

MANAGING WATERWAY NAVIGATION CHANNELS WITH GIS

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Managing waterways requires quick access and rapid visualization of organized historical and recent navigation channel project information. Project information includes channel information and geometry, recent and historical waterway bathymetric survey, shoaling data, dredged material management area location and characterization, and excellent knowledge of emerging and recurring channel shoaling problem areas. The U.S. Army Engineer Research and Development Center and the Florida Inland Navigation District have sponsored research projects to develop decision management systems to help waterway engineers and managers with the organization, display, reporting and analysis of navigation channel information. Engineers have successfully applied these systems in the management of information from the Jacksonville Harbor, Ft. George, Nassau Sound, East Pass, and Atlantic Intracoastal and Okeechobee Waterways in Florida, St Mary Inlet in Georgia, Northeast Cape Fear and Morehead City Harbor in North Carolina.

INTRODUCTION

This paper describes some of the features of several GIS applications developed for the U.S. Army Engineer Research and Development Center, for the U.S. Army Corps of Engineers Jacksonville and Wilmington Districts, and for the Florida Inland Navigation District. The applications developed provide waterway managers and waterway operations and maintenance (O&M) personnel with quick access and rapid visualization of organized historical and recent navigation channel project information.

Project information in navigation channels includes channel information and geometry, recent and historical waterway bathymetric survey, shoaling data, dredged material management area location and characterization, identification and location of emerging and recurring channel shoaling problem areas.

The applications developed also have tools with capabilities to provide rapid, inexpensive, and reliable capabilities to develop and evaluate navigation channel operations and maintenance (O&M) alternatives based on limited hydrodynamic and sediment transport information. The tools also help engineers identify problem areas of shoaling, characterization of the possible causes of these problems, and development of practical, cost-effective solutions for channel maintenance.

CREATING AND ORGANIZING INFORMATION

The key element behind these applications is the creation of a uniform workspace structure to facilitate the organization and analysis of the channel information. Meeting this objective requires storing projects data in a structured and organized geodatabase.

The second key element of these applications is a series of tools that allow GIS staff to upload the waterway information to the geodatabase, for delivery to waterway and O&M managers. These tools are the channel builder and the survey import tool.

The channel builder tool imports channel components (channel geometry, centerline, stations), from CAD project control sheets and survey templates into the geodatabase and creates 3D surfaces of the channel. The import survey tool imports XYZ survey coordinates to the geodatabase and creates 3D bathymetric surfaces and survey boundaries. The 3d surfaces from channel and surveys are for use with the cross section and volume calculator analysis tools discussed later.

Checking and Correcting Survey Data

Quality control of the survey data is essential in order to upload accurate information to the geodatabase. One of the features of the import survey tool is that it can produce GIS data for review (shapefiles) without storing them in the geodatabase. This way staff has the opportunity to check the quality of the data before it stores in the geodatabase. Figure 1 shows an example of a survey data set that will require further editing and bad data removal.

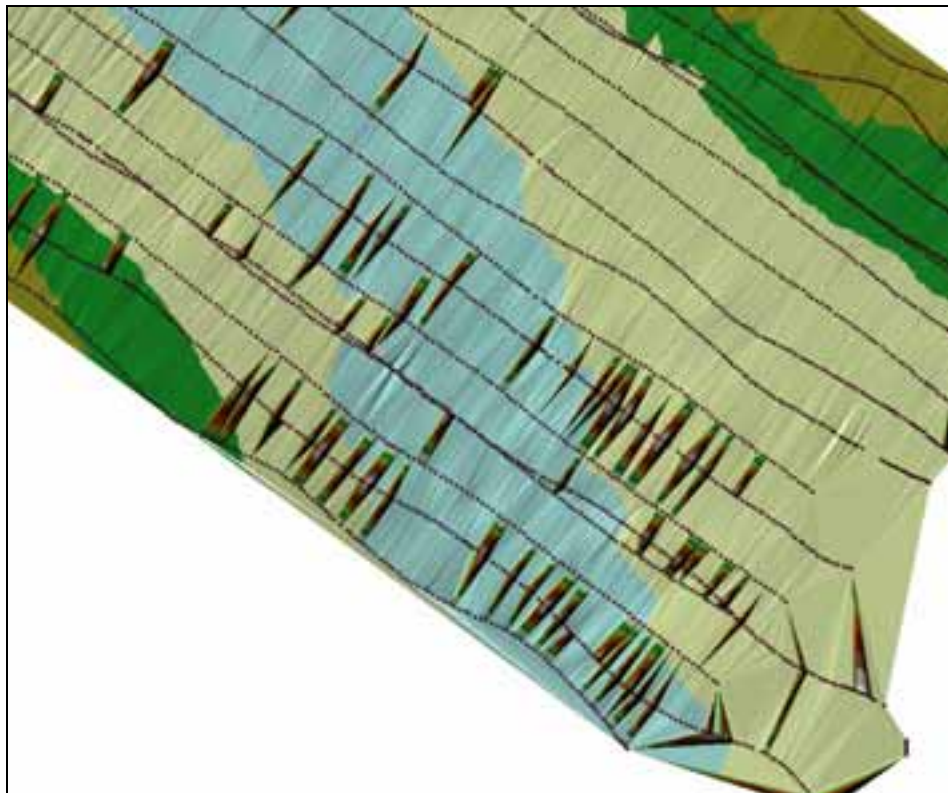


Figure 1 3D Survey Surface with Bad Data

WATERWAY MANAGERS ACCESS TO COMPILED INFORMATION

Once the information is stored in the geodatabase GIS staff may organize the data in ArcGIS documents (Figure 2) or publish it for Arc Reader use (Figures 3 and 4). The data display capabilities of either application — ArcMap or ArcReader — provide managers rapid access to organized information, in addition to the visualization and query capabilities.

The Arc Reader application, prepared for FIND although easy to distribute, and share with interest parties, lacks the ability needed in the case of O&M managers to further analyze the data. However the objective of that application was easy access to information by non ArcMap users.

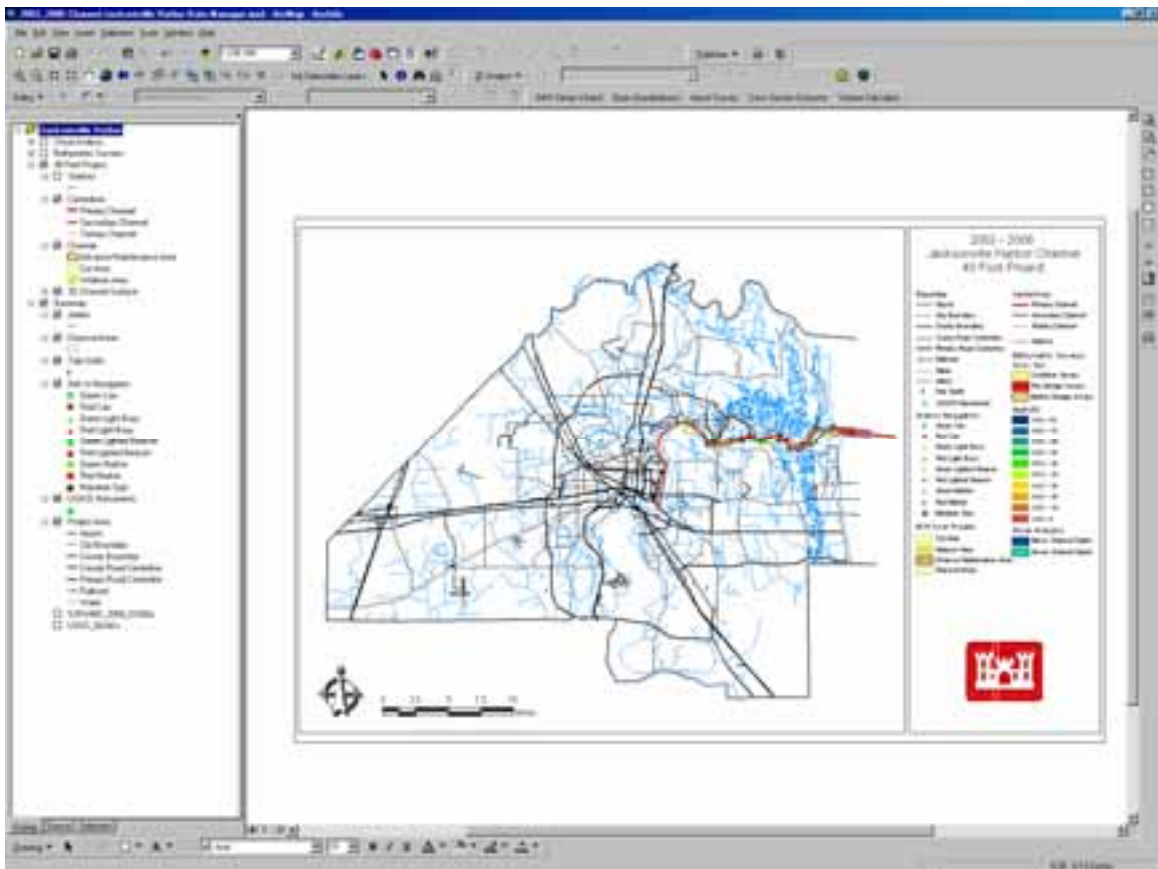


Figure 2 Jacksonville Harbor Project ArcMap Project Prepared for the USACE Jacksonville District.

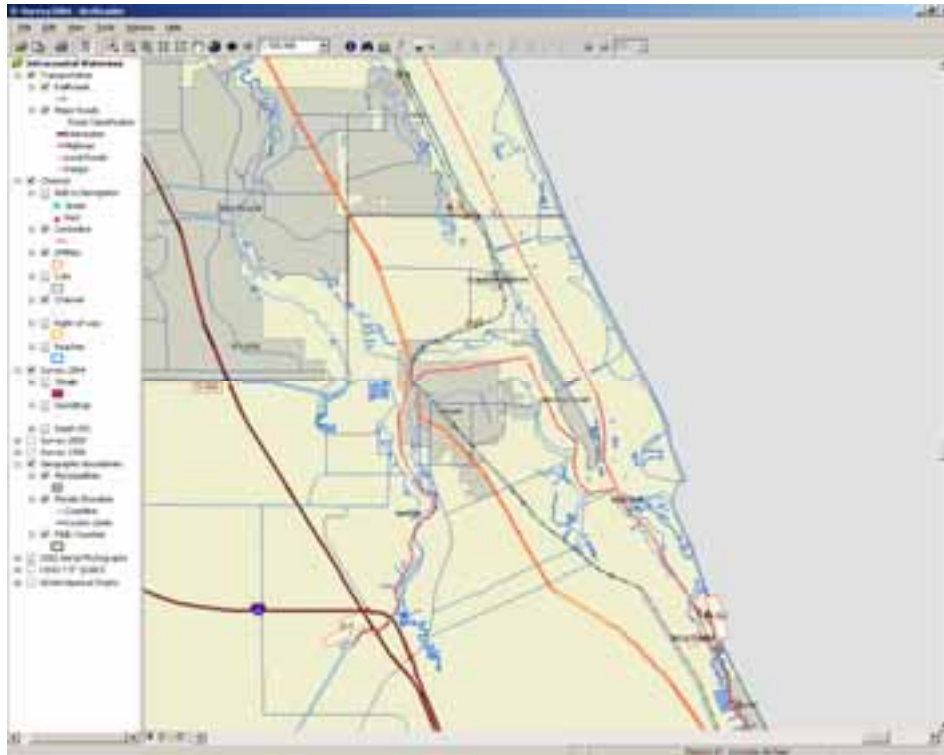


Figure 3 Atlantic, Intracoastal, and Okeechobee Waterway Project developed for FIND

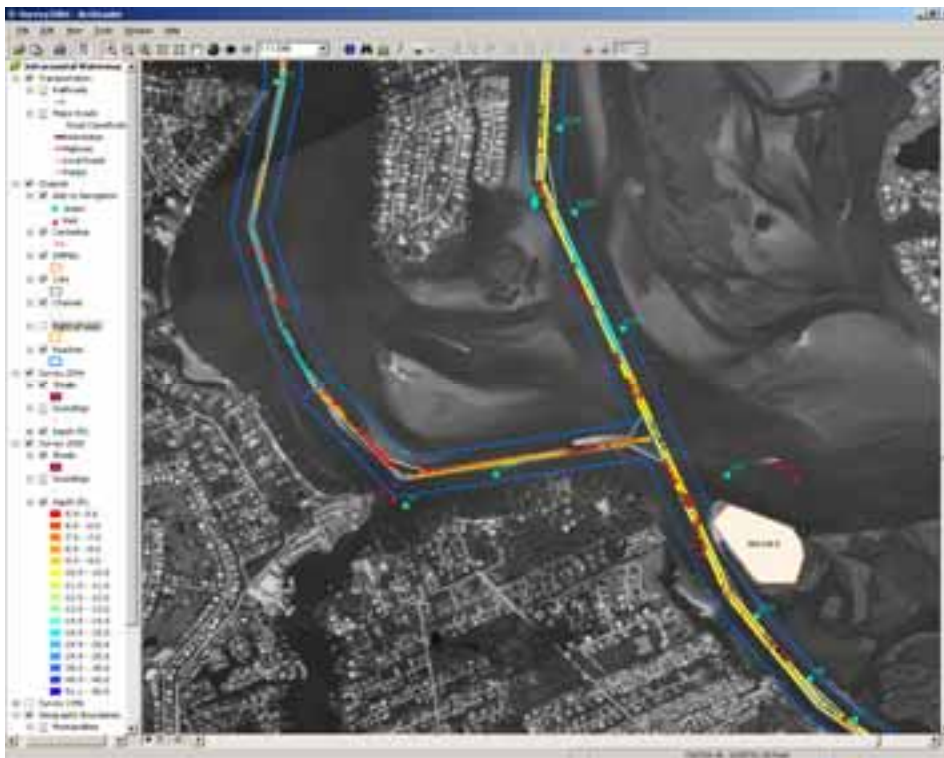


Figure 4 Jacksonville Harbor Project ArcMap Project Prepared for the USACE Jacksonville District.

ANALYSING AND INTERPRETING WATERWAY INFORMATION

This section describes a set of tools developed for the USACE Jacksonville District to further analyze the data stored in the geodatabase. Keeping the waterways navigable in the most cost effective way is one of the goals of the O&M. Channel cross sections, and quantification of shoaling rates based on the evolution of shoals are two ways to analyze the maintenance need of a navigation channel over time, and to collect information to prioritize dredging locations and maintenance intervals.

Extracting Cross Section from 3D surfaces

The Cross Section Tools allow the user to extract, plot, print, and export multiple cross sections from multiple 3D surfaces. The cross section tools include a cross section extractor tool and a cross section plotter tool. With the cross section tool waterway managers can extract multiple cross section data from tin surfaces, visualize the cross sections, print the plot and, export the cross section data.

The following example illustrates the application of the Cross Section Extractor and Plotter Cross Section Tools from a waterway operation perspective given the existence of survey and dredging event information. Figure 5 compares bathymetric data from survey taken between 1999 and 2000 in a section of Jacksonville Harbor's 38 ft channel (Cut 48). The cross section's starting point begins on the right side of the channel (to right of the centerline going west); accordingly, the plot's x-axis zero represents the right side of the channel.

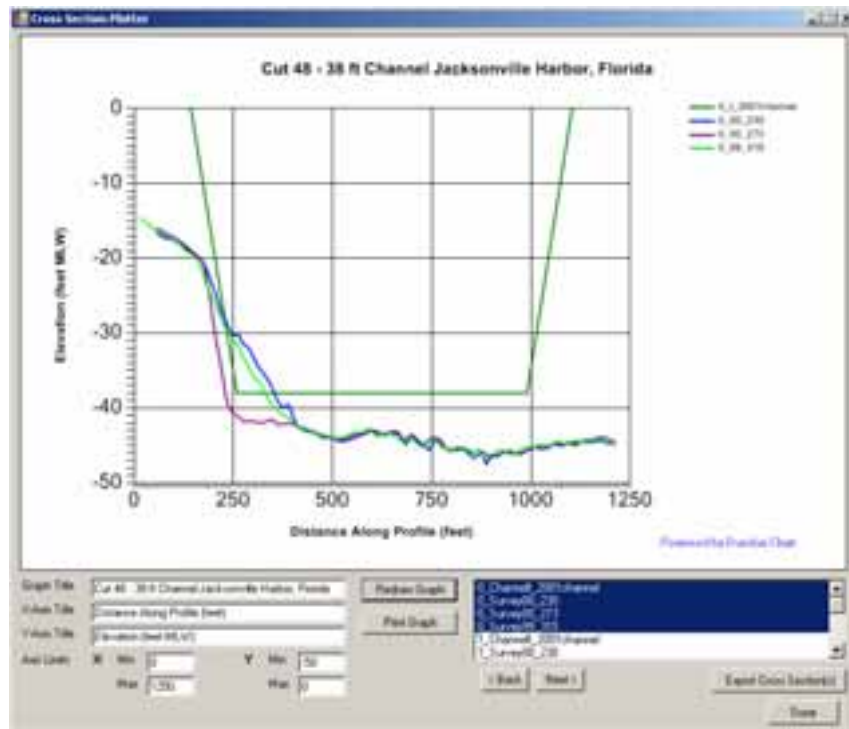


Figure 5 Cross Section Plotter Tool

Table 1 lists the selected survey's characteristics and the dredging events that occurred between those surveys.

Table 1 Selected Surveys and Dredging Events

Survey Name	Survey Date	Survey Type
99-315	December 1999 – February 2000	Condition
00-230	August 2000	Before Dredge
Dredging Event DACW17-00-C-0018		
00-273	September 2000	After Dredge

The combined analysis of figure 2 and Table 1 show that the September 2000 dredging event removed the shoal observed in the northern bent of the channel (right side) (deeper profile of the after dredge survey 00-273 (in purple)). This type of information can be very useful to assess the success of a dredging event.

Calculating shoal volumes and comparing bathymetries

The volume calculator tools allow managers to quickly calculate changes in volume between two 3D surfaces and to identify and extract shoal boundaries. The Volume Calculator tools include the Volume Calculator Tool and the Shoals Boundary Extractor Tool. The following example illustrates the application of these tools. Figure 3 shows the volume and shoal boundary of a before dredge 3D surface for the Jacksonville Harbor channel Cut 47 through Cut 50.

Table 2 shows the summary of the calculated shoal volumes and the yearly shoaling rates for the three surveys shown in Figure 6. The table depicts the shoaling history of Cut 48 and 49 between January of 1999 and September of 2000.

The survey history in Table 2 includes elapsed time between surveys. The elapsed time forms the basis for the yearly shoaling rate calculation. Each dredging event serves as a “reference event” to calculate shoaling rates between surveys.

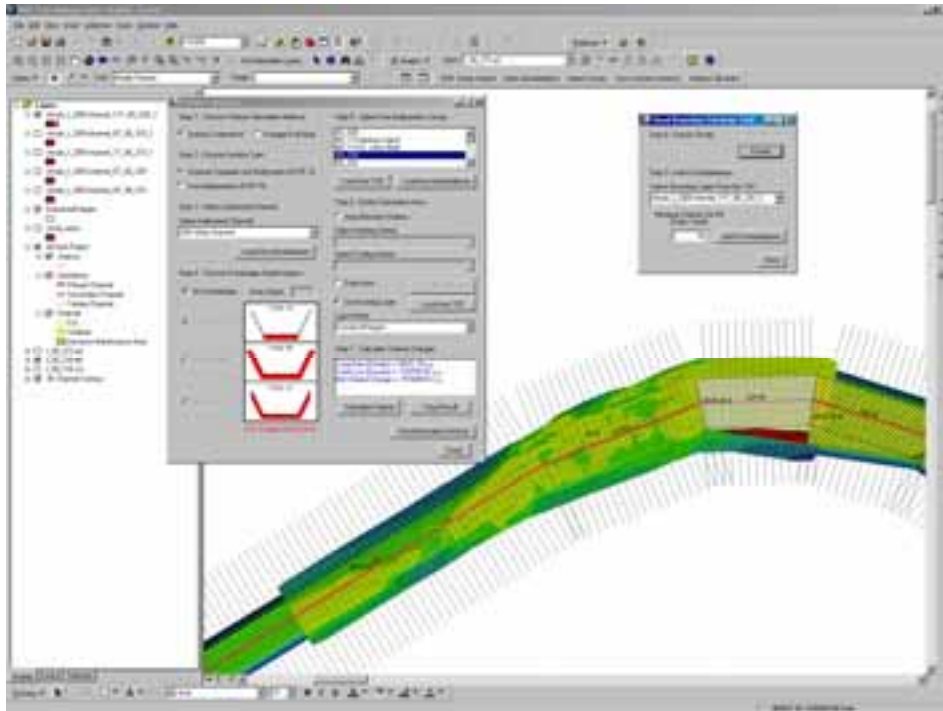


Figure 6 00_230 Before Dredge Survey Shoal Volume and Boundaries for Cut 48

Table 2 Cut 48 and 49 Volume and Shoaling Rate Analysis

Survey			Volume (cubic yards)		Shoaling Rate (cubic yards / year)	
Name	Date	Type	Cut 48	Cut 49 w/ widener	Cut 48	Cut 49 w/ widener
99-315	January 2000	Condition	10353	144		
00-230	August 2000	Before Dredge	18101	258	4645	68
Dredging Event DACW17-00-C-0018						
00-273	September 2000	After Dredge	4.45	51.59	–	–

CONCLUSIONS

Engineers have successfully applied these systems in the management of information from the Jacksonville Harbor, Ft. George, Nassau Sound, East Pass, and Atlantic Intracoastal and Okeechobee Waterways in Florida, St Mary Inlet in Georgia, Northeast Cape Fear and Morehead City Harbor in North Carolina. The examples described here show the main features of the applications. Further development of tools to help manage waterway navigation channels are currently being considered

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