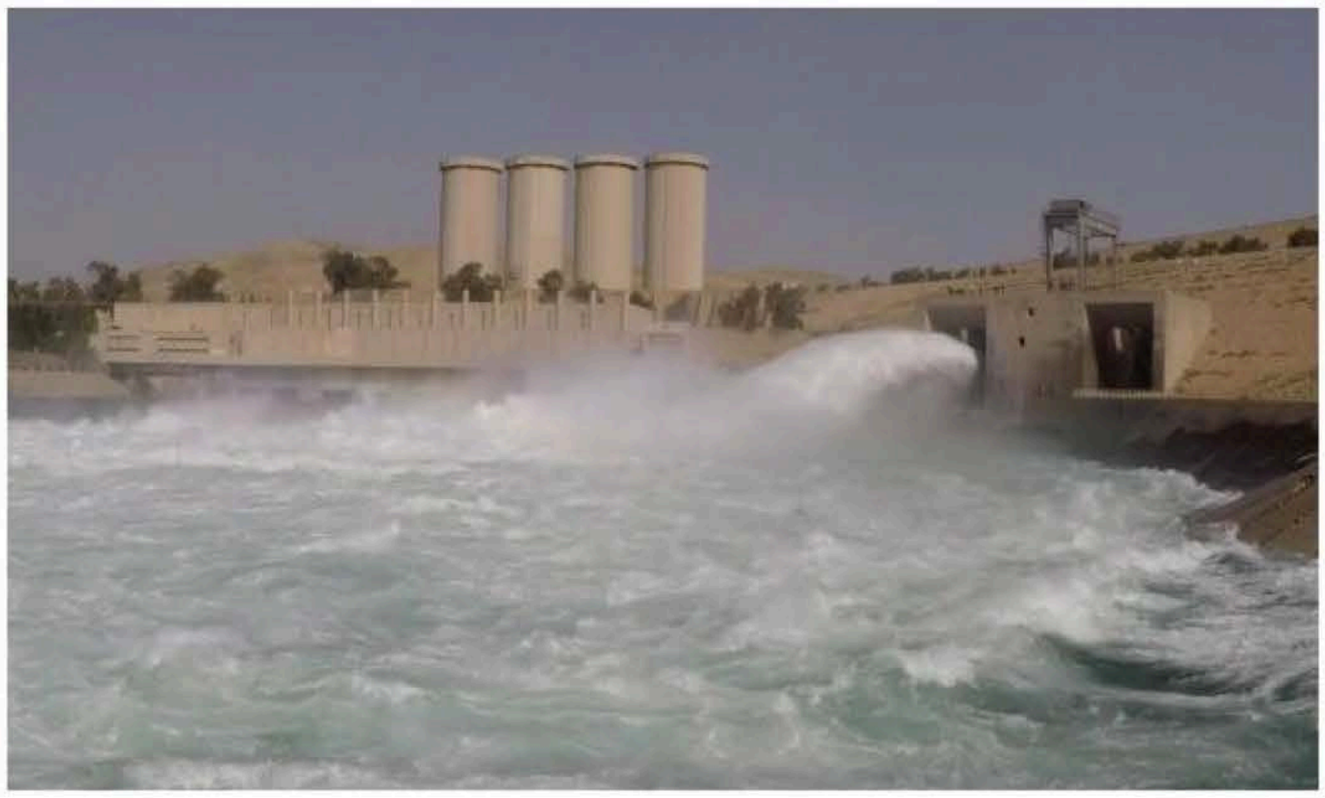

CONTENTS

INTERVIEW WITH LT. GEN. TODD SEMONITE **10**
USACE Commanding General and Chief of Engineers
BY BILL COSTLOW, USACE Headquarters

MANAGING THE 2019 FLOOD EVENTS: DIVISION HIGHLIGHTS **18**
BY LOUIE WEIN, USACE Headquarters

MOSUL DAM TASK FORCE DECLARES "MISSION COMPLETE," DEPARTS IRAQ **28**
BY MOSUL DAM TASK FORCE PROGRAM OFFICE

DIVISIONS

NORTH ATLANTIC DIVISION **34**

GREAT LAKES AND OHIO RIVER DIVISION **44**

MISSISSIPPI VALLEY DIVISION **56**

SOUTH ATLANTIC DIVISION **66**

SOUTHWESTERN DIVISION **76**

NORTHWESTERN DIVISION **86**

SOUTH PACIFIC DIVISION **96**

MOSUL DAM TASK FORCE DECLARES "MISSION COMPLETE," DEPARTS IRAQ

BY MOSUL DAM TASK FORCE PROGRAM OFFICE

After nearly three years in Iraq, the Mosul Dam Task Force (MDTF) declared "mission complete" on July 4, 2019.

MDTF deployed to Mosul Dam in September 2016 at the request of the government of Iraq. The dam was built on a foundation with a geology that continues to dissolve and after decades of conflict and deferred maintenance, the dam's collapse loomed as a humanitarian crisis that threatened regional stability. The MDTF's job was to serve as "the engineer," providing engineering and technical expertise for a contract between the Iraqi government and Italian contractor Trevi S.p.A. to repair and stabilize the dam.

Col. Philip Secrist assumed command of the MDTF in June 2019 from Col. Michael Farrell, the initial MDTF commander. Throughout the project's life cycle, the MDTF was comprised of 50-70 Soldiers, U.S. Army Corps of Engineers (USACE) civilians, AECOM employees, and Iraqi engineers provided by Versar, Inc., working on site at the dam. An equal number of USACE and AECOM employees provided technical support from the United States via reachback, minimizing the number of workers required on site in Iraq.

The MDTF objective was "not to depart Iraq until we were confident a sufficiently resourced and well-informed Ministry of Water Resources [MoWR] was fully capable of executing an improved maintenance drilling and grouting [D&G] program that sustains the integrity of the Mosul Dam grout curtain until a permanent solution is implemented," according to Secrist.

"After two-and-a-half years of drilling and grouting operations 24 hours a day, six days a week, we are confident the dam's foundation stability has been significantly improved. Additionally, the MoWR Mosul Dam Project Office staff is trained on state-of-the-art drilling and grouting procedures, and they have the equipment and materials necessary to maintain the dam for years to come," Secrist said.

WORLD-CLASS DELIVERY

The original one-year contract to stabilize Mosul Dam's foundation consisted of a double-row grout curtain across the entire 3.2 kilometers of the dam from both the grouting gallery and the east and west crest. It also included repairs to the bottom outlet works that are critical to the dam's ability to discharge water into the Tigris River. The initial contract was modified twice and resulted in an end to contracted D&G operations in July 2019.

USACE faced significant challenges directing the D&G operations at Mosul Dam. A typical project requires years of investigations and studies prior to developing a repair strategy and awarding a construction contract. However, the Iraqi government believed Mosul Dam faced imminent failure and emergency repairs had to begin immediately. Professional geologists and dam safety engineers developed method statements and learned how to treat the complex Mosul Dam foundation in the field while executing the D&G program. Additionally, Trevi installed a new grouting program, "T-grout," that enabled monitoring of all grouting activities in the dam. T-Grout collected pressure, depth, grout quantity, and artesian pressure information at every 5- to 10-meter stage for each borehole.

IMPROVED STABILITY

Production D&G began in January 2017 and became the largest ongoing dam safety D&G operation in the world. Simultaneous to the D&G, Trevi installed 62 miles of electrical infrastructure, 9.6 miles of piping, and 2 miles of new communications lines due to the dam's infrastructure being original to the project and not capable of supporting the huge D&G operations. Over the course of the MDTF, Trevi-MoWR crews drilled and grouted 5,200 boreholes, resulting in 400,000 meters drilled, and placed more than 41,000 cubic meters of grout in Mosul Dam's foundation. Mosul Dam's improved stability was demonstrated as its reservoir reached its sixth-highest pool of record in April 2019 and showed no signs of distress.

The initial D&G priorities (2017-2018) were based on a potential failure mode analysis (PFMA) developed for Mosul Dam in 2016. The PFMA recommended gallery and surface grouting be focused on five priority areas (right and left abutments, in the foundations beneath the historical Tigris River flow, and around the two bottom outlet tunnels), with the intention of grouting all areas of the foundation beneath the embankment. For the second phase of the contract (2018-2019), USACE identified 34 critical D&G priorities and 36 additional dam safety recommendations. All 34 critical priorities were completed along with 33 of the dam safety recommendations.

PHOTO COURTESY OF TRANSATLANTIC DIVISION

Mosul Dam, with its hydropower plant and four water storage towers, sits in a valley along the Tigris River 30 miles outside Mosul City in Iraq. It is the largest dam in Iraq and the fourth largest in the Middle East and supplies water, hydropower, irrigation, and flood control to the region. The governments of Iraq, Italy, and the United States have combined their efforts to stabilize Mosul Dam.

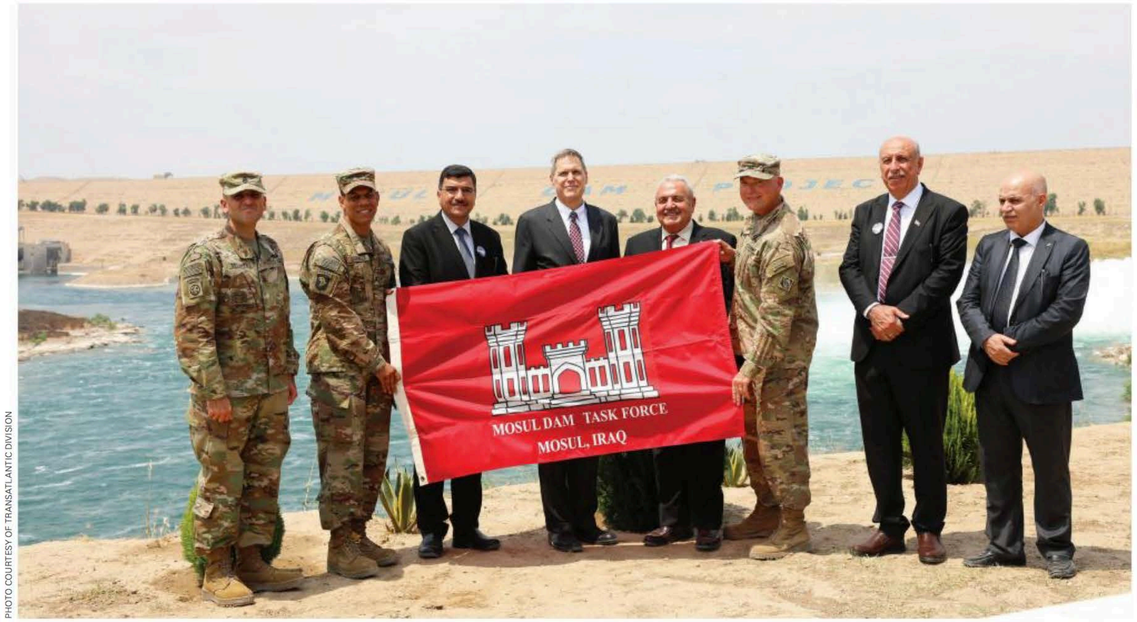

PHOTO COURTESY OF TRANSATLANTIC DIVISION

Participants celebrate the completion of the Mosul Dam Task Force (MDTF) mission on the bank of the Tigris River. Pictured left to right are: USACE TAD Command Sgt. Maj. Randolph Delapena; former TAD Commander Col. Mark Quander; Iraq MoWR Director General Mahdi Rashid; U.S. Ambassador to Iraq Matthew H. Tueller; Iraq Water Resources Minister Jamal al-Adili; MDTF Commander Col. Philip Secrist; Mosul Dam Project Manager Riyadh Ali; and Jamal Mohsin, Iraq director general of Planning and Follow-up. The dignitaries visited the MDTF on June 15, 2019, for a ceremony commemorating the completion of the Mosul Dam Project.

INFRASTRUCTURE REPAIR AND IMPROVEMENTS

Repairs to the bottom outlets began immediately upon the arrival of the MDTF. The MoWR had not been able to use the west bottom outlet tunnel for several years because the intake gate was jammed by a 34-foot-long bent indicator rod. By the end of the project, indicator rods in both bottom outlet tunnels had been replaced with mechanical improvements to prevent a similar failure in the future. Another major improvement to the bottom outlet works was the design and construction of hydraulic dentates at the bottom outlet tunnel exits to reduce backward erosion into the dam's foundation caused by the energy of the water flow. The bottom outlet works are now ready to serve Mosul Dam for years to come.

"Mosul Dam is now one of the most instrumented dams in the world," Secrist said. "When USACE arrived at Mosul Dam in 2016, the [MoWR] had 250-plus instruments that had to be manually read. Today, Mosul Dam has over 720 instruments of which over 500 are automated and can be viewed online in near real time." Mosul Dam's upgraded instrumentation system is critical in that it provides the MoWR the data needed to understand how well the dam's foundation is performing and where to conduct future grouting operations.

MODERN EQUIPMENT PROCUREMENT

To execute improved D&G operations, the procurement of new equipment was critical. Two old grout mixing plants in various states of disrepair were replaced with three new mixing plants capable of providing 24/7 grout production. Eight old drill rigs were augmented with 18 new state-of-the-art drill rigs. MoWR production was limited with only three batch grouting units (BGUs) required to adjust grout composition at each specific hole. Now the MoWR has 32 modern BGUs. Finally, "through the contract procurement process, the MoWR now has approximately three to five years' [worth] of spare parts and five-plus years of grouting consumable materials on site and ready for use," said Secrist.

STRENGTHENING THE CAPABILITIES OF IRAQ'S MINISTRY OF WATER RESOURCES

Getting to "mission complete" required a lot of time, sweat, and the implementation of an integration program that resulted in the hands-on training and validation of 245 MoWR employees.

Following the formation of the Mosul Dam Task Force, the need for MoWR employees to work alongside Trevi in all operations on Mosul Dam was recognized. Trevi partnered with USACE to develop a training and integration program that assimilated MoWR employees into the project's D&G works. The objective was to build Iraqi capacity to conduct maintenance D&G using the latest technologies. The Integration Program was launched initially in November 2016, with 26 MoWR employees working in two shifts, seven hours each. Additional employees were added over time, and within a

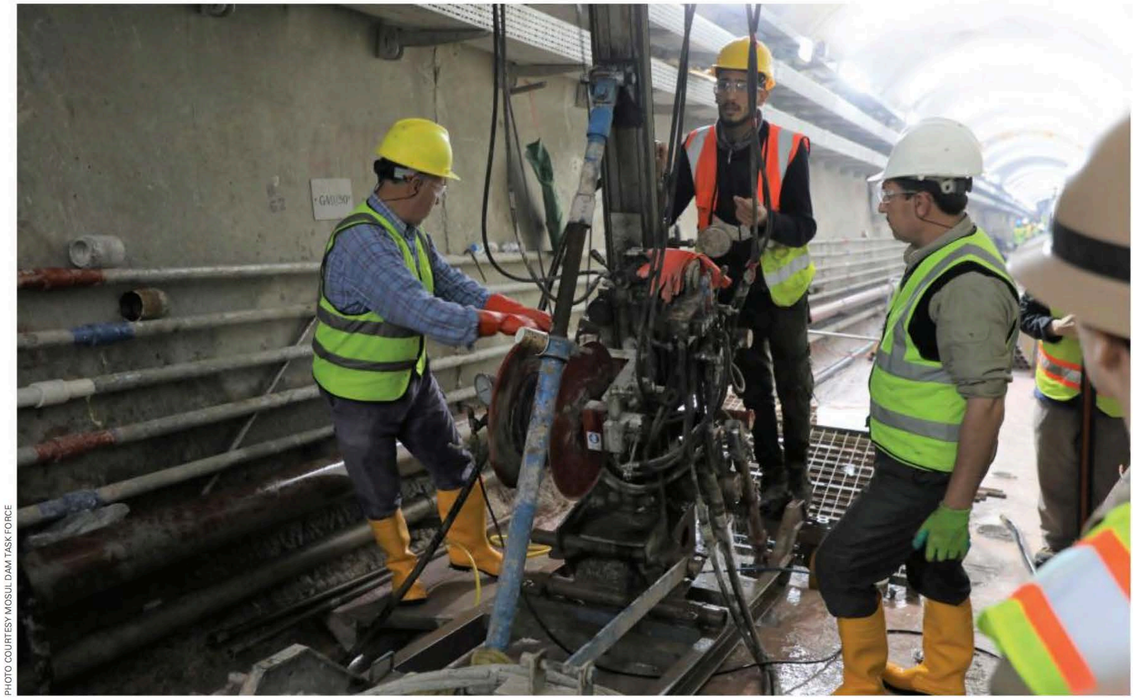

PHOTO COURTESY MOSUL DAM TASK FORCE

Team members from Versar, Inc., and the Ministry of Water Resources of Iraq work together, drilling a grout hole inside the grout tunnel at Mosul Dam.

month, there were 115 MoWR employees integrated with Trevi working two 12-hour shifts, six days a week.

In July 2018, the Integration Program was formalized and the MoWR integration staff immediately expanded to 155 employees working alongside Trevi on the dam and support areas, including the control room, laboratory, main mixing plants, warehouse, and workshop. MoWR and Trevi worked together to integrate additional employees each month, and by the end of the project, the number of operational staff had increased to 225.

An Engineer Integration Program was initiated in August 2018 so engineers and technical specialists could work side by side with their USACE and AECOM counterparts in specialties such as dam safety, quality assurance, instrumentation, and geospatial information systems. Throughout the project, the MoWR's hands-on experience was reinforced with workshops and training courses in specific areas including Instrumentation, dam safety, mix design, water pressure testing, optical televiewer operations, and geology.

Following the success of the integration programs, the MDTF took the teamwork approach to the next level and identified MoWR-only critical organizations/functions (COFs) required to maintain Mosul Dam. The COFs marked the transition from MoWR employees performing as individuals to performing cohesively as teams. As work proceeded, MoWR COFs took progressively more responsibility across all aspects of the project.

During the last month of the project, the MoWR COFs operated as a "closed loop," with MoWR operators, helpers, geologists, foremen, tablet operators, control room operators, and workshop maintenance crews coordinating efforts with minimal Trevi and USACE intervention. All COFs were validated by USACE, as they demonstrated proficiency to operate independently.

USACE GLOBAL IMPACT

The accomplishments of the Mosul Dam Task Force over the past three years changed Mosul Dam from being known as the "world's most-dangerous dam" to a dam that saw its sixth-highest pool of record this past spring and showed no signs of distress. MDTF's dedicated team of Soldiers, Department of Army civilians, and contractors, working side by side with Trevi and Iraq's Ministry of Water Resources, delivered the world's largest dam safety drilling and grouting project. More importantly, the Mosul Dam Task Force ensured that almost 250 MoWR workers, technicians, and engineers completed an intense training program to develop their skills to properly maintain Mosul Dam in the future.

"The MDTF is just another example of how USACE is working with our partners around the globe to develop innovative solutions aimed at strengthening partner-nation capacity to address resource security and disaster risk management challenges, which are critical to achieving state and regional stability, sustainability, and economic development," Secrist said. ■