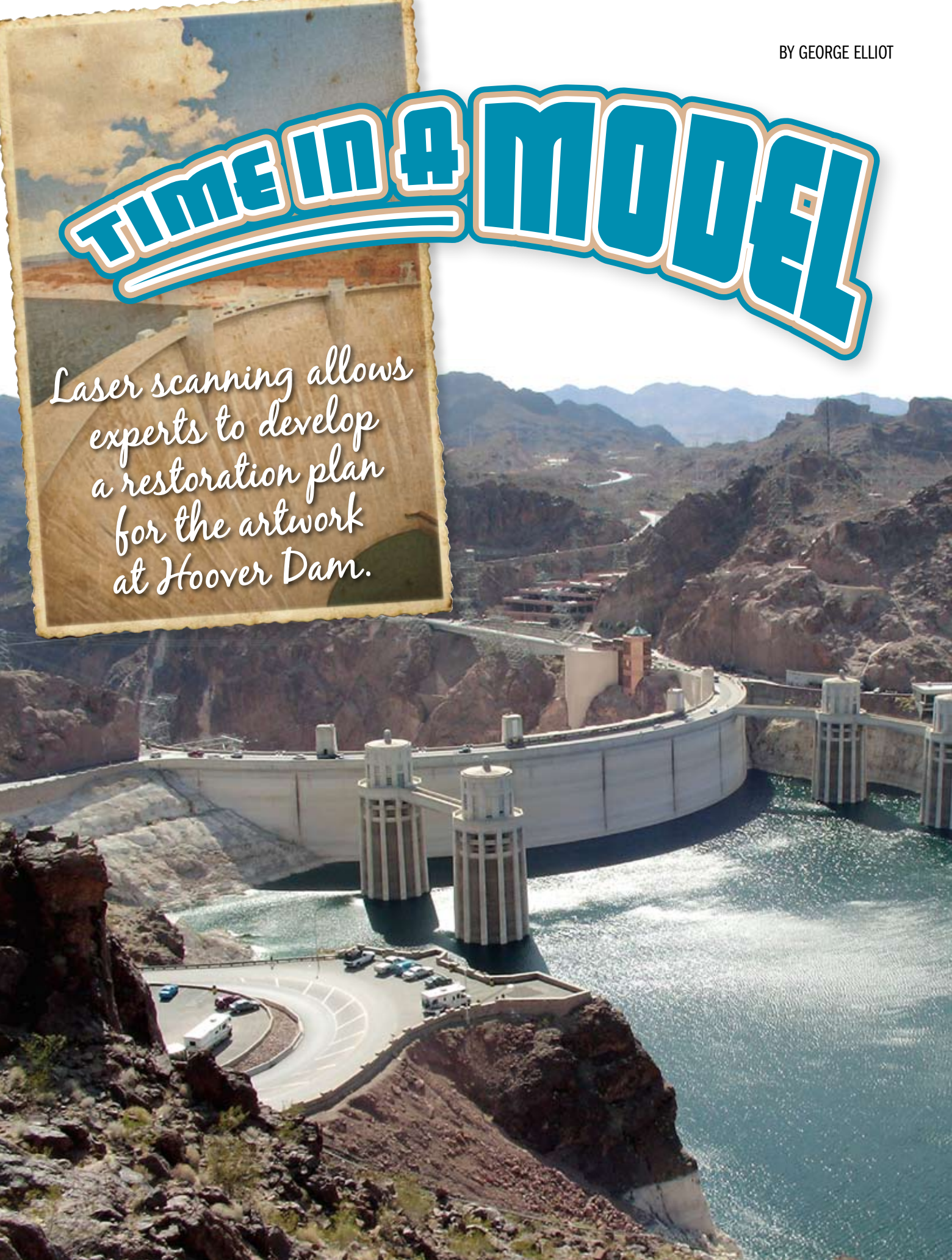
BY GEORGE ELLIOT

TIME IN A MODEL

Laser scanning allows experts to develop a restoration plan for the artwork at Hoover Dam.



An estimated three million visitors each year take the opportunity to stand on top of the magnificent Hoover Dam. For many, an unexpected highlight of that visit is a walk around the exhibit area commonly called Monument Plaza to admire the beautiful artwork. From the statuesque Winged Figures of the Republic to the inlaid celestial map, the artwork reflects the creativity and determination of those who constructed Hoover Dam almost 75 years ago.

In recent years, the sculptures and other artwork have begun to show signs of wear as a result of weather, pedestrian traffic and age. Since Hoover Dam is a National Historic Landmark, the Bureau of Reclamation is charged with the care of these treasures. "It's a significant challenge," says Ken Rice, the area manager for Reclamation's Lower Colorado Dams Office, which oversees Hoover Dam. "If we take the 'do nothing' approach, the plaza will continue to deteriorate. Yet, if we elect to repair the plaza, and those repairs are extensive and/or carried out in an insensitive manner, we could create an adverse impact, as well. It's imperative that we gather as much information as possible about the existing conditions and fully understand the reasons for deterioration before making a decision on how to proceed."

Built soon after Hoover Dam's completion, historic Monument Plaza is showing signs of age. The Bureau of Reclamation looked to noninvasive, nondestructive laser scanning technology to gather as-built conditions.

A Path to Restoration

The Winged Figures of the Republic are the two most prominent sculptures in the plaza. At 30 feet high, the figures contain more than four tons of statuary bronze. They rest on a base of black diorite set atop a terrazzo floor. The floor is inlaid with a celestial map that pinpoints the precise astronomical time when Franklin Delano Roosevelt dedicated the dam–Sept. 30, 1935, 8:56 p.m. Near the figures and elevated above the floor is a compass that is framed by the signs of the zodiac. There is also a nearby plaque commemorating the 96 men who died during construction of the dam.

The terrazzo floor is cracking and showing weather damage. The Winged Figures are patinated and appear to be aging well. However, other bronze features on the plaza are cracking and showing wear, and some are missing pieces.

In 2008, Reclamation received Southern Nevada Public Lands Management Act (SNPLMA) funding to conduct a pre-proposal planning (PPP) effort to analyze the plaza. The objective of this PPP was to assess the plaza's condition, explore options and costs for repair, and analyze a range of alternatives for repairing the plaza in consultation with the National Historic Landmarks Program, the Nevada and Arizona State Historic Preservation Office (SHPO), the Advisory Council on Historic Preservation, and interested members of the public.

Survey Solution Alternatives

With the funding secured and preliminary research complete, Reclamation looked to its Engineering Services Office to develop a detailed as-built model of the plaza. The agency had a few stipulations with regard to the data gathering methodology. The process had to be noninvasive, and the surveyors had to gather data without impeding visitors. Shutting down the plaza for the survey was not an option.

GNSS seemed like an obvious choice because of its light weight and transportability, but the plaza sits against a canyon wall that blocks the line of sight. "We could have worked around this problem, except the times available for the satellites just didn't synchronize with our schedule," explains Alejandro Orosco, LSI, surveyor with the Engineering Services Office. "Total stations would have worked as well but didn't provide the scope of data we needed to gather for the study."

Ultimately, Orosco and his team opted to try laser scanning. "We selected laser scanning because of the technology's overall price, performance and ability to integrate with our existing software and hardware inventory," Orosco explains. "The cost of laser scanning was slightly higher than a conventional survey that relied on traditional tools such as total stations and GPS. However, the added value we gained from mining the laser scanning data made it a better choice."

After looking at several systems, the team purchased a Leica ScanStation 2 scan-

With a detailed 3D model laser-scanned to engineering accuracy, Reclamation and its consultants are able evaluate structural deterioration of Monument Plaza and determine an effective plan for rehabilitation.

ner from Leica Geosystems because it met the agency's budget constraints and could be easily integrated into existing operations. The surveyors also used Leica TPS 1201 total stations to measure crack propagation over the course of the year-long project.

Scanning in Shadow

Monument Plaza is approximately 90 feet by 38 feet. To ensure full coverage, the surveyors mounted the scanner on a tripod that rises 15 feet above the ground and then moved it as needed to gather a full depth of field. The biggest challenge was time. "We needed to ensure that the scan captured all the details on the floor and islands that are in the plaza," Orosco recalls. "Visiting patrons start arriving at about 9:00 a.m."

The canyon wall casts a shadow over the plaza during the early hours of the day, which affects the quality of the pictures taken by the scanner. As pedestrian traffic increased on the plaza, it would block the scanner from picking up the smaller pieces that lie on the terrazzo floor. The surveyors found that they needed to perform scans from three different positions to gather all the necessary data. "The equipment (both hardware and software) was easy to use. The only minor inconvenience was the setup of the 25 pound scanner on a tripod," Orosco says.

At the end of each day, the team performed quality assurance/quality control checks of the scans to identify excesses or deficiencies in the datasets. For instance, the terrazzo includes small stars, planets and inscriptions that depict a constellation, and some pieces are 2 inches or less in diameter. "A patron walking could cover one of these items with their foot, preventing the scanner from capturing the targeted piece," Orosco explains.

Orosco's team gathered over two million data points in four days. They used the Leica Cyclone 3D point cloud processing software to manage most of the point cloud data and Leica CloudWorx to translate data into Autodesk's Civil 3D application.

Restoration Recommendations

To date, the entire surface area of Monument Plaza has been surveyed twice–once in the summer and once in the winter. "The results are impressive," Orosco says. "In a very short time, we have created a baseline 3D model of Monument Plaza that is helping us evaluate structural changes in a clear visual manner. The scanner's capabilities have allowed us to cut down on field labor costs, and the capture of additional data has been extremely useful for Reclamation clients."

Reclamation and its partners are able to view and study the model using the free Leica TruView software. The software allows users to zoom in and out and rotate the 3D model of the plaza, measure distances, extract 3D coordinates, and create markups and hyperlinks.

Reclamation expects to contract an expert to review the facility history, scanner and survey data, and perhaps do some additional nondestructive geophysical exploration and core sampling in the next few months. With the consultant's recommendations and assistance, the agency can develop a plan for returning the plaza to its original condition.

George Elliot is a freelance writer specializing in land surveying, GIS and laser scanning technology. He can be reached at 770/326-9557. For more information about Hoover Dam, visit www.usbr.gov/lc/hooverdam. Additional details about scanning equipment and software can be found at www.leica-geosystems.us.