ENTERPRISE DREDGE (eDREDGE):
A DREDGING BUSINESS PRACTICE ENTERPRISE GIS APPLICATION

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ABSTRACT

Implementation and management of US Army Corps of Engineers (USACE) dredging operations requires close, often daily, coordination between the USACE Districts, dredging contractors, and environmental agencies. The processes to plan, manage, monitor, and close-out of dredging operations can be labor intensive, cumbersome, and current methods and procedures are not standardized. Means for data storage and retrieval are also not standardized or consistent. With the advancements in data management and enterprise Geographic Information System (eGIS) technologies, the existing tools, methodologies, and procedures utilized to implement a dredging operation can be enhanced and integrated to provide a comprehensive standardized system. Through the development and linking of standardized tools and visualization features which access eCoastal GIS, Silent Inspector (SI), Dredging Information System (DIS), Inland Electronic Navigation Charts (IENC), and other databases, the dredging operation could be planned, managed, and monitored through a system accessible through the web and on board the dredge. Archiving all information and data on the USACE District GIS server would make the data readily available for future access. The USACE Engineer Research and Development Center (ERDC) is developing the eGIS dredging application, eDredge, a national capability which builds on existing eGIS architecture and applications, and accesses databases with pertinent dredging information. The eDredge application will provide a comprehensive, standardized system to assist the USACE dredging mission by improving coordination, communication, and the ability to more efficiency plan and implement dredging operations. This paper discusses the development of the eDredge application.

Keywords: Silent Inspector (SI), eGIS, eCoastal, dredge monitoring, dredge toolbox

INTRODUCTION

The processes to plan, manage, monitor, and close-out of US Army Corps of Engineers (USACE) dredging operations can be labor intensive, cumbersome, and current methods and procedures are not consistent or standardized. To improve these processes, the USACE Engineer Research and Development Center (ERDC) is developing eDredge, a single integrated system to automate the start-to-finish process from planning, implementation, and completion of USACE dredging operations. The eDredge application will standardize procedures, reduce timelines, improve the USACE ability to monitor and report environmental compliance, and manage dredging operations. The standardization of tools and procedures will result in consistency among USACE dredging operations yet remain flexible and tailored to support District individuality. Automation of the Silent Inspector (SI) system programming also provides uniformity, reduces timelines, and reduces potential error. The eDredge system will provide long-term storage of dredging information and contract actions, as well as a means to retain institutional knowledge. Additionally, the eDredge system will assist and encourage regionalization by providing standardized procedures, tools, formats, and access to regional databases. Overall project coordination and oversight will be improved for dredging managers, inspectors, and contractors through web based and on board capabilities accessible throughout the dredging operation. The integrated system which may automate dredging contract planning, creation of dredging bid specifications, etc., will greatly enhance emergency dredging operations which require short timeframes (e.g., Hurricanes), and will improve the overall efficiency of USACE dredging operations.

ENTERPRISE GIS AND eCOASTAL GIS

The principal purposes of an enterprise GIS (eGIS) are to provide broad access to geospatial data, a common infrastructure upon which to build and deploy GIS applications, a common GIS data management framework, and significant economies of scale and resulting business value through organization-wide deployment and use. The

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concept of eGIS is taking a complete organizational approach to sharing, using, and managing spatial information. The eGIS infrastructure delivers spatial information products, services and standard datasets to all functional elements and business processes of the organization. The benefits of implementing an eGIS infrastructure include reduced redundancy of data acquisition by enabling data sharing; allows custom GIS applications to be built upon a common framework; allows easy distribution of applications with little to no reprogramming; allows easy data sharing across various USACE Districts and the public; increased productivity by eliminating data converting or translating; provides the most accurate and up-to-date data; improved communication; and increased data security.

In response to the needs of the USACE Regional Sediment Management Program, the USACE Mobile District developed the eCoastal GIS which is designed specifically for the needs of the coastal engineering business practices and is essentially the coastal-specific datasets within an eGIS system. eCoastal links geospatial and tabular database information to assist coastal engineers in visualizing patterns, relationships, and trends in coastal datasets. The major principles of eCoastal are the abilities to effectively store, access, and distribute data to all interested users. Specialized applications assist in the planning and prediction of coastal processes. Some common types of data included in the geodatabase include: hydrographic and topographic data, shoreline position, aerial and oblique photography, hyperspectral imagery, dredging records, environmental data, wetland boundaries, sediment data, digital nautical charts and USGS quad sheets, and other data regarding regional utilities, infrastructure, and land use. To assist in data sharing and community participation, eCoastal is accessible through the ArcGIS desktop or ArcIMS web-based service. The eCoastal system is compliant with the Spatial Data Standards and all data must have Federal Geographic Data Committee (FGDC) compliant metadata.

eDREDGE APPLICATION

With advancing technologies and expanding needs for planning and managing dredging operations, the need to expand the eGIS architecture for the dredging community became apparent through the implementation of eCoastal. Much of the data and information populated in the eGIS geodatabase are applicable to the dredging mission. Similarly, many of the eGIS tools are applicable to monitor and manage dredging operations. The eDredge application will build on the eGIS geodatabase architecture, Figure 1, by linking to additional databases with pertinent information and data related to dredging. These additional databases include the Silent Inspector (SI), Dredging Information System (DIS), Inland Electronic Navigation Charts (IENC), eCoastal, financial information such as CEFMS and P2, and other identified sources of relevant information such as environmental and regulatory data. The suite of eDredge tools will build on the eGIS tools, and will include capabilities to access and analyze survey data to identify and assess dredging needs, plan a dredging event, create dredging specifications packages, create electronic notice to proceed packages, program the SI system, monitor and manage dredging operations through near-real time data, and perform project close out with data archival. This application with specialized dredging tools will assist in the planning, management, and monitoring of dredging operations.

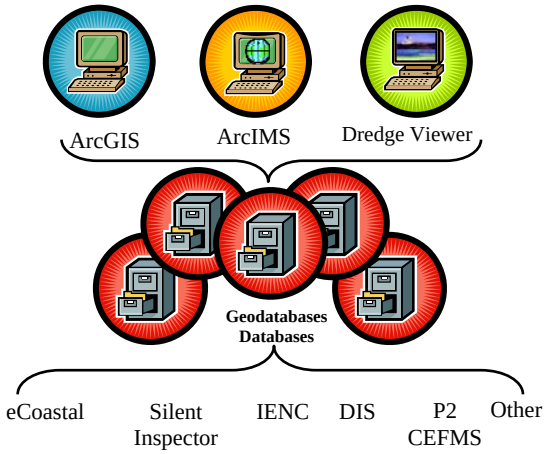

Figure 1. eGIS/eDredge architechture.

The goal of eDredge is to develop a start to finish capability to assist in the implementation of the following tasks:

Identify Need to Dredge

Identify need to dredge through calculation of shoaling volumes using a web-based tool along with project and channel boundaries. This includes accessing historic dredging data and contract information for a specified project.

Plan Dredging Event

Develop web-based tools to access or develop contract information to create dredging specifications; pull general specific requirements; allow insertion of documents, text, images, and information from standard formats; and assemble dredge specification in digital format.

Dredging Specifications

Create dredging specifications package for bid. Integrate various forms, information, calculations and data to produce a digital bid package complete with drawings. The plans and specifications drawing will be generated from information created through identifying the need to dredge and planning the dredging event. The information generated for the dredging specifications package will be linked with other relevant databases and stored for use throughout the remaining dredging operation and for the final project summaries and reports.

Award and Notice to Proceed

Create Electronic Award Contract and Notice to Proceed package. Once the bid process is successfully concluded, electronic media will provide relevant information to initiate dredging. This requires creating automatic controls to initialize the SI running on a dredge and provide a visualization capability. To support emergency operations, a telemetry system will be evaluated to transmit relevant information directly to the dredge.

Monitor and Manage Dredging Operation

The SI system provides the basic dredge monitoring information from a dredging operation. By linking the SI, eGIS, and ancillary data from other databases, comprehensive data and information can be provided via a single web interface. These functions will provide the user with a single access point for all dredging information to assist in managing and monitoring a dredging operation.

Tracking and Disposal Positioning Quality Assurance

An ocean disposal dredge tracking, disposal positioning, and quality assurance (QA) capability has been developed through use of the Silent Inspector data and the eGIS. An ArcIMS map service (web interface) for the ocean disposal tracking, positioning, and QA capability has been established.

Project Close-out and Reporting

To protect the information and make it available for future use on operation and maintenance of the project, the technical and administrative details of the contract will be summarized in a report and detailed information will be stored in the database. This will ensure the information will be available and accessible in the future.

eDREDGE TOOLBOX

The eDredge tools will build on the existing eGIS Toolboxes. The following sections describe eGIS tools, the dredging relevant eCoastal tools, and the eDredge tools which are currently available or have been proposed for development.

eGIS Toolbox

The eGIS Toolbox is a global set of tools designed to assist all GIS users in data analysis and access to the geodatabase through user-friendly tools and forms available in the ArcGIS and ArcMap application. Each toolbar is a combination of smaller tools. These tools have been categorized and stored on a series of toolbars: Data Viewer, Report Tools, and Imagery Manager Toolbars.

The Data Viewer toolbar provides users with a direct connection to data stored in the geodatabase, provides tools that simplify searching and adding data, viewing and analysis, and creating maps. The Report Tools provide an interface to non-spatial data such as reports, digital photos, sediment analysis, and other documents. The Imagery Manager Toolbar assists in the management of multiple raster images in ArcGIS that can be otherwise cumbersome and time consuming.

Dredging History

Many USACE Districts and stakeholders have realized that archiving and retrieving historical dredging information is not a standardized practice and obtaining this information can be difficult. Dredging histories can be obtained from index cards where dredging information has been manually recorded, from spreadsheets managed by individuals, and in limited cases information is stored in a database. In some cases the historical dredging information is lost. Using eDredge, dredging information maybe populated through links to existing databases such as the Silent Inspector and DIS, or information can be populated manually. By managing dredging histories through eDredge, Figure 2, a user may visualize basemap information such as navigation channels, dredging and disposal locations, nautical charts, in addition to contract, volumes, start and end dates, and other pertinent information.

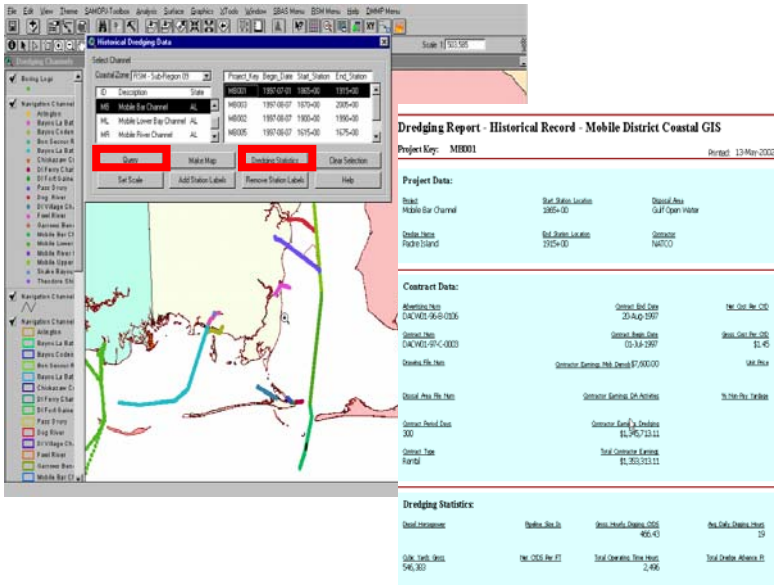

Figure 2. Dredging history.

Ocean Disposal Monitoring Tool

All USACE contract and permit dredging operations which utilize an Environmental Protection Agency (EPA) ocean disposal site for the placement of dredge material must meet the EPA monitoring conditions for environmental compliance. To be environmentally compliant, a dredge must dispose material within the confines of the specified ocean disposal area. The Ocean Disposal Monitoring (ODM) Tool, Figure 3, allows near-real time dredging data to be viewed with geospatial information in the enterprise geodatabase. This technology allows the USACE to monitor the ocean disposal activities of dredge contractors, run initial quality control queries, and produce reports to inform the EPA of dredge disposal activities. Along with basemap information such as nautical charts in the vicinity of the dredging and disposal locations, navigation channel and disposal area boundaries, and aerial imagery, the user may view the status and positions of the hopper dredge or scow and whether the hopper or scow doors are open or closed. Forms are available to allow the user to comment on each load prior to reporting to EPA. This application is available through web-based access.

On-Board Dredge Viewer

The On-Board dredge Viewer, Figure 4, is interconnected with SI, and provides a user friendly interface and access to data while being physically located on board the dredge. The near-real time dredging data maybe viewed alongside geospatial information (NOAA nautical charts, IENC data, survey data, navigation channel and disposal area boundaries, etc) stored in the eGIS geodatabase. Using this technology, the USACE inspector can monitor vessel positioning and ocean disposal activities overlaid on geospatial basemap information. This tool also provides the capability to run initial quality control queries, produce reports, etc while on board the vessel.

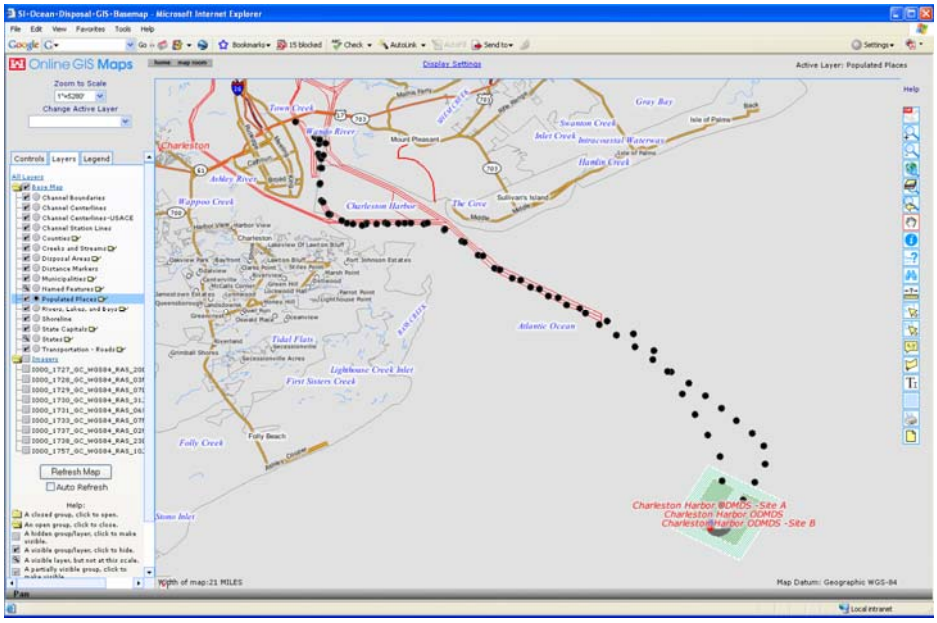

Figure 3. Ocean disposal monitoring tool.

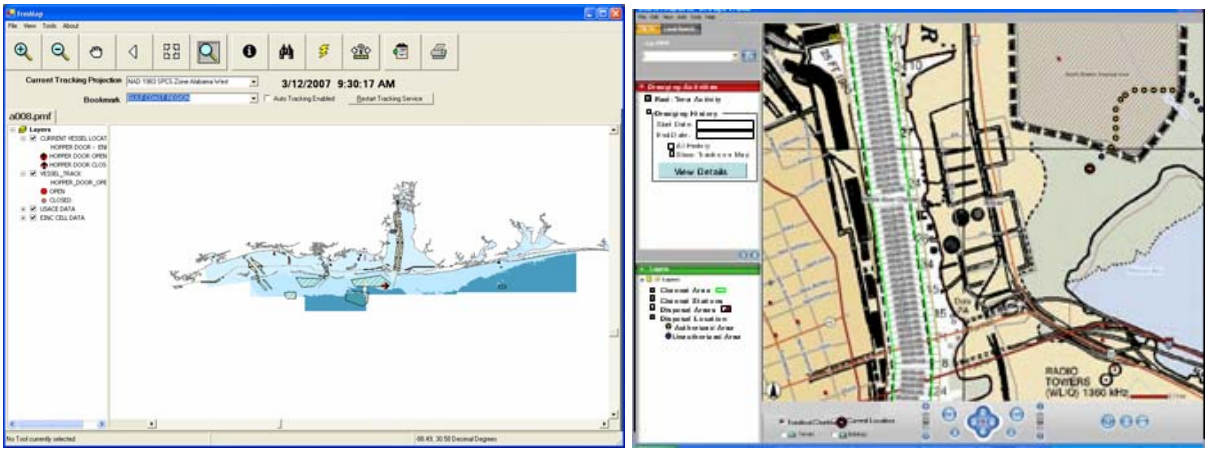

Figure 4. On-board dredge viewer.

Cross-Section Viewer

To compare cross sections or beach profile data with higher-density datasets (such as SHOALS or multibeam), users must be able to extract data from the higher density datasets. The Cross-Section Viewer tool allows users to extract cross sections and profiles from higher density datasets based on a user defined line graphic intersecting a survey, Figure 5. This tool creates a set of elevations along a line based on the grid surfaces included in the GIS.

Calculate Depth Difference

This tool provides the capability to compute volumes between datasets based on the grids created from the original datasets. The user can compute the volume differential between the pre- and post- surfaces of two existing grid surfaces. The 3D Viewer allows users to view raster layers in 3D, and gain different perspectives on survey data. Users may opt to view a subset or the entire surface and change the viewing conditions.

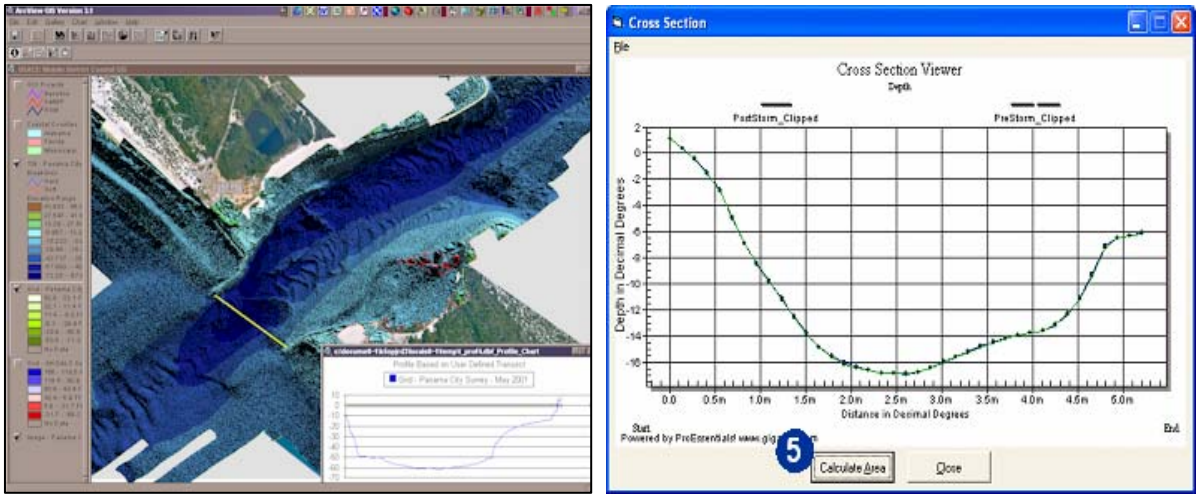

Figure 5. Cross section viewer.

Survey Analysis & Management System (SAMS)

A primary use of hydrographic surveys supporting navigation operations and maintenance is to determine the quantity of material that has shoaled in a channel and is in need of dredging. These material quantity estimates are used for planning dredging operations and for computing payment volumes. One key aspect in this process is the issue of survey data management. The Survey Analysis and Management System (SAMS), currently under development through the ERDC Navigation Systems Program and based on the ERDC IENC Program, provides the capability for handling, storing, formatting, and converting of raw ASCII survey data into useable GIS data layers where analytical methods and visualization techniques are ultimately employed.

The SAMS tool efficiently moves survey data from the organization collecting the survey data to the eGIS where mapping and analysis tools can be used to compute accurate dredging volumes, Figure 6. During this process the data is reprojected to geographic WGS84 coordinates and properly attributed. Supporting business tables are properly populated to support data access and other analysis applications. The processing of the survey data in ArcMap can be performed interactively by a user or as an unattended process on a dedicated GIS workstation. The SAMS tool accepts traditional bathymetric profile surveys, multi-beam hydrographic, or bathymetric and topographic LIDAR surveys.

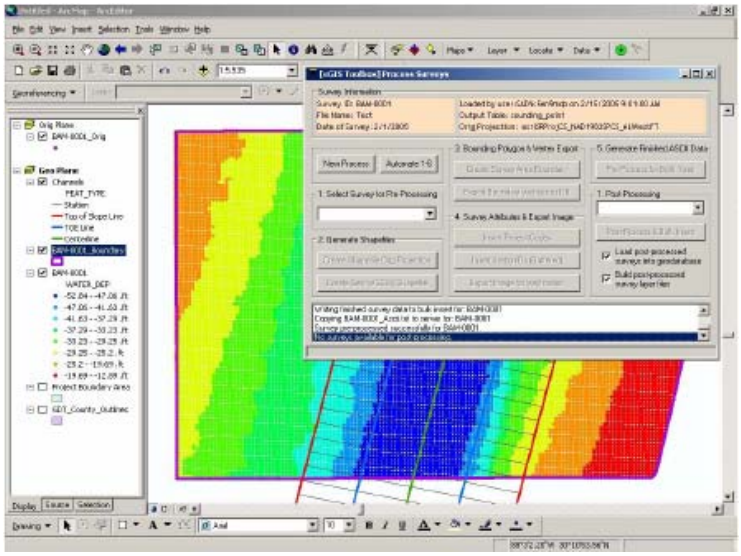

Figure 6. SAMS survey loading menu.

Channel Framework

Integral to SAMS is the fundamental requirement that the channel framework is stored as a collection of 3D lines. The polylines include top of slope lines, toe lines, channel centerlines, and channel stationing, Figure 7. Channels are designed as 3D entities in CADD and are processed in ArcMap to produce the desired shapefile. This shapefile is then loaded into the geodatabase. One key aspect of the channel framework is each individual station line in the entire system is uniquely identified with a channel station identifier. Information about the channel geometry is extracted and stored in the survey channel template table in the geodatabase. Figure 8 illustrates the overlay of the 3D channel framework and a 3D survey along the channel.

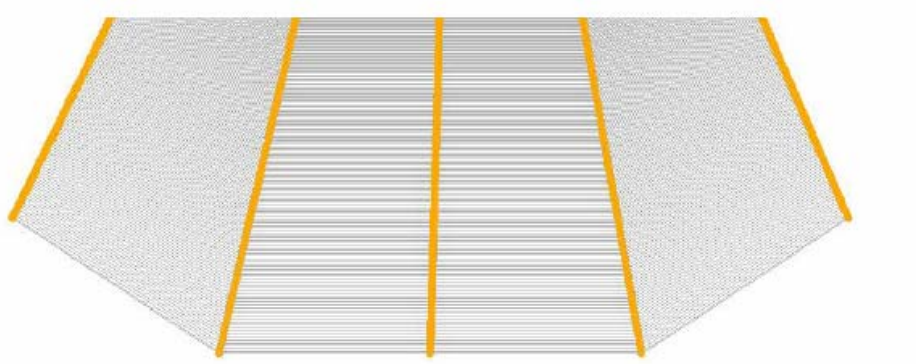

Figure 7. 3-D perspective channel framework.

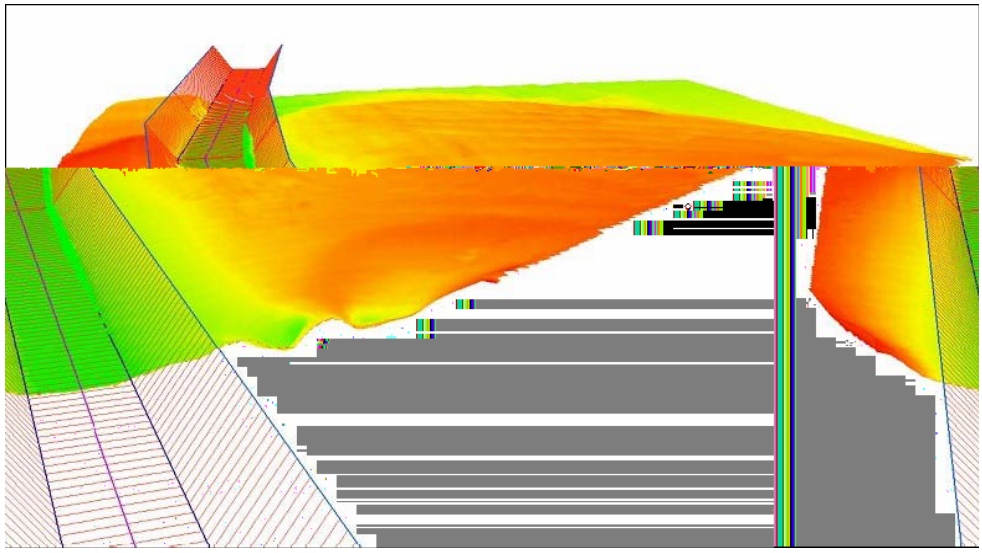

Figure 8. 3-D channel framework and 3D survey.

Channel Profile Tool

The interactive Channel Profile Tool interacts with the 3D channel framework and the survey data through the eCoastal ArcIMS web-mapping interface, Figure 9. The Profiler tool allows users to overlay a select profile from a survey against the channel design template, Figure 10. The Tool has the capability to calculate volumes between any two consecutive stations based on average end area methodology. Total volume for the survey can also be calculated and printed in report form. This tool only requires access to Internet Explorer.

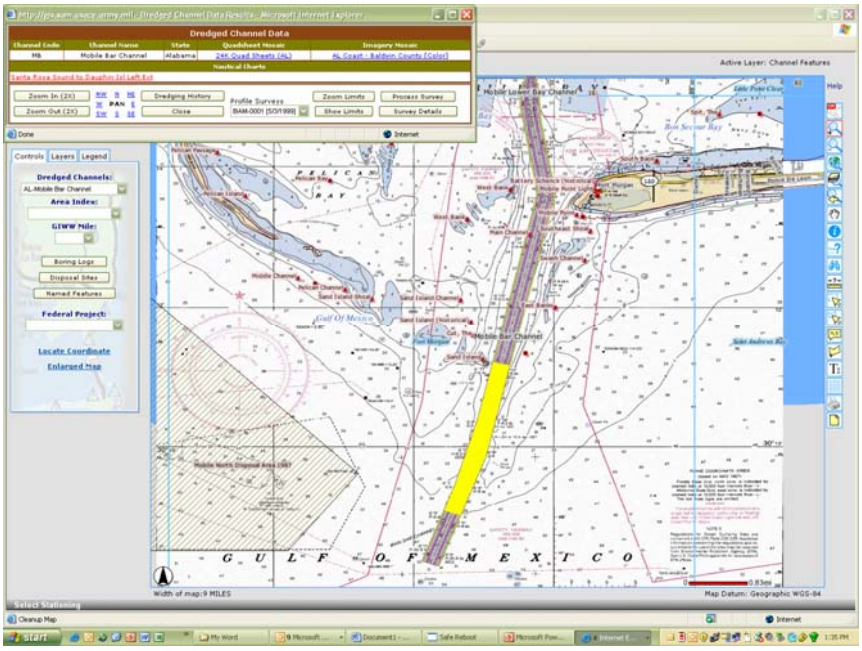

Figure 9. SAMS ArcIMS interface view.

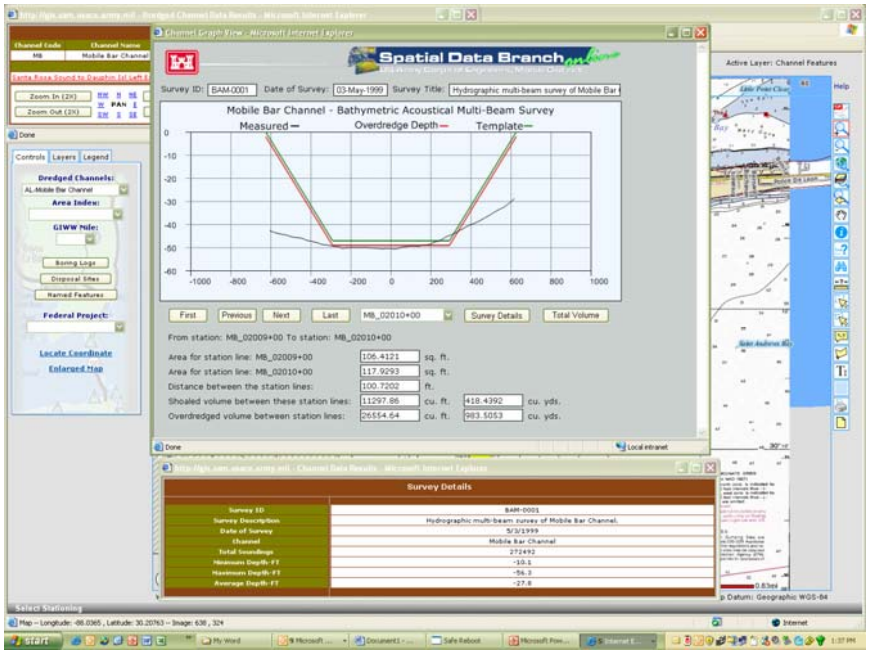

Figure 10. Channel profiler tool.

CONCLUSIONS

The USACE ERDC is currently developing the eGIS application, eDredge, a national capability which builds on existing eGIS architecture and applications, and accesses databases with pertinent dredging information to provide a single integrated system to assist in the planning, implementation, and completion of USACE dredging operations. The eDredge application will standardize procedures, reduce timelines, improve the USACE ability to monitor and

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