tules TERRESTRIAL & UNDERWATER LEVEE EVALUATION SYSTEM

BACKGROUND

DOER Marine is a robotics engineering firm located in the San Francisco Bay Area, providing specialized solutions for challenging underwater and harsh environment tasks. The basic premise behind the DOER approach to solving these problems is to select the best technology and complementary technologies to accomplish the goals – be they for scientific, engineering, or commercial applications.

Over the past 5 years, awareness about civil infrastructure has increased. Examples of these include underground tunnels, pipelines, aqueducts, dams, bridges, and levees. These are structures that one rarely considers until they fail with devastating results. DOER has worked steadily to adapt both land and ocean sensor technologies for new applications including confined spaces and shallow turbid water.

DOER has completed many challenging tunnel and pipeline inspections, some in excess of 8 miles with real time data, video, gas monitoring, and communications. Utilizing the internet, engineers observe, comment, and recommend from offices without ever traveling to the site. Remotely Operated Vehicles have been used with similar effect in water filled tunnels around the word. Data collected yields valuable information about condition, faults, and expected lifespan.

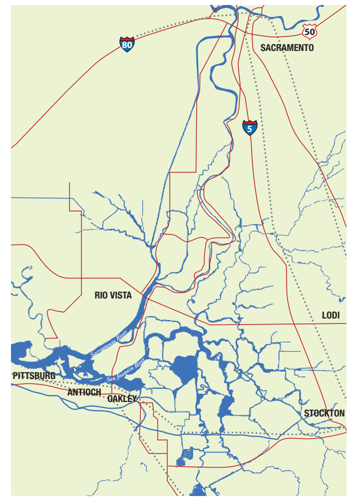
Levees and earthen dams present special problems. Turbid muddy waters, vegetation, mixed or unknown construction, poor access, and environmental concerns have made them difficult to proactively monitor and repair with assurance. In most cases, levee repair means dumping more rock or sandbagging along the top while inspection means drilling cores and noting visual damage. DOER has developed a suite of sensors and vehicle delivery systems that complement and enhance traditional levee inspection protocols. This group is collectively called **TULES**, Terrestrial & Underwater Levee Evaluation Systems.

Utilizing cutting edge technology, the engineering and technical staff at DOER combines sensor technology along with electronic media and integrated software. These components are then incorporated into application specific vehicle platforms capable of accomplishing both internal and external inspection and investigations, yielding in situ data and images. These data sets are then analyzed and post processed into interpretable results that are geo-referenced for future inspection and ongoing monitoring.

By building the data into a Geographical Information System (GIS), engineers, scientists, and policy makers can be provided with the most comprehensive and up-to-date data sets permitting informed decision making and effective resource allocation. Over time, both historical data and visual inspection data can be incorporated, resulting in a fully classified inventory.

RATIONALE BEHIND TULES

As technology has advanced we have seen profound changes in the way we live our lives. Cell phones have changed the way we communicate, the Internet has changed the way we disseminate information, and Magnetic Resonance Imaging (MRI) has changed the way medical testing is done. Our society has embraced preventive diagnosis and non invasive testing for the health of our bodies. A number of these same principals can be applied to the infrastructure we depend upon everyday, identifying decay, averting sudden failure, and targeting repair.



The Sacramento San Joaquin Delta

Armed with facts, engineers, scientists, and policy makers can make informed decisions.

Aging levee systems and dams are all that protect many cities and the vital infrastructure that businesses and homeowners depend upon. All of the experts agree on one thing: these structures will fail given a good nudge. In New Orleans, the oft-predicted "perfect storm" arrived. In California, "the Big One" too will arrive in due course, but without the luxury of a reliable forecasting system. While we cannot predict exactly when and where a major seismic event will occur, we can diagnose the health of a structure. This information can help engineers to predict the ability of a given structure to resist a temblor or other natural forces.

PROJECT TEAM

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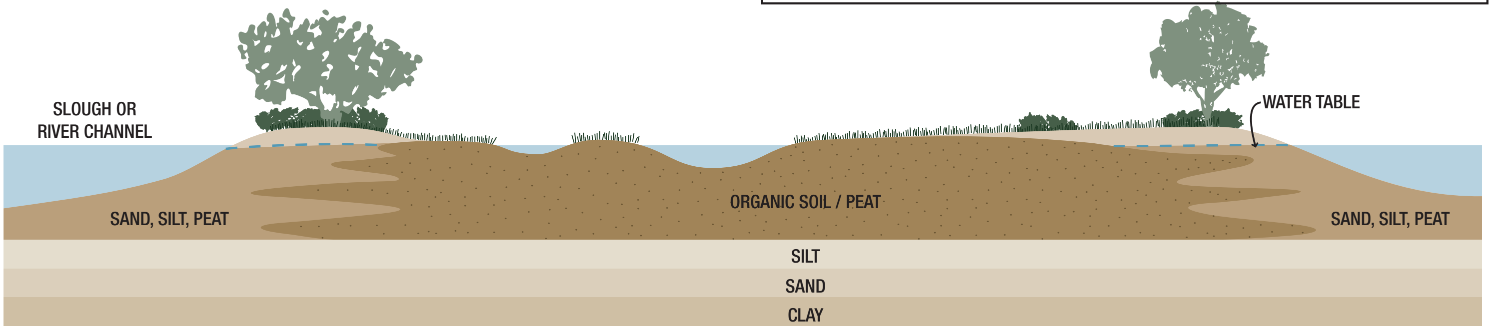
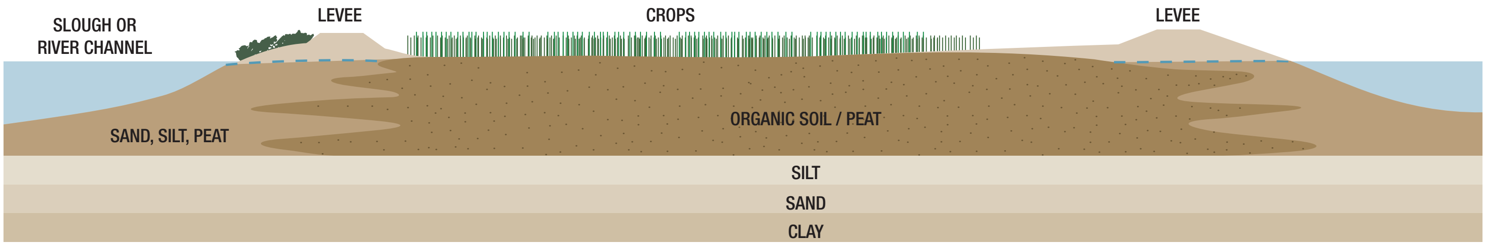
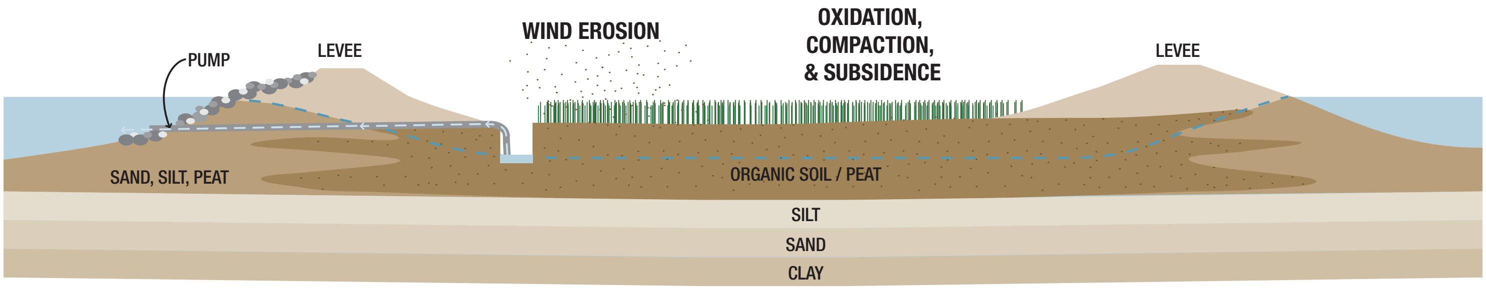
PRE-1850 DELTA: NATURAL LEVEE SYSTEM



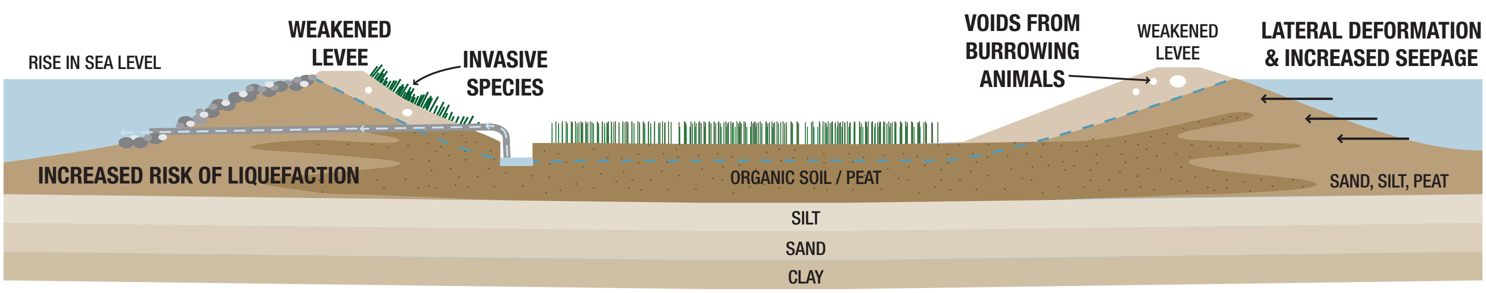
1870s: INITIAL LEVEE CONSTRUCTION



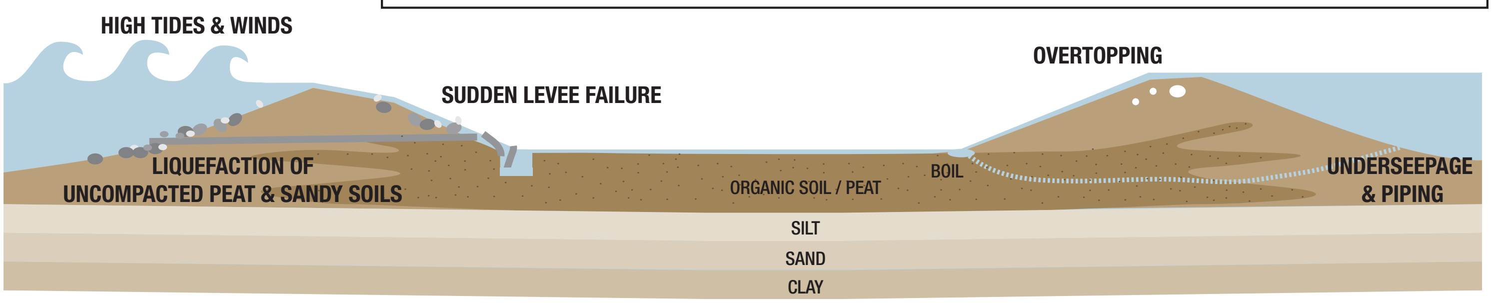
1900s: ISLAND SUBSIDENCE



1900s - 2000s: DECREASED STABILITY



PRESENT: CRITICAL WATER SUPPLIES & STATE ECONOMY AT RISK



Graphics and Layout by Sasaki Associates

Armed with science rather than conjecture, engineers can plan and allocate our limited resources for repair, reinforcement and, in some cases, removal and wetland restoration. The combined sensor technologies that are the heart of TULES provide the multifaceted "whole body" view that some have begun to call, "an MRI for the levees."

"An MRI for the levees."

WHY THIS HAS NOT BEEN DONE BEFORE

Historically, inspections have been conducted by visual observation, noting external surface defects. Destructive testing methods including coring, which provides limited amounts of data from the internal part of a levee, were combined with visual data. This allowed engineers to extrapolate and form best assumptions. This historical data is difficult to access and subject to misinterpretation. Coring, while a valuable tool, is destructive not only to the structure itself, but also to the surrounding environment due to the size and weight of the drilling equipment.

In just the past few years, new technology for securing our borders and harbors has evolved from sensors originally developed for physical oceanography and gas/oil/mineral exploration. Through integrated software and hardware development, these sensors can be applied in ways that were not possible even a year ago. The flexible architecture of TULES can adapt to these changes and is designed to grow and evolve with technology, resulting in sound data and science. From this data, along with visual inspections and targeted "ground truth coring," engineers can form a comprehensive remediation plan – one that could not be achieved in past.

Geographical Information Systems (GIS) have started to provide an electronic method of storing and accessing data for comparative analysis of the structures. This has been the first step in applying technology, yet much remains to be done in terms of incorporating current and historical data into a useable, comprehensive system. In past, experiments with GIS have sometimes become splintered depending upon which agency is providing the new data and where the historical information is located.

While TULES alone can detect voids, reveal internal composition, and find seeps and scour – providing terabytes of data – a greater long term benefit will be in compiling this data into a GIS system with provisions for baseline standards, historical data, and new provisional layers for data from Non Destructive Test (NDT) methods as they become available for future incorporation into the TULES system.

TOOLS WE CAN USE

Terrestrial Subsurface Imaging Tool

Aquatic Subsurface Imaging Tool

Aquatic Bottom Contour Mapping

Imaging of Defect Indications

Aerial Contour Identification

Global Location Identification

COMPREHENSIVE GIS SYSTEM

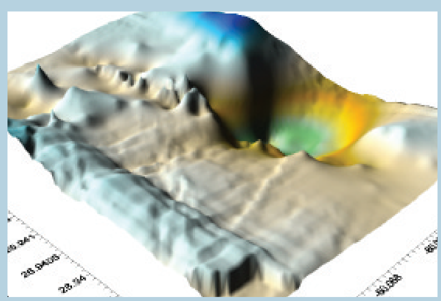
Ability for comparative analysis

Real time information

Ability to auto-flag potential problems

Multiple visualization options of asset condition

Flexibility to accommodate new technologies



PROPOSED PILOT PROJECT

DOER proposes a multi phase pilot project that would serve as a "Proof of Concept" for the Department of Water Resources. This pilot study is a very proactive and responsible approach, utilizing California small business technology to find solutions to a California crisis. Funding for the pilot study is modest as compared to the millions that stand to be squandered on expensive emergency response and what are perceived as little more than band-aid fixes by the public.

"Using California small business technology to find solutions to a California crisis."

Track 1: Workshop

Track 1 of the pilot program would consist of a hosted workshop to outline the type of data TULES is capable of providing and to identify the key needs and end products required by DWR and others for an inspection, classification, and dissemination system.

While DOER knows the data gathering power that TULES is capable of, convening a workshop will permit a general consensus to be formed on the best approach to a GIS system that will be usable to all of the operators and resource agencies. At present, contracts have been awarded for the purpose of compiling available historical data. Others have been tasked with producing an inventory of existing levees for the purposes of asset management. These systems either need to be expanded upon or supplied as a layer to a larger master product. Alternatively, the internally produced DWR user inventory GIS system might be expanded to accept a new data layer from the TULES sensors.

One goal of the workshop would be to propose or select an engineering firm to assist in developing this classification system. The classification system criteria will be critical in the development of an automated defect flagging system. Thus, when failures do occur, sites with similar characteristics will auto flag in the system, for close monitoring.

Science and environmental concerns are key players in the TULES system. The quantity and quality of data that will be collected can serve multiple purposes. If we include the requests and end use of hydrologists and environmental scientists, we maximize the return on the invested dollars past a purely engineering benefit.

Track 2: Pilot

Track 2, which can be implemented in conjunction with or ahead of Track 1, consists of selecting a test location(s) and obtaining access authorization. The sensors and application specific vehicles will be selected to undertake collection of a comprehensive data set from the pilot project site.

Although the sensors and their capabilities are known, certain on-site parameters will determine the proper frequency and configuration of sensors and antennas. Multiple sensor configurations will be evaluated during Track 2 for optimized data sets.

Presentation of the sensor to the structure is critical to stable data. During Track 2, multiple vehicles will be evaluated to see which platform is most efficient in terms of speed and data acquisition. Given the number of levees, speed of inspection will be a consideration as will the ability to move slowly over and around suspect areas where higher resolution may be critical to assessment.

Certainly, if a future State wide project is implemented, speed and efficiency will be given high priority. Track 2 testing will help DOER evaluate the maximum rate of travel while maintaining required data quality given natural variables.

Track 2 data will be fed into GIS models to test their ability to receive and classify data for real-time results while simultaneously permitting hard storage for post process study. Another goal is to test the processed data, including its ability to be incorporated into existing GIS databases or to become a framework for a master GIS product.

TASK 1

Workshop to:
- determine optimal GIS system
- select engineering firm to develop classification system

TASK 2

- Select test location(s)
- Fine-tune frequency and configuration of the sensors and antennas to optimize data sets
- Optimize testing platforms for speed of data acquisition
- Input into GIS models to test data processing and analysis