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Regional Morphology Analysis Package (RMAP): Part 1, Overview

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PURPOSE. This Coastal and Hydraulics Engineering Technical Note (CHETN) describes the Regional Morphology Analysis Package (RMAP), an integrated set of tools developed for manipulating, analyzing, visualizing, and archiving data on shoreline positions and beach profiles in a georeferenced environment on a personal computer. Information can be referenced to and displayed on aerial photographs and maps. Data types and analysis procedures, which were developed to support regional as well as local project studies, are applicable to coasts, estuaries, and rivers. This technical note provides an overview of RMAP. Future technical notes in the RMAP series will describe specific features and new capabilities.

BACKGROUND. RMAP evolved from the Beach Morphology Analysis Package (BMAP) (Sommerfeld et al. 1993, 1994, Wise 1995), which was conceived to simplify and automate numerical modeling work flow and associated analysis of beach profile data and results of computations from SBEACH (Storm-induced BEAch CHange Model, a numerical model for simulating storm-induced beach profile change; see Larson and Kraus 1989, Larson et al. 1990). Although BMAP provides a robust toolset for profile analysis, it is limited to data in distance-elevation space. BMAP requires the user to discard the geospatial aspect of profile data, essential in data assembly and quality control. Regional analysis requires manipulation of another type of two-dimensional (2-D) data, the shoreline, which is georeferenced. Numerical simulation models under development in the Regional Sediment Management (RSM) program involve manipulation of data and corresponding outputs in a georeferenced coordinate system, often over wide geographic areas and different coordinate systems. These and other US Army Corps of Engineers' needs identified at a field data collection workshop were the stimulus for creation of RMAP.

Typically, analysis of beach profile and shoreline position data requires several software packages. On the other hand, the engineering and numerical modeling work environment calls for tools directly supporting workflow from the original surveys to quality control, analysis, and input to a project report or model. RMAP contains a comprehensive set of analysis and visualization tools required for project workflow, from the import of raw data and coordinate conversion through detailed analysis to report quality graphics. RMAP supports analysis of beach profile, channel or river cross-sectional data, and shoreline position data for engineering and science applications. Capabilities extend from generation of spatially referenced shoreline change maps to a large suite of beach profile analysis tools. Data can be examined in both cross-sectional and map views to simplify data assembly, quality control and assurance, data analysis, and generation of report figures. The map viewer supports the display of profiles, shorelines, aerial imagery and ArcView© shapefiles in a geospatial environment. Data options allow storage, organization, and analysis of data in a single application, with support for a variety of import/export formats. Chart options allow tailoring of graphics to personal needs, supporting export of images and direct copy and paste into word processing software. Metadata can be stored at project, group, or individual data item levels. RMAP is backwards-compatible with

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BMAP project files and supports calculation of geographic coordinates from reduced distance-elevation data pairs.

This technical note summarizes present capabilities of the RMAP software. Planned work in the RSM Program will add routines to RMAP for analyzing and visualizing three-dimensional (3-D) (X,Y,Z) data, where X and Y denote horizontal coordinates, and Z denotes the vertical coordinate. In addition, the final version will include relational database capability to archive and access large data in space and time that are often encountered in RSM applications.

RMAP INTERFACE. RMAP runs in the Microsoft Windows® environment and requires computer resources available on typical personal computers. The RMAP interface comprises four main features (Figure 1).

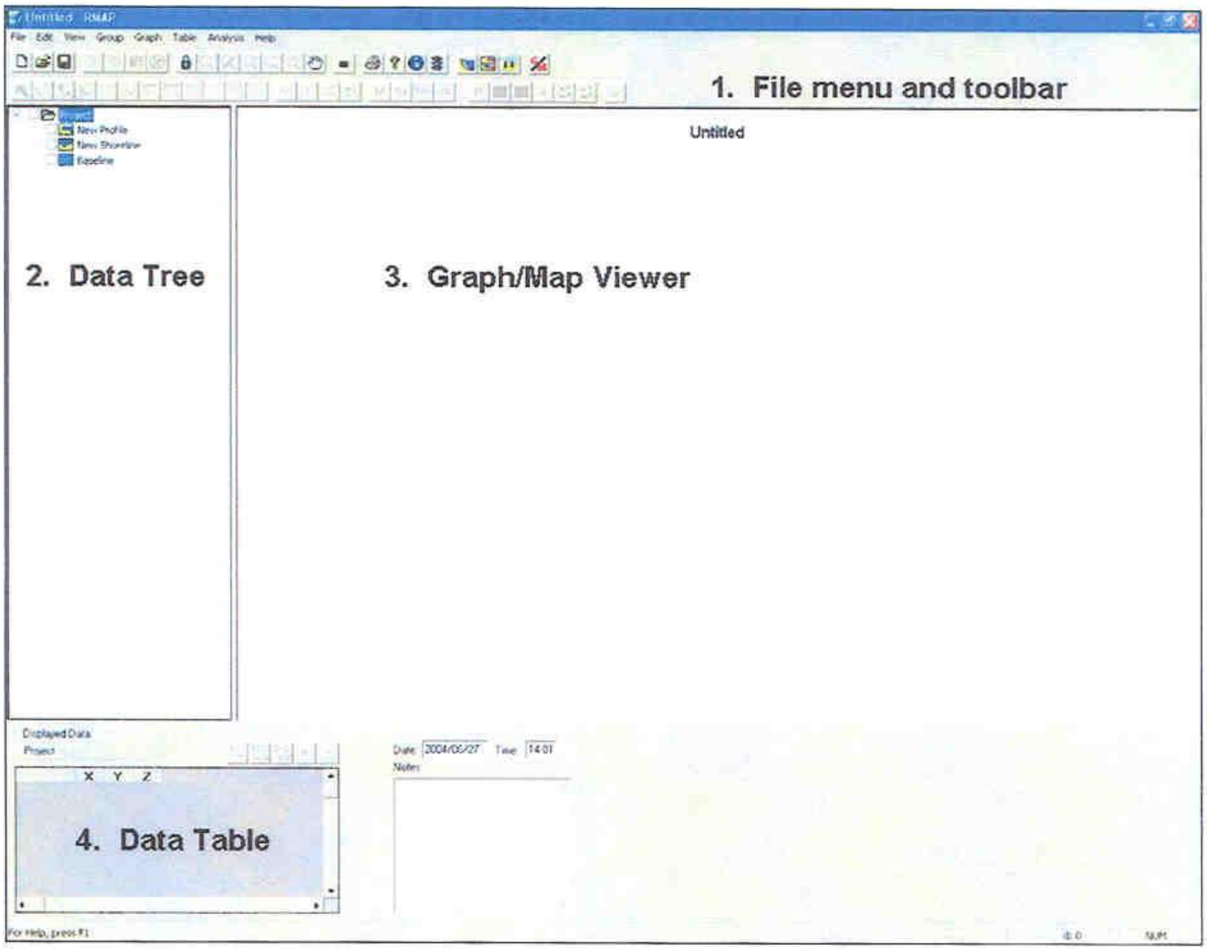

Figure 1. The RMAP interface is comprised of (1) file menu and toolbar, (2) data tree, (3) graph/map viewer, and (4) data table.

- **File menu and toolbar:** Data import/export, analysis functions, and viewer controls are accessed through the file menu and toolbar.
- **Data tree.** The data tree displays data items present in the software package and allows selection of multiple items for batch conversion or analysis.

- **Graph/map viewer.** The graph/map view window supports visualization of data by cross section in graph mode and plan view in map mode.
- **Data table.** The data table allows the user to view and edit data for each item in the data tree. This area also stores the time stamp of the data entry and allows the user to store comments on each item in the data tree.

File Menu and Toolbar. The RMAP file menu provides access to functions common in Windows applications (such as *Save*, *Open*, etc.), and those functions unique to RMAP, such as graph controls, data grid functions and profile and shoreline analysis tools. Many functions can also be accessed from the RMAP toolbar, where they are grouped by functionality (Figure 2). Functions unique to RMAP are discussed here.

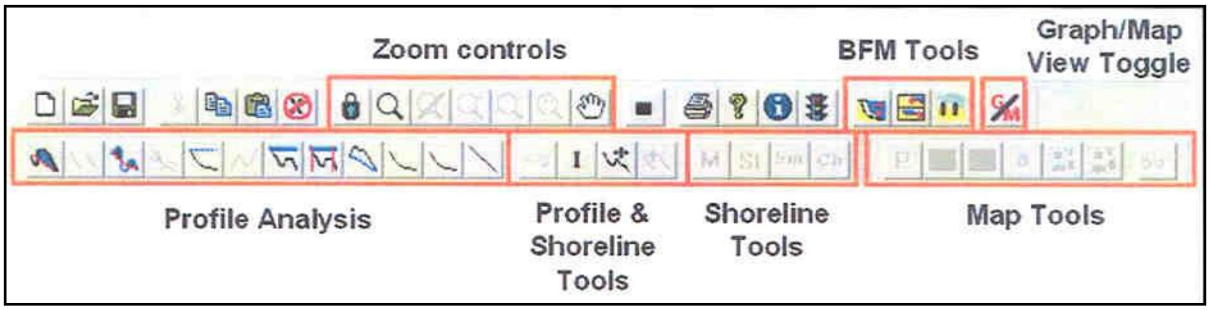

Figure 2. RMAP toolbar is organized by file/program functions, zoom controls, Beach Fill Module tools, profile analysis, shared profile and shoreline tools, shoreline tools and analysis, and map tools.

Items under the *File* menu support import/export of project data from ASCII text files or the RMAP free format. The RMAP freeformat allows users to import entire data sets at once, or archive RMAP projects into an ASCII text file that can be accessed by spreadsheet applications or text viewers. The *Edit* menu allows access to data management functions for the data tree, project options and settings. Multiple items in the data tree can be moved, copied or deleted using the item checkboxes and the command under the menu. Also, coordinate conversion for single or multiple items is performed here. For beach profiles, tools are provided to calculate distance D from the transect origin (X,Y to D) or to calculate geographic coordinates from a transect origin along an azimuth (D to X,Y). The project options dialogue allows the user to specify the project units, store project metadata and name the project. The *View* menu allows the user to toggle the toolbars, status bar, and data table on or off.

Items in the data tree can be sorted by date or name (alphanumeric). The *Group* menu allows the user to add or delete groups or data tree items. This is also accomplished by right-clicking the mouse in the data tree. The *Graph* menu accesses options for the graph control. The graph appearance is customizable by the user, including background colors, line colors, width, axes scaling, etc. This menu also allows the user to export beach profile data plotted in the graph view to SBEACH. Future export options will include output to the GENESIS and CASCADE models, and to the Sediment Budget Analysis System (SBAS). The *Table* menu allows the user to insert and delete rows in the data table, as well as write protecting data. The *Analysis* menu contains analysis tools and algorithms for beach profile and shoreline data. The following sections discuss these tools. Finally, the *Help* menu provides user support and access to documentation on the analysis routines.

Data Tree. Data are managed and selected for analysis in the data tree. The data tree in RMAP displays and organizes project data into three categories: beach profiles, shorelines and baselines, each identified by a unique icon (Figure 3). Data can be brought into RMAP by importing from ASCII text or RMAP free format, copying and pasting from spreadsheet applications, converted from ArcView© shapefile format (shorelines and baselines only), or entered into the data table by the user. Data tree entries are generated and named automatically when importing profile, shoreline, or baseline data into RMAP from ASCII text. In copying and pasting data into RMAP, data tree entries must be created first and then renamed by the user.

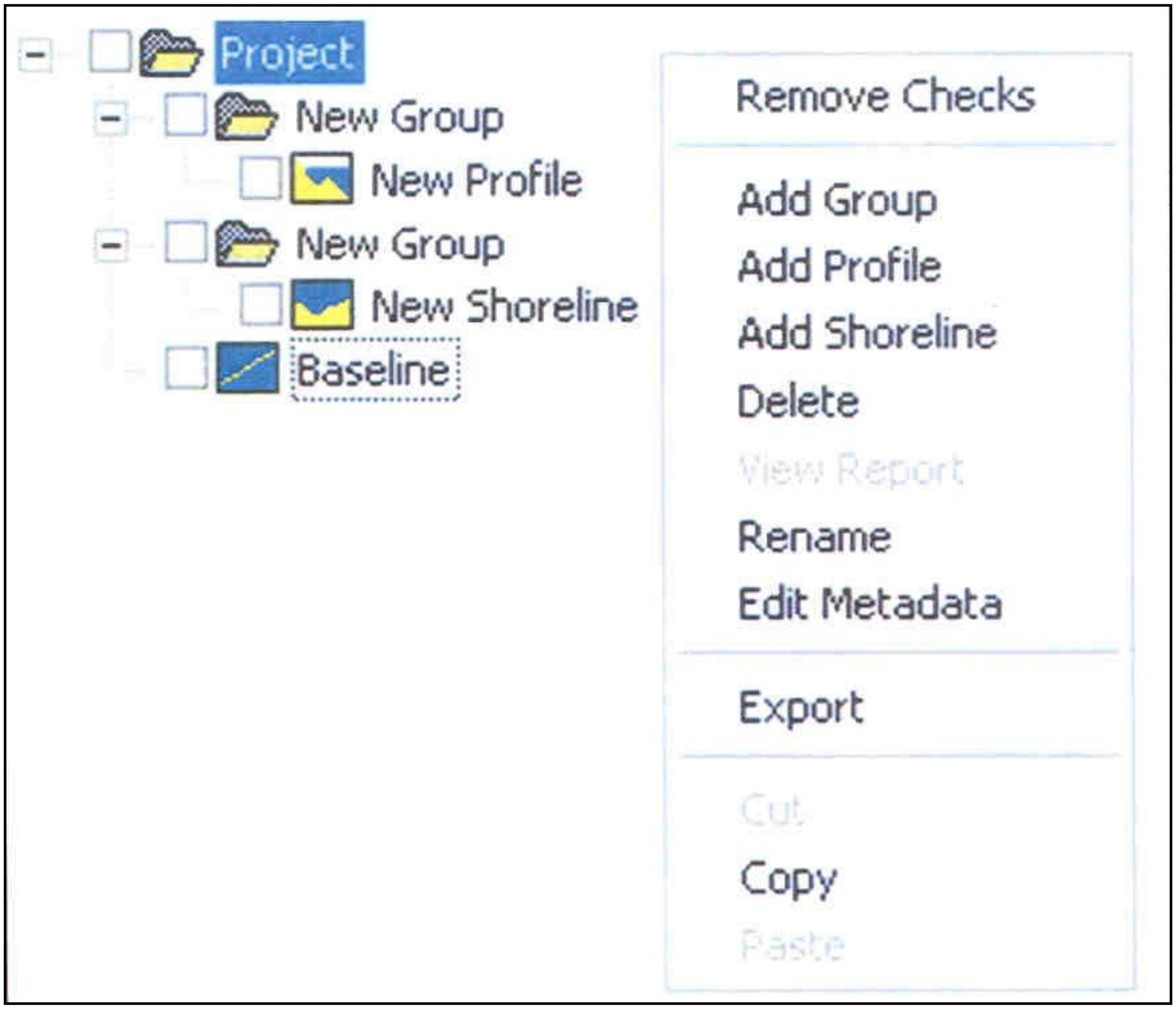

Figure 3. RMAP provides for three types of items in data tree: (a) profiles, (b) shorelines, and (c) baselines. Unique icon in data tree identifies each type.

Items can be arranged into groups and subgroups under the *Project* menu. Data items can be sorted by date or name, or manually sorted by the user by dragging and dropping in desired order. Metadata settings include origin location and transect azimuth for profiles and definition for shorelines (e.g., high-water line (HWL), wetted bound, and others (Kraus and Rosati [1998]).

A data item is plotted in the graph/map viewer and made available for analysis by activating the selection box beside the data type icon. The selection box also provides a means of copying, pasting, moving, and deleting multiple data items in the tree. In addition, selection boxes are used to conduct analysis functions, coordinate conversion, and distance calculations for multiple items.

Graph/map Viewer. The graph/map viewer provides visualization of both profile and shoreline data in graph (cross-section) or map (plan) views. The window is toggled between the two views by means of the RMAP toolbar (Figure 2). Data are plotted in the viewer by activating the selection box next to the item. In graph view, a typical cross section plot is generated in the viewer (Figure 4). The plot legend is automatically generated on the plot as data are added. Plot axes adjust to the full extent of plotted data; however, the user can manually set the axis extent. The user can zoom into areas of interest and pan around the viewer to investigate data. Data values in the view automatically refresh as the data table is edited. The user has full control over graph appearance with the options available under the *Graph* menu.

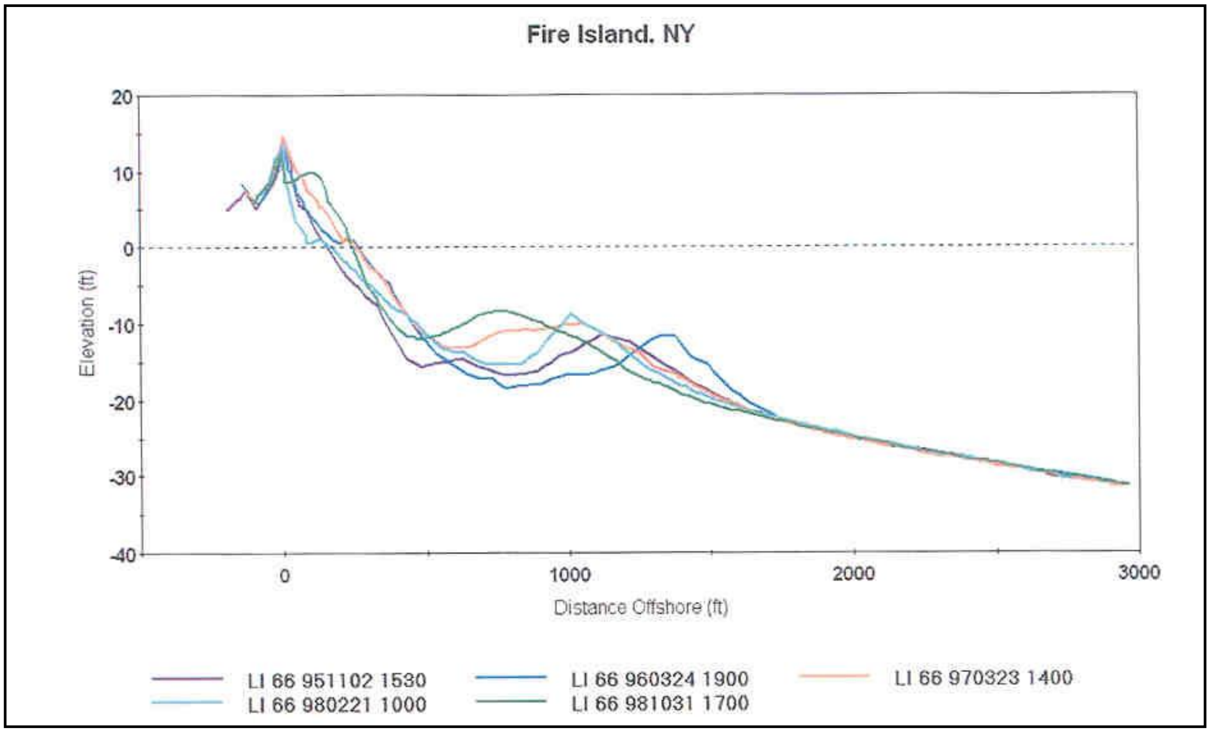

Figure 4. Example of cross-section plot of beach profile data in RMAP. Data legend is generated automatically as data are added to plot. Plots can be copied directly from RMAP into word processing applications.

The map view allows visualization of spatially referenced profile, shoreline and baseline data, in addition to geo-referenced aerial photography and ArcView© shapefiles. The ability to view data in plan view overlaid with ground imagery assists with data assembly, quality control, and data analysis. Each item is labeled according to the object name in the data tree as it is added to the view. Labels, feature items, and legends can be edited individually or as a group. The display properties of all items in the map view can be customized to individual preferences in the map properties dialogue (Figure 5).

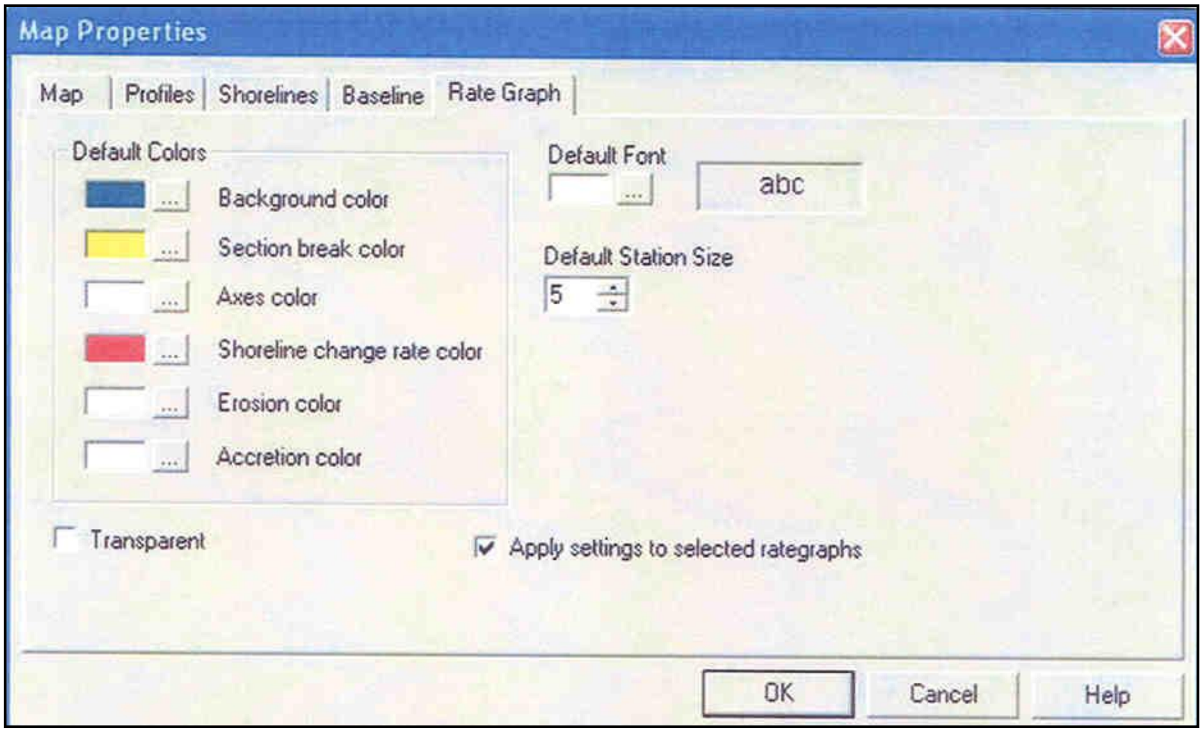

Figure 5. RMAP allows extensive customization of visual properties of all items featured in map view (illustrated here are available options for shoreline change maps).

RMAP supports a variety of geographic and projected coordinate systems, including North American Datum (1927 and 1983), Geographic Coordinate Systems, US State Plane, Universal Transverse Mercator, and World Geodetic System coordinates, in addition to many other systems in use worldwide. Units can be in either feet or meters. The user selects the project coordinate system in the map view properties; all data imported into RMAP can be then be converted to the project datum from within the application (Figure 6). Once the conversion is complete, the data table is refreshed with the new coordinates, and the conversion is recorded as metadata in the "Notes" section of the data table (Figure 7).

Shoreline analysis is directly supported in the map view. RMAP allows the user to calculate change rates between two shorelines from a user-defined baseline. Shoreline analysis transects are established perpendicular to the baseline at a user-specified interval, and then shoreline change and change rates can be calculated at each transect along the baseline. Shorelines and baselines can be imported from text, converted from ArcView© shapefiles, or drawn in the map viewer. Tools are provided to allow the user to annotate shoreline position on a photograph, creating a geo-referenced shoreline entry in the data tree on completion. After shoreline analysis is complete, RMAP generates an analysis report (Figure 8), a spatially referenced shoreline change map (Figure 9), and a shoreline change rate plot in graph mode (Figure 10).

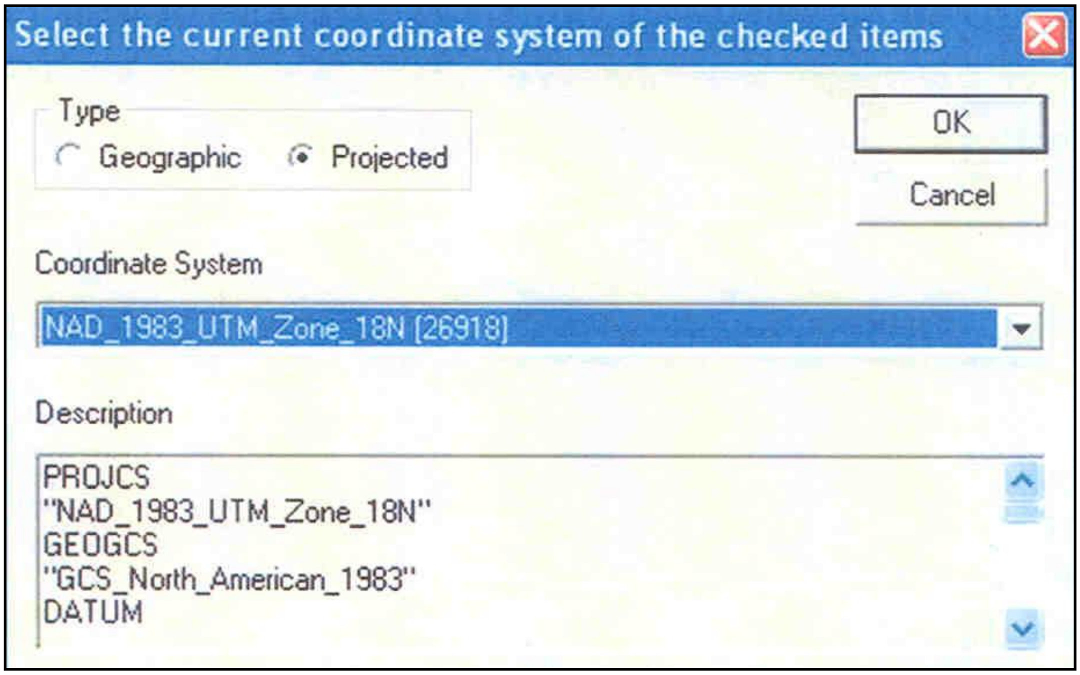

Figure 6. Beach profile, shoreline, and baseline coordinates can be converted to project coordinate system within RMAP using coordinate conversion dialogue box.

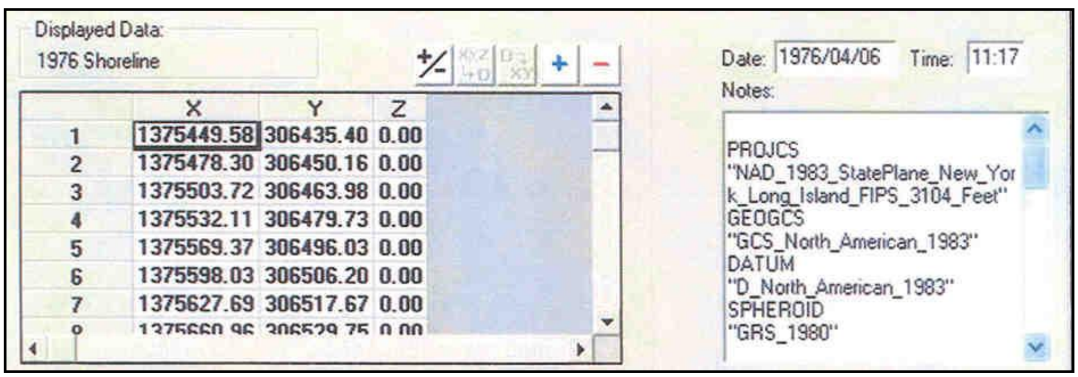

Figure 7. Coordinate conversions are recorded under item notes, located in data table.

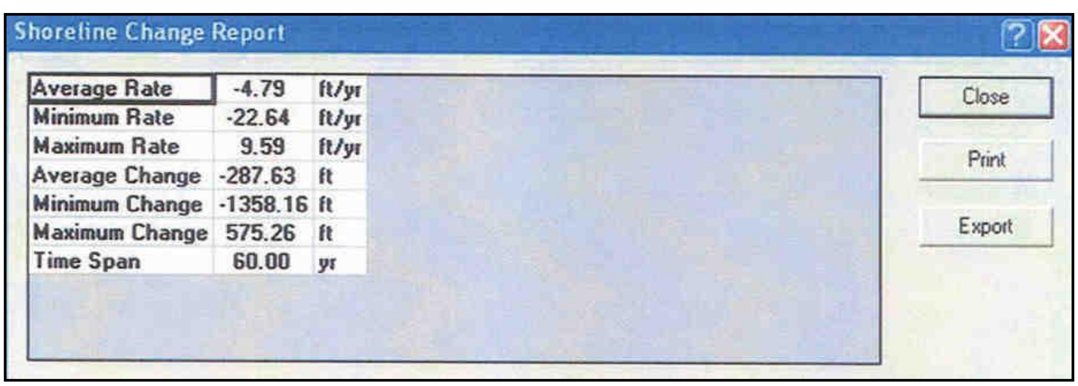

Figure 8. Shoreline change report. Average, minimum, and maximum shoreline change, and change rates are given.

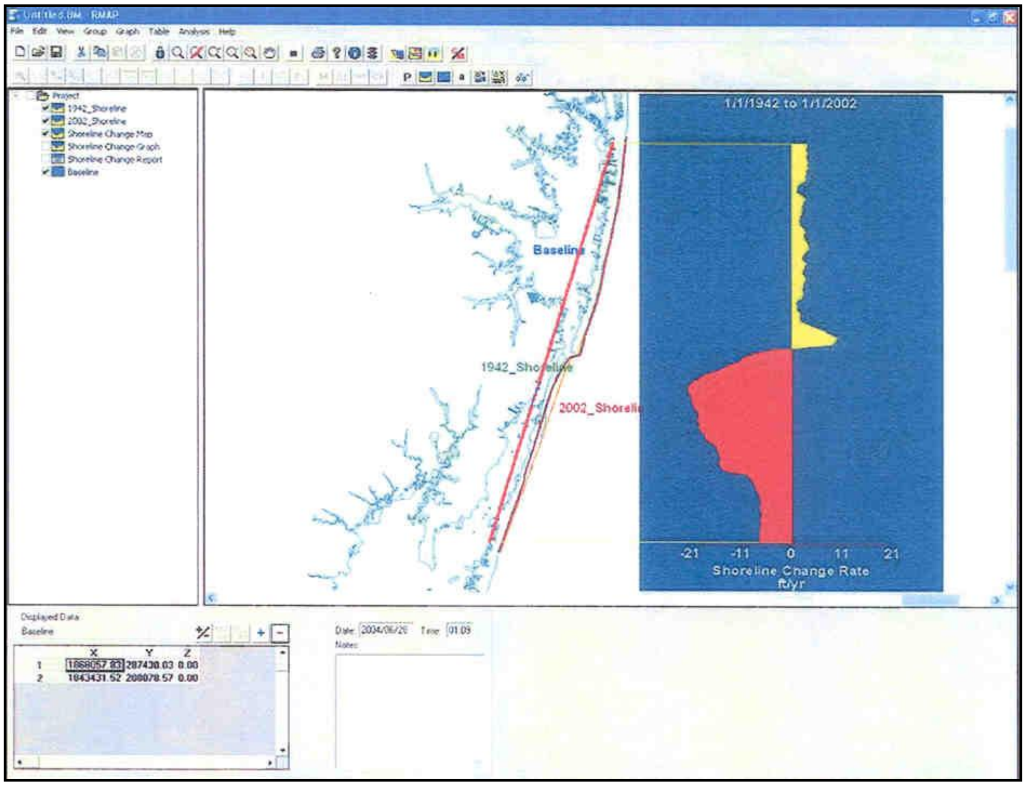

Figure 9. Spatially referenced shoreline change rate map for eastern shore of Maryland showing erosion downdrift of Ocean City Inlet.

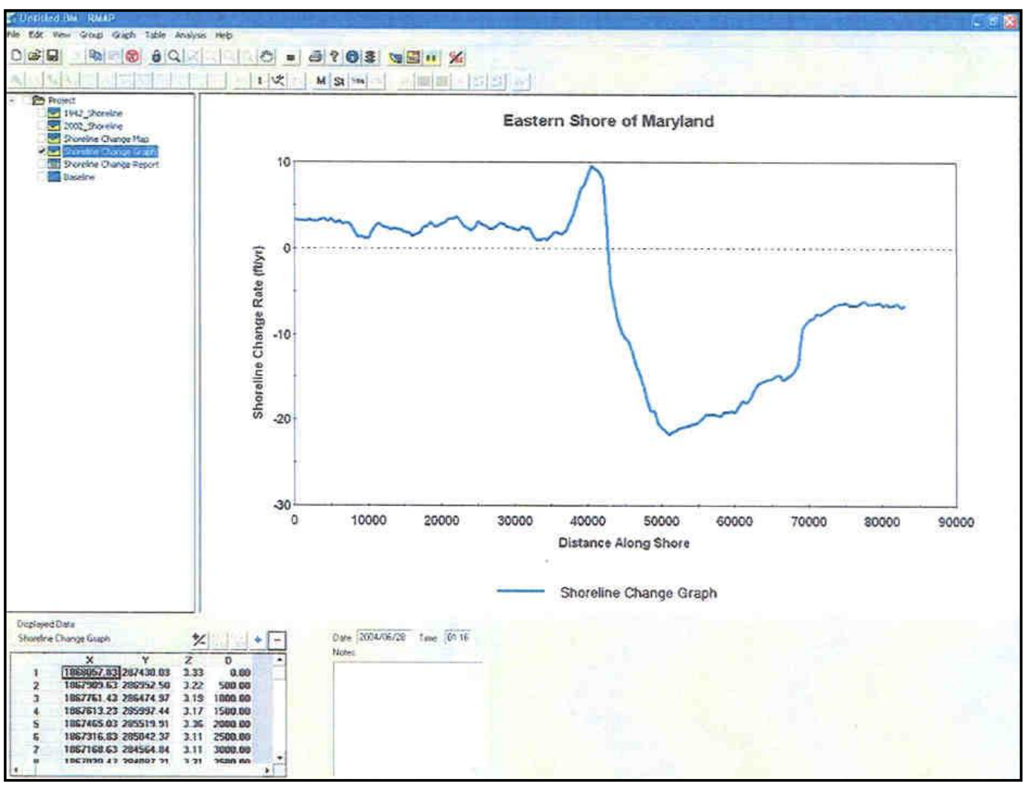

Figure 10. Traditional shoreline change rate plot is available in graph mode.

Profile data are also projected in the map view, simplifying the creation of base maps, easing data assembly and streamlining quality control of data. As profile data are plotted, a color map elevation gradient is generated along the profile line to allow the user to distinguish shallow and deep portions of the profile (Figure 11). Profile overlap, distance off the transect azimuth, and the overall goodness of fit of the data are easily evaluated by switching back and forth between map and graph modes (Figure 12). Ready availability of map and graph modes makes convenient the translation or shifting of data, because results can be easily evaluated in both cross-section and plan views.

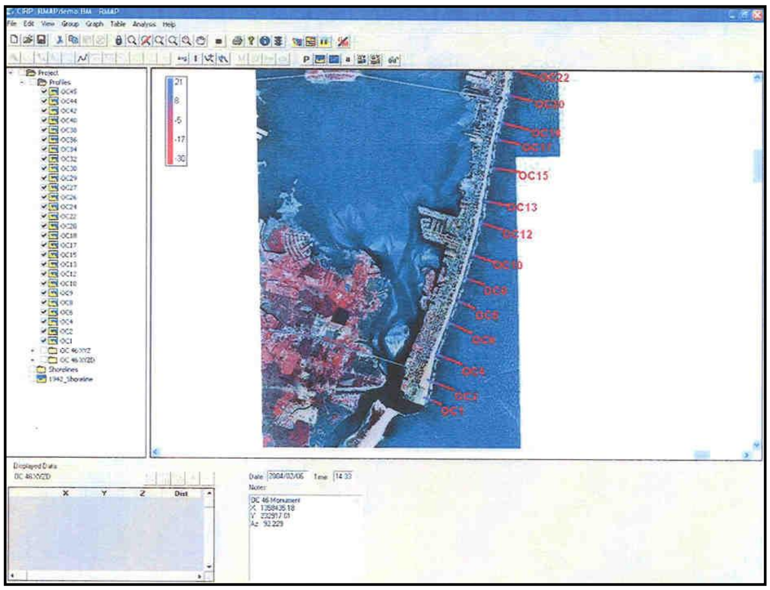

Figure 11. Profile data plotted in may view with geo-referenced aerial photography in background.

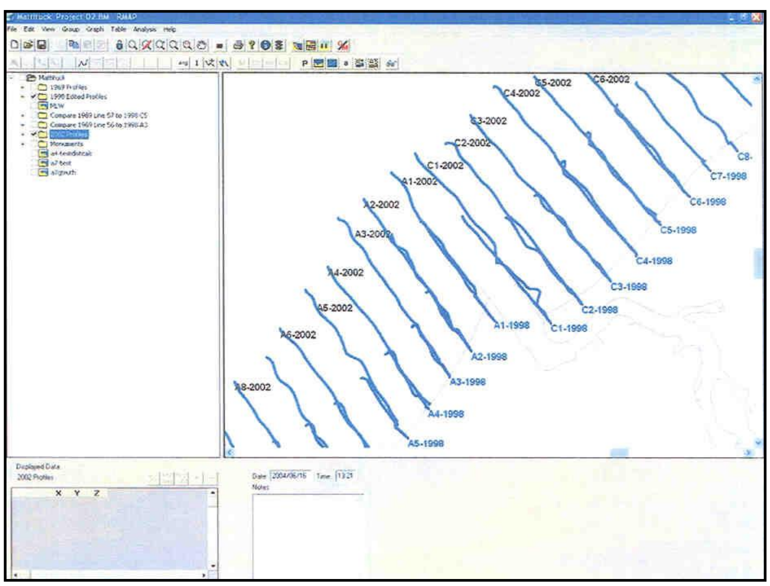

Figure 12. Map view allows investigators to view profile data in plan view, simplifying project data assembly and quality control of successive survey data.

Data Table. The data table allows the user to view and edit the time stamp, coordinate, elevation and distance values for each item in the data tree (Figure 13). A "Notes" Window is also provided to allow storage of metadata for individual items. Data in the grid are edited in a fashion similar to standard spreadsheet applications. Formats for the different data types are described in the following paragraphs.

For beach profile data, the grid contains four columns: geographic horizontal coordinates (X and Y), elevation (Z), and distance (D). Tools are provided in the data grid for calculation of distances along the transect from the geographic coordinates, in addition to calculation of the geographic coordinates from distance elevation pairs given profile origin coordinates and transect azimuth. Consideration was given for accommodating BMAP project files while implementing RMAP coordinate capabilities. BMAP data columns (distance/elevation pairs) are automatically assigned to the Z and D columns on opening. In addition, data are assigned to different columns depending on the number of columns present: pasting two columns places data in the D and Z columns; pasting three columns places data in the X, Y, and Z columns; or pasting four columns places data X, Y, Z, and D columns. Shoreline and baseline data types have three data columns: geographic horizontal coordinates (X and Y) and elevation (Z), though in the case of baseline data, the Z column is not applicable.

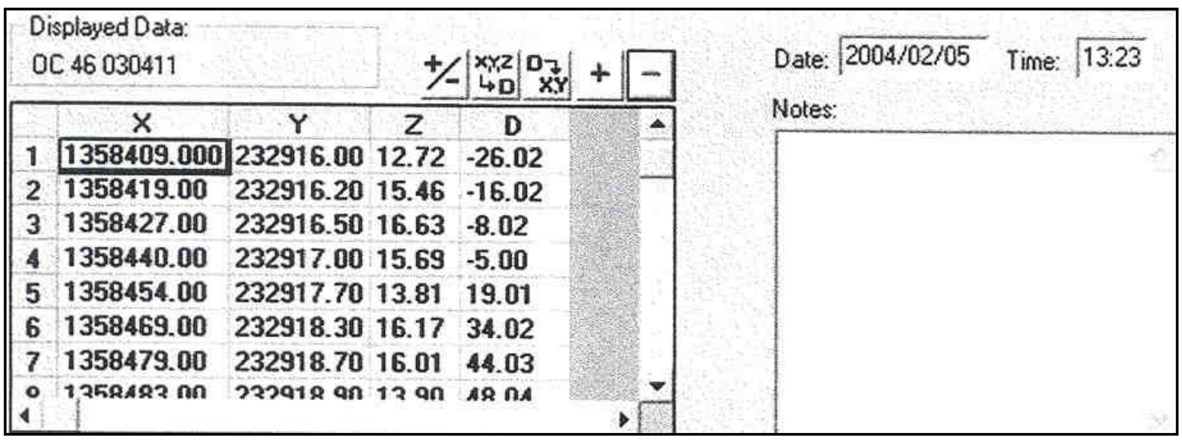

Figure 13. The data table in RMAP allows user to edit items in spreadsheet format and store documentation relating to individual items.

SHORELINE ANALYSIS TOOLS.

Shoreline Change. Calculates shoreline change rates between two shorelines. Generates report including average, minimum and maximum change, change rates, and time span of analysis. Generates shoreline change graph (graph mode) and a spatially referenced shoreline change map.

Shapefile Convert. Converts ArcView© shapefiles into RMAP shoreline or baseline data items in the data tree.

Draw Shoreline/Baseline. Allows the user to digitize a georeferenced shoreline or baseline in the map viewer and creates a new item in the data tree.

Combine Shoreline. Combines adjacent shoreline segments in order of increasing easting distance. Generates new entry in the data tree.

Interpolate Shoreline. Re-samples the shoreline at a user-specified interval and generates a new item in the data tree.

Smooth Shoreline. Uses a running average of points to smooth a shoreline. User can specify number of points. Generates new entry in the data tree.

Mean Shoreline. Calculates an average shoreline position for a series of selected shorelines, generates new item in the data tree.

Shoreline Statistics. Calculates the number of points, variance, standard deviation, and minimum and maximum distances of a shoreline from the baseline.

BEACH PROFILE ANALYSIS TOOLS. RMAP includes a diverse set of tools for analyzing beach profile data. RMAP generates a report for each analysis, which can be exported as text, printed, or copied to the clipboard. Functions and analysis routines are described in the following text.

Bar Properties. Bar properties are analyzed in RMAP by drawing a selection box around the bar form. Although defining a bar feature visually may be subjective, negligible differences in bar volume typically result from this method if done by an experienced user. Bar volume, length, center of mass, minimum depth and location, and maximum depth and location are reported.

Profile Comparison. The profile comparison routine calculates the volume and contour location change for two profiles within a user-defined area.

Cut and Fill. This routine compares two profiles and defines cells defined by intersections between the two profiles. The analysis report gives the distance and elevation boundaries of each cell, in addition to volume change within the cell. Total volume change, volume change above and below the vertical datum, and shoreline change at the datum are also calculated.

Horizontal Alignment. The horizontal alignment routine translates profiles an arbitrary distance to horizontally align all selected profiles to the user-specified elevation contour.

Least Square Estimate. Estimates the A-parameter and median grain size (d_{50}) over a user-specified extent of a cross-sectional beach profile. Provides correlation coefficient (r^2) for the solution.

Volume and Sectional Volume. Calculates the volume of a beach profile above a user-specified elevation contour and/or to a user-specified spatial extent. Reports volume and contour location. The algorithm will interpolate profiles or modify analysis bounds if profile extent does not meet the analysis extent.

Transport Rate. Calculates the cross-shore transport rates for a time period at user-specified interval between two succeeding profiles. Plots the cross-shore transport rate and reports maximum and minimum rates, as well as the rate at the most seaward point of the pair or profiles.

Average. Calculates, plots, and generates new items under the data tree for the average, maximum and minimum profiles. The standard deviation for the analyzed profile is plotted on the graph.

Interpolate. Interpolates the profile at a user-specified interval. Generates a new profile under the data tree.

Translation. Allows the user to translate profiles vertically or horizontally (or both). Horizontal translations can be applied to the X and Y coordinates if the profile is in geographic space.

Combine Profiles. Combines selected profiles. Profiles are selected using the checkbox in the data tree, then combined in order of ascending distance or horizontal (X) coordinate values. A new profile is generated under the data tree on completion.

Synthetic profiles. RMAP allows the user to generate several types of synthetic profiles, including beach-fill templates, equilibrium profile (Dean 1991) and modified equilibrium profile (Larson 1991), interpolated profiles, and plane sloping profiles.

Depth of Closure Calculation (Beach-fill Module). Estimates the depth of closure (Kraus et al. 1998) calculated by the Hallermeier (1978) equation for local significant wave height exceeded in a 12-hr interval, or through the mean annual significant wave height for a coastal area.

Erosion/Accretion Predictor (Beach-fill Module). Predicts erosion or accretion based on the sediment fall speed parameter for either deep water or finite depth based on equations in Kraus et al. (1991).

Planform Evolution Model (Beach-fill Module). The planform evolution model provides an estimate of the alongshore redistribution of beach nourishment material resulting from the interaction between the fill material and wave conditions at the fill site. The model embraces concept of background erosion in the prediction of shoreline change and has the capability to impose the effect of a user-specified rate of background erosion. Methodology is based on Dean and Grant (1989).

PRODUCT DEVELOPMENT AND AVAILBILITY. The RSM Program develops products to support engineers in the work force. Improvements or additions to RMAP are dependent on user comments. Please forward comments and suggestions to RMAP point of contact listed in the following section.

ADDITIONAL INFORMATION. This Coastal and Hydraulics Engineering Technical Note (CHETN) was written by Dr. Brian K. Batten, Research Physical Scientist, and Dr. Nicholas C. Kraus, Senior Scientist, Coastal and Hydraulics Laboratory, US Army Engineer Research and Development Center, Vicksburg, MS. The work described herein was supported by the National Regional Sediment Management (RSM) Demonstration Program (DP). Additional information pertaining to the RSM can be found at the Regional Sediment Management web site http://rsm.usace.army.mil

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