GIS and IMS Support for Gulf Intracoastal Waterway Re-certification Process

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Abstract:

The U.S. Army Corps of Engineers has developed a Geographic Information System (GIS) to aid in building sound Environmental Assessments to satisfy the waterways re-certification process for the Florida Department of Environmental Protection. This process involves an assessment of potential environmental impacts associated with the maintenance of the Federal navigation project. The preparation of the environmental assessment and re-certification process involves review and coordination with multiple State and Federal agencies. The goal is to insure that continued maintenance of the waterway is conducted in a manner consistent with applicable law and guidance such as the National Environmental Policy Act (NEPA), Clean Water Act, Endangered Species Act and Coastal Zone Management Act.

The GIS provides baseline information for 300 miles of shoreline including shoreline position, multi-spectral imagery, dredging records, nautical charts, soils, land use, and vital environmental data. The project combines fragmented CADD channel and disposal area information into a comprehensive, continuous, centralized waterway channel data set.

An Internet Map Server (IMS) was developed to allow individuals and organizations to interact with the GIS on the Intranet or Internet in order to create maps, integrate information, and visualize scenarios. Specifically, the Coastal Navigation IMS allows the user direct access to large amounts of channel data and environmental information, and includes the capability to zoom in/out and turn on/off specific map features; perform queries based on colloquial geographic names and site specific disposal areas, and print maps at several selectable scales.

Introduction:

The Gulf Intracoastal Waterway (GIWW) is a Federal shallow-draft navigation project that extends approximately 1,115 miles along the coast of the Gulf of Mexico from northwestern Florida to the southern tip of Texas. The waterway connects southern ports with the Midwest, the east, and the Great Lakes region. The US Army Corps of Engineers (USACE) Mobile District has jurisdiction over the portion of the GIWW from Rigolets, Louisiana, to Apalachee Bay, Florida (Figure 1), a total of approximately 380 miles.

The (FLDEP) GIWW Re-certification Process requires an Environmental Assessment (EA) to ensure that all dredging activities conform to the Clean Water Act and are consistent with the Florida Coastal Management Program. To complete the environmental

Figure 1. Gulf Intracoastal Waterway, USACE Mobile District jurisdiction.

assessment, the USACE was required to review each navigable channel maintained inside the panhandle of Florida and assess the impacts of dredging that channel on the surrounding environment, both physical and socio-economic. Impacts to the physical environment may include changes in climate, topography, soils, hydrology and water resources, air quality, hazard material, sediment quantity, or biological resources. Changes in economic activities, land use, and cultural resources are possible impacts to the socio-economic environment surrounding a dredging project.

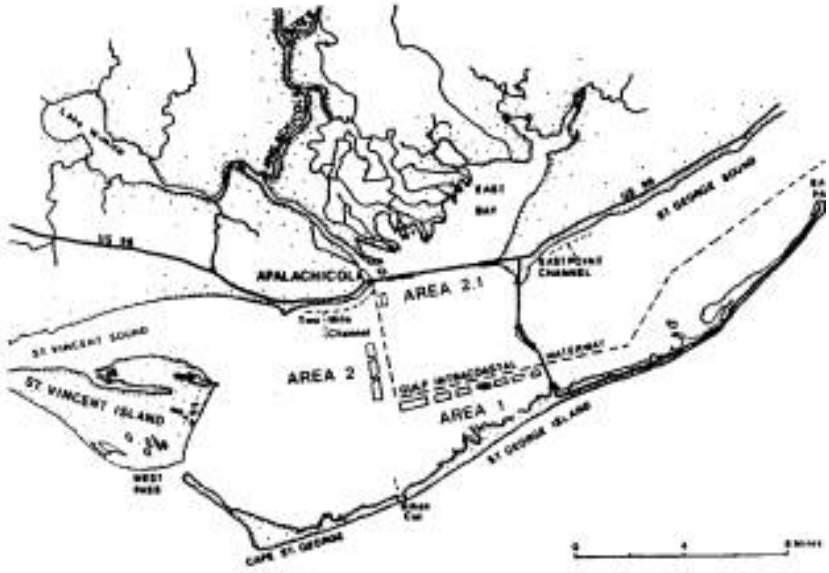
During the 1993 EA, biologists at the USACE had to rely on hand drawn maps displaying only the most

basic of baseline information, such as a shoreline, channel and disposal site locations, and small scale roads (Figure 2). Not only were these maps limited, they constrained the biologist by forcing him to review several different paper maps in order to make an accurate assessment for a single channel. This made any visual representation of the findings for the FLDEP extremely difficult and, in most cases, impossible.

To overcome these difficulties, the Spatial Data Branch in the Mobile District of the US Army Corps of Engineers incorporated the various datasets in the latest GIS and IMS technologies. Using this new technology, the Mobile District engineers involved in the EA were able to access GIS capabilities using only a commercial web browser, including the ability to view all data layers, plot channel locations, locate disposal areas, and environmental data, and raster data using the query tool. They were able to visually display their EA findings with a plotting utility. The IMS is available not only to the USACE, but also to administrators in the FLDEP and the public.

The Data:

Massive amounts of data were collected from various state and Federal agencies: the USACE, FLDEP, Florida Fish and Wildlife Conservation Commission (FWC), County Planning Departments, Nation Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and the University of Florida.



NOTE: DISPOSAL AREA 2.1 EXPANSION PROPOSED (23 AC TO 86 AC)

GULF INTRACOASTAL WATERWAY
DISPOSAL AREA LOCATION MAP

Figure 2. Map created for 1993 Re-certification Process.

With the variety of organizations providing raster and vector data, the data were in an array of projections. This project was originally for a re-certification process for the state of Florida, however, since the project area extends across three states, the Spatial Data Branch decided to use the Geographic WGS84 projection.

All of the GIWW, channel, and disposal site locations were built directly from the engineering drawings produced by the USACE. Features, such as channel limits, centerline, and stationing were extracted from these drawings and migrated to the realm of GIS applications. Not only was this useful for re-certification, it was a new beginning for the USACE's management of these projects. It now allows the USACE the ability to view every project along the Mobile District coastline on a simple Internet web browser.

The University of Florida hosts a Metadata sever called the Florida Geographic Data Library (FGDL), http://www.fgdl.org/. The FGDL has been compiled from data and images collected from numerous state and federal governmental agencies, as well as, nonprofit organizations and private companies. The (FDEP) has been the lead agency contributing to the development of FGDL, but the Florida Department of Transportation (FDOT) has made contributions, as well. The FGDL was a vital tool in helping the USACE in its needs for accurate GIS data collection. The United States Geological Survey (USGS) provided seamless data sets along the entire coastline dealing with sea grass location and wetland habitat location.

Three major raster data sets along the coast were provided to the USACE to assist in visual representations for each project area: 1:24000 scale quad sheets for all of the coastline, varying scales of nautical charts, and digital imagery along the GIWW. Each paper quad sheet was scanned, georeferenced, cropped, placed into a mosaic, and then encoded using MrSid. MrSid files provide only the amount of image data needed for a specific viewing scale. This optimizes workflow by eliminating wasted data transfer, speeding up transfer times, and dramatically decreasing storage requirements. All nautical charts were collected for the Mobile District and then encoded using MrSid. The Spatial Data Branch opted to use digital multispectural imagery from a Digital Airborn Imaging System (DAIS) to satisfy the need for current photography. The sensor was custom-built for Space Imaging and collects digital, true multispectral imagery with one half-meter to two-meter ground resolution. The multispectral qualities of the DAIS imagery make it uniquely positioned to respond to a variety of customer requirements. The imagery offers four, true multispectral bands: blue, green, red and near-infrared. A four band--red, blue, green, and near-infrared -- digital imagery product was obtained with a one meter spatial and four meter positional accuracy. Not only does this imagery provide an aesthetically pleasing image, but land-cover analysis can be performed.

Functions and Tools:

An Internet Mapping Service built with ESRI's IMS 4.0 was the delivery tool for the GIWW project. ESRI built its IMS technology to deliver GIS vector and raster data, at both large and small scales, over the Internet.

Because of the unique query capability requested by our users, the IMS had to be customized far beyond its original shape and form. The customizations were engineered using a combination of web technologies, such as JavaScript, XML, and ASP. These behind the scenes customizations gave all users, regardless of skill level, the ability to retrieve, analyze, and query a wide variety of information through a web browser. (Dopsovic and Penton 2002)

I. The Interface

The initial interface of the Coastal Navigation Internet Map Server (Figure 3) displays the extent of the project area. This interface was customized for a larger viewing area. Here, users can run a query on the map based on a specific channel location, quads sheet, GIWW channel mile, geographic feature, environmental species, boring log, dredge disposal site, coordinate, or GIWW re-certification Project.

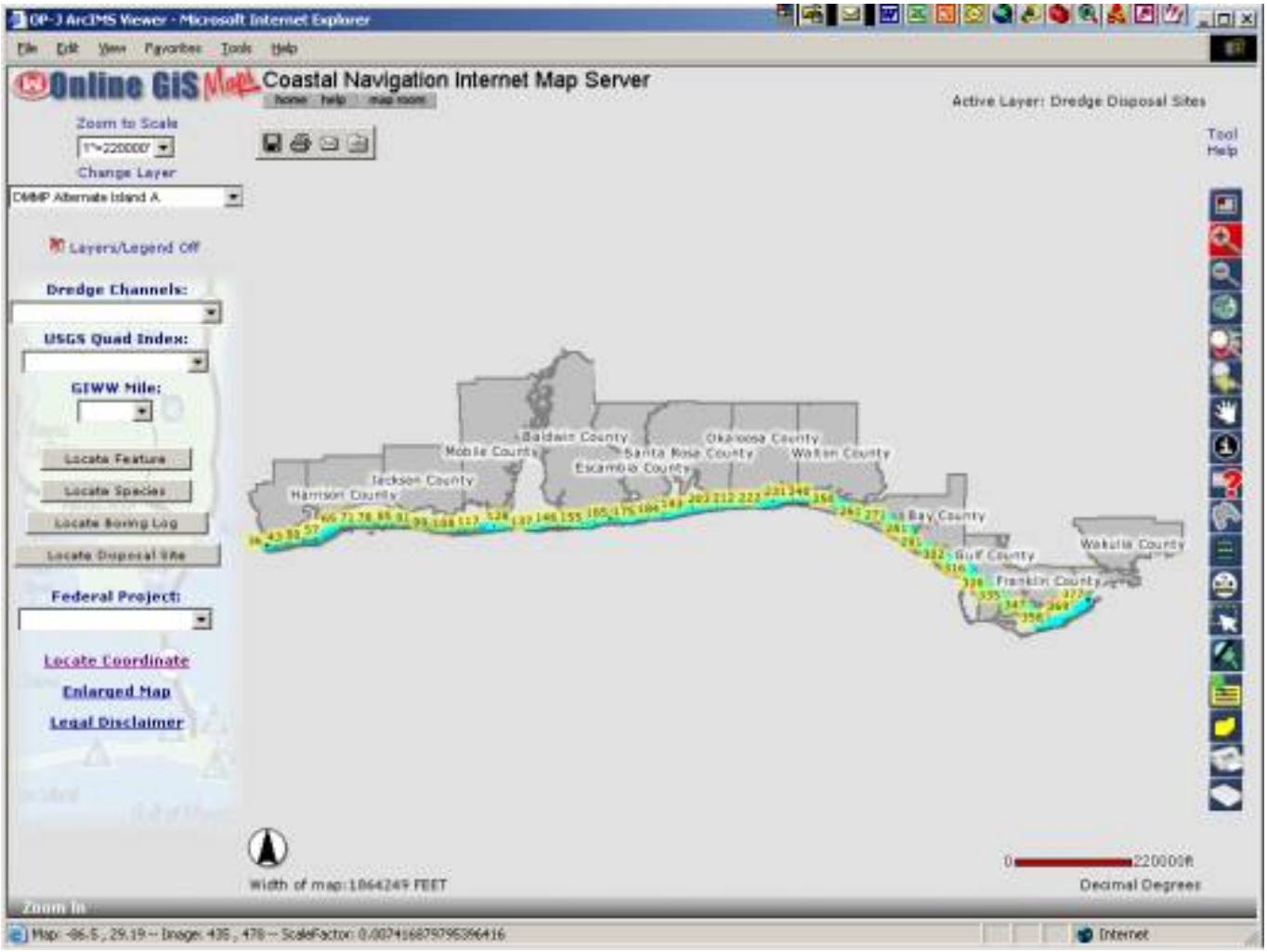


Figure 3. Initial interface of the Coastal Navigation Internet Map Server.

Toggling *Layers / Legend On* allows the user to view which layers are available at a particular scale. The list updates when the user increases or decreases the viewing scale. With the amount of data contained within the GIS, many of the layers are scale-dependent and are toggled on and off when zooming. Within the Layers/Legend dialog box, the user can toggle on/off layers as needed (see Table 1). Once a user has customized a map, they can print the map at any scale.

ArcIMS Map Layers	
Roads, County Boundaries Common Coastal Features	Salt marsh locations
Species locations for Birds, Fish, Invertebrates, Marine and Terrestrial Mammals, Reptiles, and Shellfish	Sea grass and Sea grass Scaring Areas
GIWW Mile Markers	Wetland habitat location
Nesting Locations	Artificial Reefs
Coast Guard Nesting Locations	Oyster Reef Management Zones
Military Restricted Zones	Soil Classifications
Environmental Sensitive Shoreline	Stratigraphy
Historical Areas	NOAA Carts
Digital Imagery	Quads Sheets

Table 1. Layers available in the Coastal Navigation Internet Map Server.

II. Available online Mapping Tools

The goal of an IMS is to give users capability to perform many of the spatial data functions that exist in a desktop GIS environment. Some of these functions include, but are not limited to, displaying and viewing multiple data sets, plotting maps, performing spatial data analysis, and running attribute queries. To aid users in the online mapping experience, the following set of tools are provided. (In order from top to bottom) (Dopsovic and Penton 2002)

Toggle Overview Map: This tool opens a window that displays the full extent of the map. When a Zoom tool is used, Overview Map uses a small, red rectangle to denote the zoom location. Click on this tool again to turn off the overview map.

Zoom In: To zoom into an area of the map, click and drag to draw a rectangle over the area of interest. You can also click once on the map to zoom in slightly.

Zoom Out: To zoom out of an area of the map, click and drag to draw a rectangle.

Full Extent: When clicked, this tool zooms to the extents of the entire map.

Zoom to Active Layer: To zoom to the extents of the active layer, first make a theme active by selecting the "Active" radio button in front of the desired theme and refresh map. Then click on the "Zoom to Active Layer" tool.

Back to Last Extent: The view is zoomed to previous extent.

Pan: Click and drag on the display to move to the desired area of the map.

Identify: The Identify tool allows the user to display identifying information of the Active theme. Select the Identify tool then click on a feature. A popup window will display all information for the selected record within that theme. Close the popup windows when finished.

Query: The Query tool allows the user to search for particular information about the active theme. When this tool is selected, a query window will appear at the bottom of the screen. To execute a query, three values need to be defined: Field, Operator and Value. Using the drop-down menu, select the desired field to query. Then select an operator (=, >, <, LIKE, >=, <=). Next, either type in a value, or to populate the Value field with attributes from the active theme, select the "Get Samples" button. Use the "Add Query String" button to write your query statement, and then click the "Execute" button to run your query. All entries that meet the query statement's requirements will be highlighted in yellow on the map. A popup window will display the query results. To zoom to the selected entries on the map, simply click on the record hyperlink in the popup window. To refine query results, create the additional query statements and click the "Add Query String" button, then execute the query. To begin a new query, select the "Clear" button. Use the "And", "Or", and "Not" buttons to further customize your queries.

Find: This tool performs a quick, case-sensitive text search of the Active Theme. A Find window is displayed at the bottom of the screen. Type in a string of characters, then click, "Find Channel". A popup window will open and display the search results. Click on the record number to zoom to that feature on the map.

Set Units: To change map units, click on this tool and select the desired units. Click the “Set Units” button to enforce these changes, or select the “Cancel” button.

Measure: This tool can be used to measure distances on the map. Using the Set Units tool can change its units. To measure a distance, click once at the starting point, then again at the finishing point. The line segment distance will be calculated and displayed at the top of the screen. To remove line segments, click on the Clear Selection tool.

Select by Rectangle: The Select by Rectangle tool is used to select a group of features within the active theme. To use, click and drag diagonally until a box is formed. When the mouse button is released, a popup window will open and display all selected features. To zoom to a particular record, follow the hyperlink of the record number.

Select by Line/Polygon: To select items on the map in an irregular shape, the Select by Line/ Polygon tool can be used. Clicking desired locations on the map will create polygons or lines. A succession of clicks will result in a polygon. Click on the “Complete… ” Button to run the query. Polygons and lines can be removed by selecting the “Clear Selection” tool.

Place Coordinate Label: This tool places coordinate labels for desired locations on the map. Simply click on a map location and a marker with its accompanying label will appear.

Calculate Polygonal Area: This tool calculates an area on a map by drawing a polygon. Click on the map to drop point locations for each polygon vertex. To complete polygon, select the “Complete Polygon” button. The area of the polygon will be displayed at the top of the screen. Polygons can be removed from the map by selecting the “Clear Selection” tool.

Buffer: This tool creates a buffered area of a customized width around selected features on the map. Use a selection tool to select features of the active theme. Click on the “Buffer” tool to set the buffer distance. The “Buffer” tool also has the ability to highlight features of an additional theme that may reside in the buffer area. To display these attributes, select the “Display Attributes” checkbox before clicking the “Create Buffer” button. Buffers can be removed from the map by selecting the “Clear Selection” tool.

Print: Clicking the “Print” tool will automatically create the layout, to scale, of the map based on the format of the user’ s screen. Users supply title information and the option to display the Overview Map, and the map is printed by selecting the print button on the browser.

Clear Selection: This tool removes “acetate” layers, including, selections, points, lines, buffers, polygons and labels present on the map. (ESRI, p.130)

III. Custom Online Mapping Tools

All of the queries were built in order to reduce searching for layers inside of the Layers / Legend dialog box, as well as, to perform quick searches based on user demands and needs. These unique queries provide the user the ability to search the IMS for specific needs, and provide a simple method for organizing data access within the IMS.

Dredge Channels: This drop down menu allows the user to view every channel located along the Mobile District coastline. Once a channel is selected, the channels layer is toggled on and the map zooms to the extent of the desired channel.

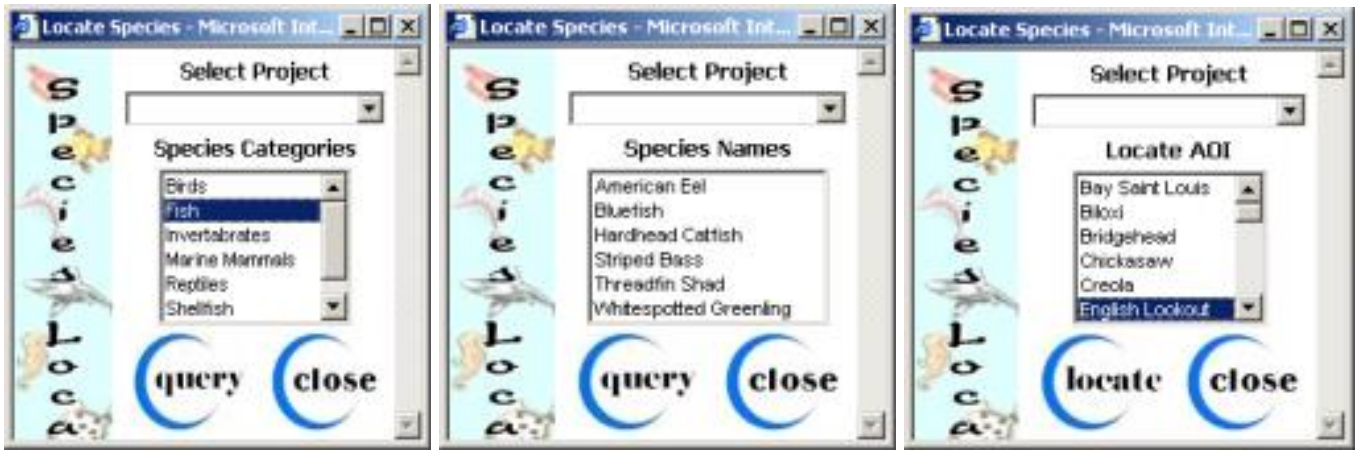
USGS Quad Index: This drop down menu allows the user to view and zoom to the quad sheet location within the project area. Once a quad sheet is selected, the map zooms to the extent of the quad and toggles on the mosaic containing that particular area.

GIWW Miles: This drop down menu allows the user to locate a mile marker along the GIWW.

Locate Feature: This button toggles on an ASP application allowing the user the ability to select one of eleven common coastal features. As an example, a user will select "bay"(Figure 4). Once selected, the application lists the features under that selection and the user can choose the exact location. Finally, the user selects "locate" and the map zooms to the selected feature.

Figure 4. Locate feature ASP application.

Locate Species: This tool was designed to select an animal species based on geographic location. The user is prompted to select the project and the type of board categories of animal for the search (Figure 5a). Then the application will query the database for all the different types of animals within that broad category (Figure 5b). Once selected, the user is prompted to select a quad sheet to search for that animal (Figure 5c). Then, the application queries the species layer for all species located within that quad, the map zooms to the quad extents, and displays the selected species for that location (Figure 6).



a b c

Figure 5. Sequence for selecting a species based on geographic location.

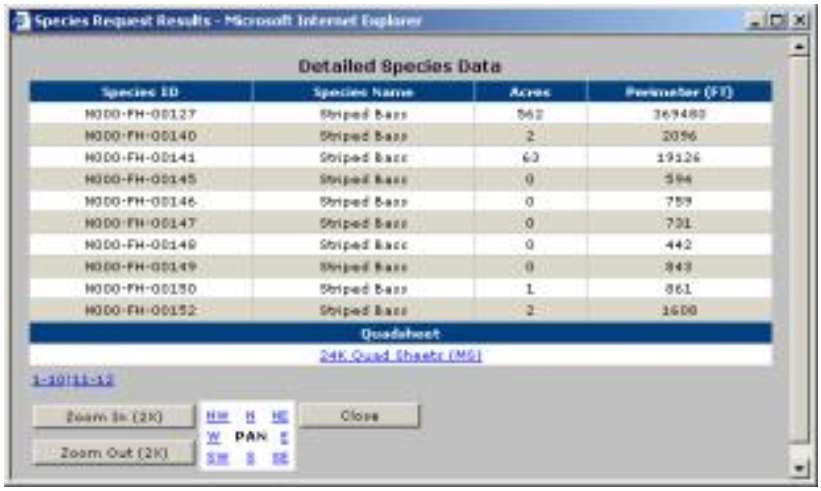


Figure 6. Results for selecting a species based on geographic location.

Locate Boring Log: This tool allows the user to first select the desired project (Figure 7) and the quad sheet containing the boring log. It then selects all the boring logs within that quad sheet. Once the quad sheet is selected, the map zooms to the extents of that quad sheet (Figure 8). Then the user can select a particular boring log and run a query of the database to find any information on the boring log (Figure 9). The information displays in a separate dialog box with hotlinks to all lab reports available, as well as hotlinks to the quad sheet, digital imagery, and NOAA charts for the area.

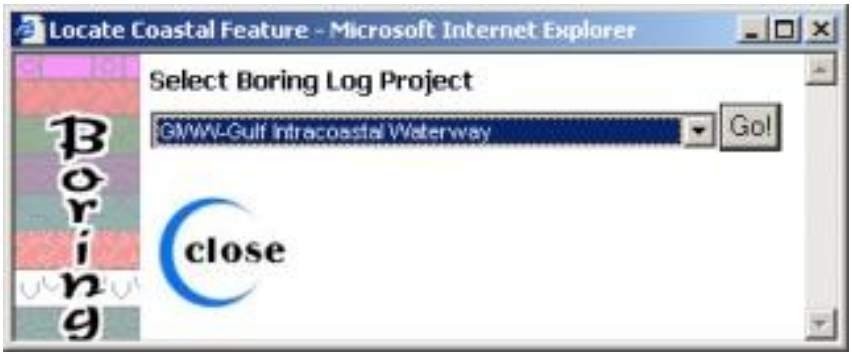


Figure 7. Select a project containing desired Boring logs.

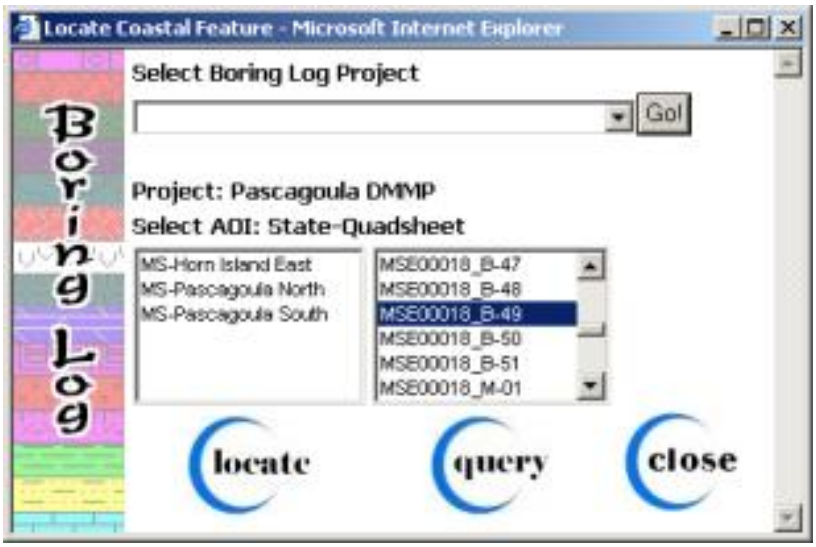


Figure 8. The user selects the quad sheet containing the boring log the boring log within that quad sheet.

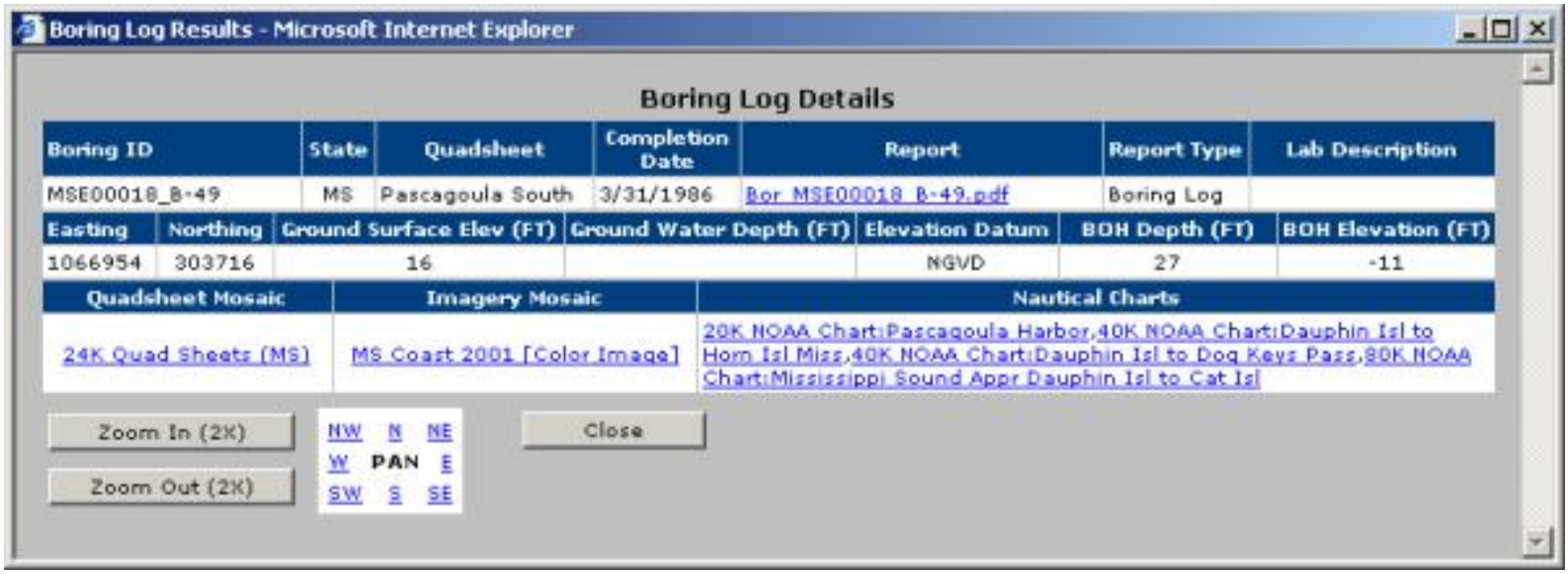
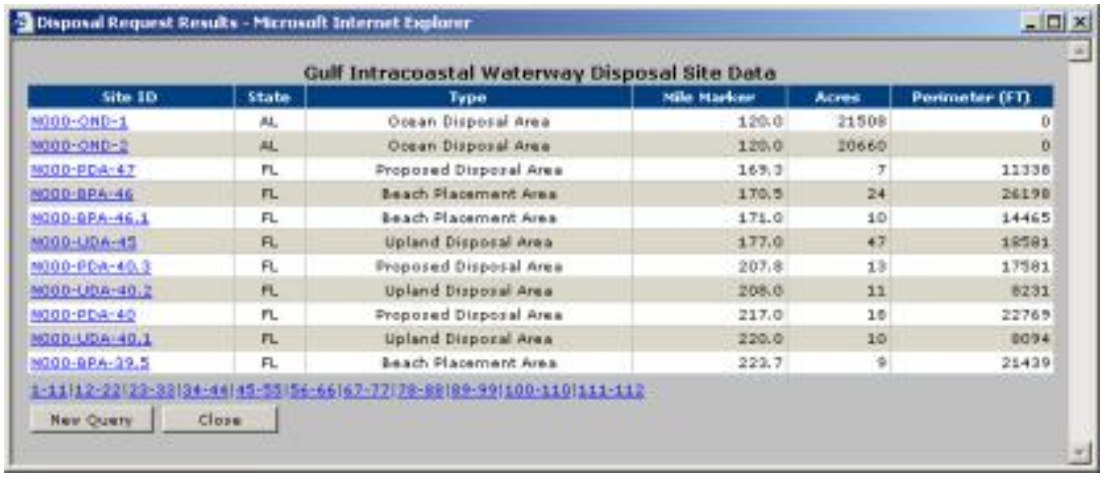


Figure9. Results for selecting a boring log based on geographic location.

Locate Disposal Site: The locate Disposal Site tool queries all the USACE maintained or proposed disposal sites within a particular project (Figure 10). This option is beneficial when dealing with multiple projects along the coastal region. Once a project is selected, this tool queries the shapefile for known disposal sites, and displays results in a separate dialog box. (Figure 11) From this dialog box, the user is able to select a particular site and the IMS zooms to the extents of the site (Figure 12). Any additional data about the disposal site is displayed in a separate dialog box, along with hotlinks to the quad sheet, digital imagery, and NOAA charts for that area is provided (Figure 13).

Figure 10. Select a project containing desired disposal site.



Site ID	State	Type	Mile Marker	Acres	Perimeter (FT)
M000-OND-1	AL	Ocean Disposal Area	120.0	21508	0
M000-OND-2	AL	Ocean Disposal Area	120.0	20660	0
M000-PDA-47	FL	Proposed Disposal Area	169.3	7	11338
M000-BPA-46	FL	Beach Placement Area	170.5	24	26198
M000-BPA-46.1	FL	Beach Placement Area	171.0	10	14465
M000-UDA-45	FL	Upland Disposal Area	177.0	47	18581
M000-PDA-40.3	FL	Proposed Disposal Area	207.8	13	17581
M000-UDA-40.2	FL	Upland Disposal Area	208.0	11	8231
M000-PDA-40	FL	Proposed Disposal Area	217.0	16	22769
M000-UDA-40.1	FL	Upland Disposal Area	220.0	10	8094
M000-BPA-39.5	FL	Beach Placement Area	223.7	9	21439

Figure 11. List of disposal sties within the selected project.

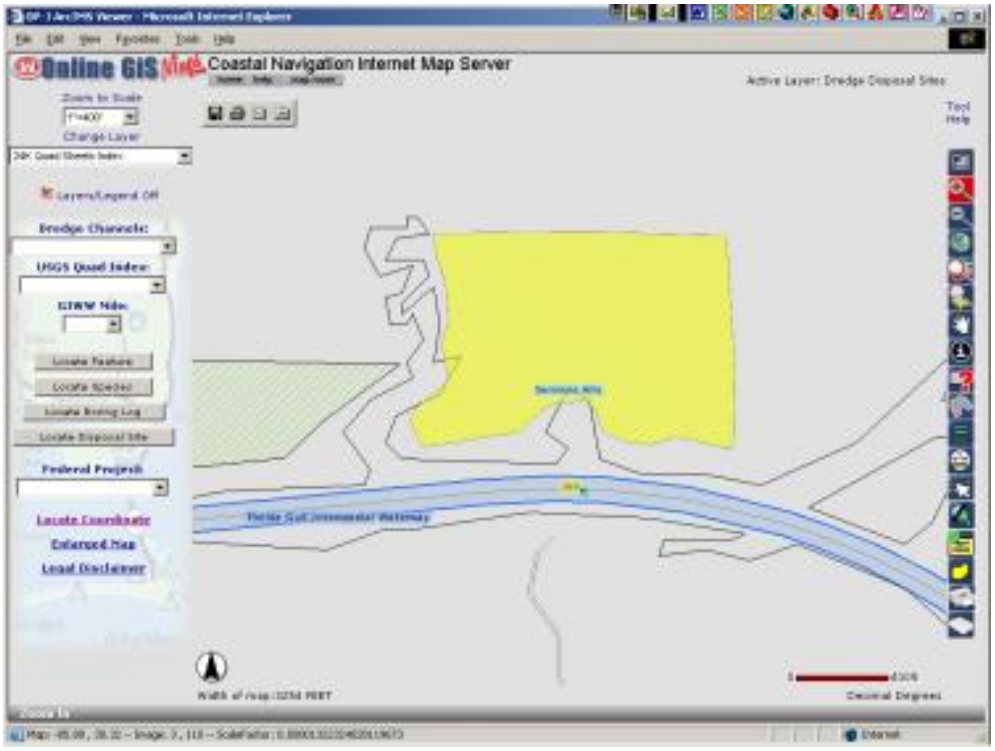


Figure 12. Once disposal area is selected, the map zooms to the location of selected disposal site.

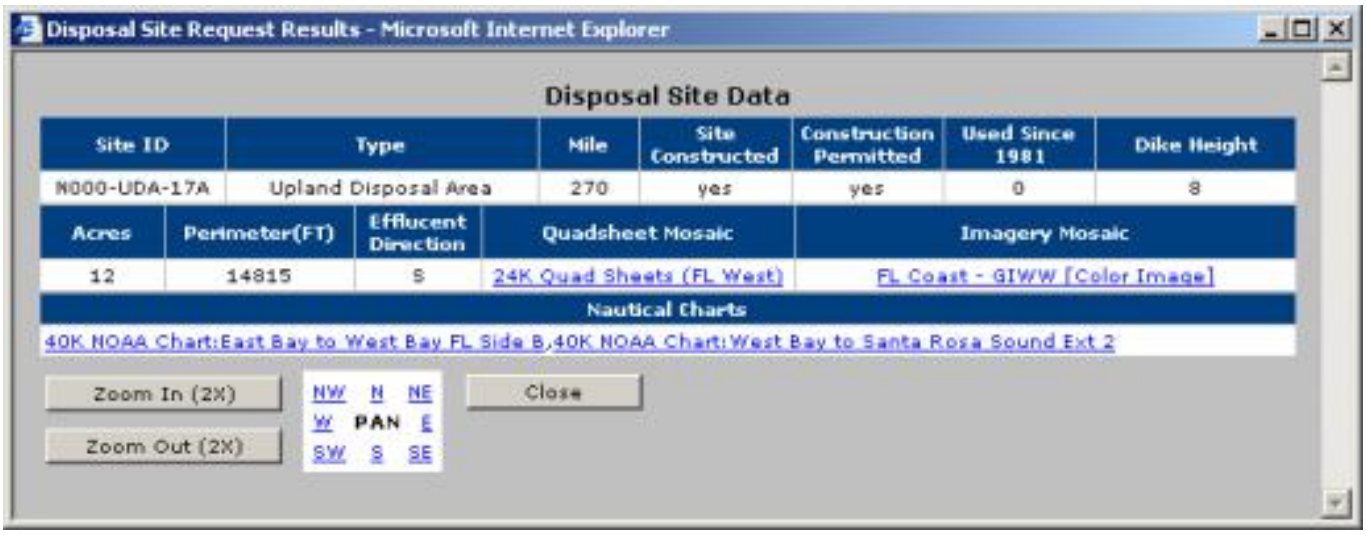


Figure 13. Results for the selected disposal site.

Locate Coordinate: This tool queries the projection information within the IMS. To assist the user, the tool first provides Map Extents, which gives the user a range of valid coordinates (Figure 14). The user can then enter the desired coordinates and the map will locate directly to them. (Figure 15).

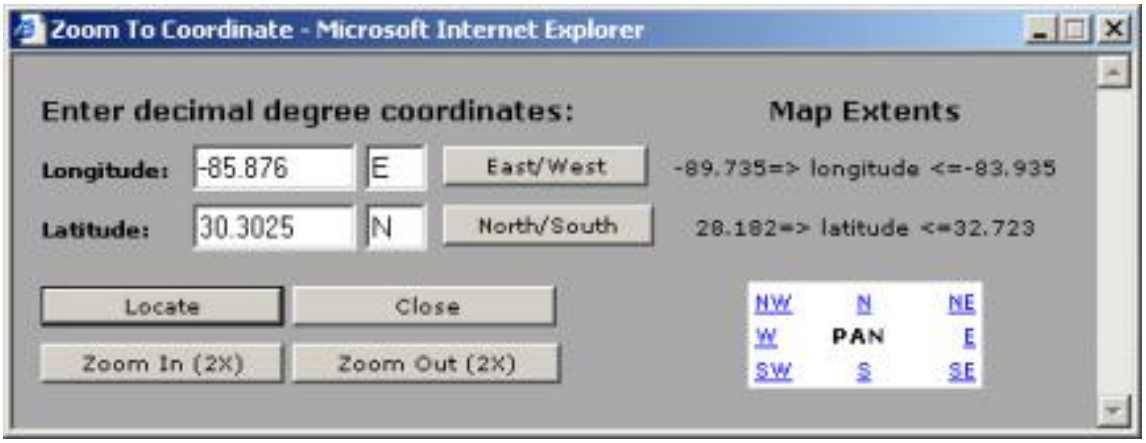


Figure 14. Coordinate Locator and map extents within the ASP application.

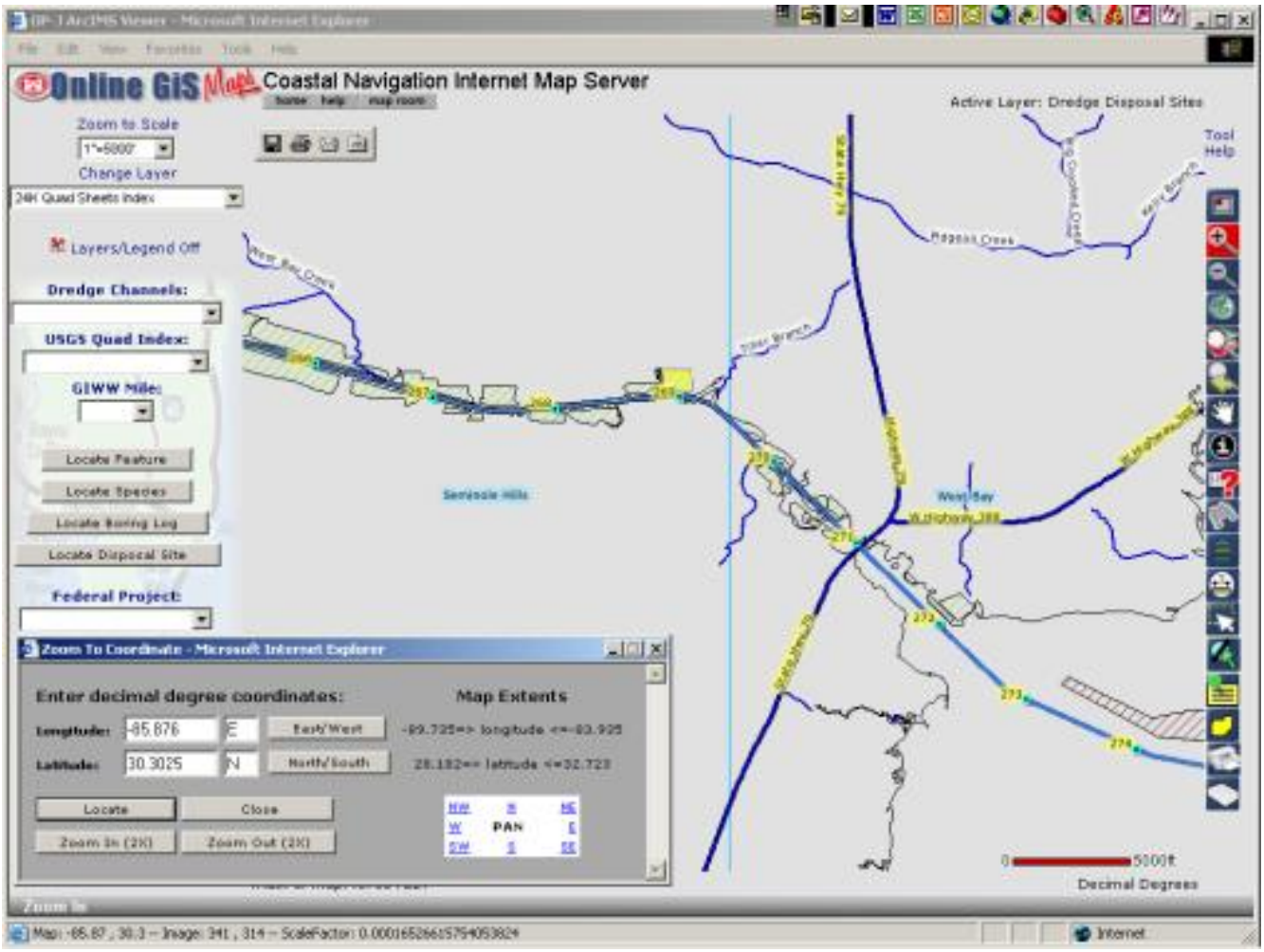


Figure 15. Results on the coordinate search.

Conclusion: The Spatial Data Branch of the USACE Mobile District created a GIS to support the EA for re-certification of the GIWW for the Florida Department of Environmental Protection. The GIS provides baseline information for 300 miles of shoreline including shoreline position, multi-spectral imagery, dredging records, nautical charts, soils, land use, and vital environmental data, to assist in accurate environmental assessment of USACE dredging practices. The Coastal Navigation IMS gives engineers and

biologists access to all data and GIS capability through a simple web browser. Finally, USACE EA findings are available to all Internet practitioners both visually and through the plotting routines. The GIWW ArcIMS can be viewed by accessing the Spatial Data Branch Map Room at http://gis.sam.usace.army.mil/.

Acknowledgement

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