

Digging Deep to Repair Critical Levee System

GIS/GPS technology plays key role in Natomas Levee Improvement Program.

By Mark H. Stanley

In 2006, California Governor Arnold Schwarzenegger declared a state of emergency for California's extensive, complex and vital levee system in response to safety concerns identified by federal, state, and local agencies. Reports indicated that many of the state's 100-year old levees, canals, and flood-control features (more than 6,000 miles) are in danger of Hurricane Katrina-like failure.

In particular, the Natomas Basin near Sacramento was deemed an urban area with the nationally highest risk of flooding during a major weather event. During an extreme weather event, the potential depth of flooding is over 20 ft, impacting more than 53,000 acres and a population of over 70,000.

In 2006, the U.S. Army Corps of Engineers (USACE) Sacramento District informed FEMA that the Natomas Basin levees did not provide a

100-year level of flood protection. As a result, FEMA published new flood-zone maps that became effective in December 2008. The subsequent rezoning led to flood insurance requirements for existing residents and a de facto moratorium on all building permits in the area.

To expedite repair and rehabilitation of the levees, the Sacramento Area Flood Control Agency (SAFCA) initiated the Natomas Levee Improvement Program (NLIP), a \$618-million project to evaluate and rehabilitate all 42 miles of the Natomas levee system in just seven years. The goal of the NLIP is to provide 100-year protection as quickly as possible (with a target of 50 percent of the levees by 2011) and 200-year protection for all levees by 2013.

To complete the project on time and within budget, the project team must rely on a wide range of capabilities, including customized GIS and GPS technologies as well as conventional and advanced analysis techniques for speedy and cost-effective environmental clearance work and geotechnical field explorations.

Along the Natomas

The NLIP site footprint includes 700 parcels of land around the perimeter of the basin. The flood protection system is composed of several major components: the Sacramento River East Levee (SREL, about 18 miles), the Natomas Cross Canal South Levee (about five miles), the American River North Levee (about two miles), and the Natomas East Main Drainage Canal West Levee (about 13 miles) with the Pleasant Grove Creek Canal West Levee (about three miles). For the purpose of levee evaluation, the project team divided the

levee into several analysis reaches. In some cases, these reaches have been further subdivided into subreaches based upon a combination of subsurface conditions and existing levee features. Also, the SREL project has been divided into four separate construction phases.

Over the last two years, the NLIP design and geotechnical evaluation team has gathered historical study data and performed a site characterization study on every levee in the Natomas Basin to develop and analyze design alternatives based on cost, environmental impacts, and property impacts. Site characterization studies included information from borings, CPTs, ground-based electrical resistivity, test pits, seismic refraction and pumping tests. In addition, the California Department of Water Resources (DWR) conducted helicopter-based, electromagnetic (HEM) site-characterization surveys, which were utilized as part of the evaluation.

The levees in the Central Valley have been constructed across many ancient and geologically recent abandoned river and creek channels that have formed in the complex Sacramento Valley. The channels provide seepage pathways beneath the levees, which can cause destabilizing conditions. Therefore, identifying the abandoned channels is critical to the levee rehabilitation program. Several geomorphic studies have been performed to identify these abandoned river and creek channels. These studies reviewed and compared historical topographic maps and aerial photographs with current topographic maps, aerial photographs, and geologic and soil maps. The results of these geomorphic studies were then compared to existing boring logs, electrical resistivity,



A triple auger DSM rig installs a cutoff wall.



Mixing of the soil-cement-bentonite cutoff wall.

and HEM surveys to develop subsurface geologic models including identification of buried channels. These models were then used to support seepage and stability models and to identify and design mitigations of potentially unstable sections of the levees.

Due to the size of the NLIP site, GIS and database technology were necessary to ensure that Kleinfelder (www.kleinfelder.com) engineers will be able to fast-track the levee investigations. The team had GIS data available to them via a networked ESRI ArcGIS-driven (www.esri.com) server database. This allowed the project team to access GIS and CAD data in various viewers and the associated information with no delay.

The ArcGIS server database consisted of completed and proposed exploration locations, project stationing, coordinates, property access issues, and various other pieces of critical information. The ability to integrate historic information from past projects in the area and CAD data, including ground survey information and design drawings, created a powerful and flexible GIS system. Everyone on the Kleinfelder team, from engineers to field staff, could access digital maps via Desktop GIS (ArcGIS/ArcReader) and browser-based maps, including the ability to produce hardcopy drafts as needed for communication with other team members. The GIS gave other staff besides GIS and CAD the ability to create cross sections, which were easily imported into the

seepage and stability modeling programs.

Field exploration was streamlined utilizing ESRI's ArcPad mobile GIS and GPS field data computers with customized ArcPad Studio interfaces for the NLIP project. The GPS is kept up to date with all proposed explorations for

easy navigation to exploration locations that are often located in the middle of agricultural fields or along miles of levees with little to no landmarks. Accurate field data helped ensure that borings and cone penetration tests placed in certain locations for specific reasons would be drilled within feet of the desired location. Following drilling, coordinate information was collected with the GPS, giving post-processed accuracy of submeter to subfoot accuracy. The precise location was combined with ground survey from the project surveyor for accurate XYZ locations. At the end of the day, the GPS data was downloaded and refreshed with the next day's proposed locations.

The GIS/GPS solution helped save the project team hours of locating exploration sites in the field and reduced the barriers between technical staff and GIS data.

With the initial studies and characterizations nearly completed, Kleinfelder and SAFCA design team members are preparing designs for the remediation of the entire Natomas Basin Levee System with each area being distinctly unique.

The Natomas East Main Drainage Canal West Levee remediation will include a fix-in-place levee with seepage berms or soil-bentonite seepage cutoff walls at former stream crossings. The SREL, on the other hand, will require an adjacent levee to raise the current crest as well as the construction of seepage berms, or soil-bentonite cutoff walls, or both to provide a levee system that

meets USACE and State of California Department of Water Resources levee design criteria. These levees protect the residential community, nearby wildlife habitats, and cultural resources.

The Natomas Cross Canal South Levee design involves degrading the existing levee by half its height, constructing 70-ft deep soil-bentonite slurry cutoff walls, and reconstructing the levees. The levees will be reconstructed to raise the crown elevation three ft above its preconstruction configuration and to flatten the landside slope. The construction of four miles of cutoff walls and levee reconstruction will be completed in November 2009. The American River North Levee improvements are anticipated to include construction of 4,000 lineal ft of soil-bentonite seepage cutoff walls.

The first of the NLIP construction projects began in 2007, with additional work in 2008. Major improvements began in spring 2009 with the \$22-million Natomas Cross Canal Phase 2 and Sacramento River East Levee Phase 1 (Reach 1) improvements. A second \$21-million Sacramento River East Levee Phase 1B (Reach 2-4B) project has been awarded that broke ground in August 2009, to be completed in 2010. Sacramento River Phases 2 and 3 projects are expected to begin construction in 2010.

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DSM rig with an 80-ft mast.