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Surface-Water Modeling System Tidal Constituents Toolbox for ADCIRC

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PURPOSE: This Coastal Engineering Technical Note provides guidance on specification of tidal boundary conditions for the ADvanced CIRCulation Multi-dimensional Hydrodynamic Model (ADCIRC) circulation model (Luettich, Westerink, and Scheffner 1994) within the Surface-Water Modeling System (SMS). This technical note is one in a series prepared by the Coastal Inlets Research Program documenting specific features of the SMS developed for ADCIRC applications.

BACKGROUND: Circulation modeling of open ocean regions applies tidal forcing as an ocean boundary condition. Tidal forcing consists of one or more tidal constituents, such as the M_2 constituent, applied at each boundary point. At tidal boundaries, time- and space-dependent information is specified that is unique for each tidal constituent. A tidal constituent toolbox was developed within the ADCIRC module of the SMS to provide a convenient user interface for specifying tidal forcing for ADCIRC circulation modeling. This technical note describes tidal constituents and the toolbox, including instruction for tidal boundary condition specification. The tidal constituents toolbox was implemented in Version 6 of the SMS.

TIDAL CONSTITUENTS: The tidal signal experienced at any location is a composite of multiple partial tides called tidal constituents. Approximately 390 tidal constituents have been defined (Doodson 1922), the most significant of which are formed by the gravitational attraction between the earth and the moon and sun. Table 1 lists the principal constituents and their periods. Sixteen of the 19 constituents listed are diurnal (one cycle per day) or semidiurnal (two cycles per day). Diurnal and semidiurnal constituents are denoted by the subscripts "1" and "2," respectively, in their symbols. For information on tides, tidal theory, and tidal prediction, see Doodson (1922), Schureman (1924), and Defant (1961).

In typical modeling applications, eight constituents are specified: K_1, O_1, P_1, Q_1, M_2, N_2, S_2, and K_2. Because these constituents make up a significant portion of the tidal signal, they are usually sufficient for calculation of tidal water level and current. The analyst should verify that these eight constituents are appropriate for a given model application.

TIDAL CONSTITUENT TOOLBOX: The tidal constituent toolbox within the SMS is a convenient interface in which tidal forcing can be specified for the ADCIRC model. The toolbox is housed within a Model Control interface that allows the user to specify control parameters for ADCIRC. Because control parameters are dependent on the mesh, the Model Control interface should be entered after the mesh has been developed.

Table 1
Principal tidal constituents (Defant 1961)

Name	Symbol	Period, solar hr
Principal lunar	M_2	12.42
Principal solar	S_2	12.00
Larger lunar elliptic	N_2	12.66
Luni-solar semidiurnal	K_2	11.97
Larger solar elliptic	T_2	12.01
Smaller solar elliptic	L_2	12.19
Lunar elliptic second order	$2N_2$	12.91
Larger lunar evectional	ν_2	12.63
Smaller lunar evectional	λ_2	12.22
Variational	μ_2	12.87
Luni-solar diurnal	K_1	23.93
Principal lunar diurnal	O_1	25.82
Principal solar diurnal	P_1	24.07
Larger lunar elliptic	Q_1	26.87
Smaller lunar elliptic	M_1	24.84
Small lunar elliptic	J_1	23.10
Lunar fortnightly	Mf	327.86
Lunar monthly	Mm	661.30
Solar semiannual	Ssa	2191.43

Tidal boundary specification within the SMS requires that nodes residing on the open ocean edges of a mesh be marked as tidal boundaries. The set of marked nodes is termed a nodestring in SMS and represents adjacent nodes sharing a particular characteristic; in this case, they share the property of being tidal-forcing nodes. Once the tidal boundary type is specified for the nodes, the tidal constituent toolbox will read those nodes automatically.

Three items can be specified in the toolbox:

1. Tide potential – on or off
2. Ramp function – on or off
3. Tidal constituent selection and time

The tide potential selection depends on the grid size. Tidal potential forcing should be turned on for large domains, such as regional grids, but is not necessary for small domains (Westerink et al. 1994).

The ramp function allows an ADCIRC simulation to be initiated without full forcing to eliminate transient shocks as the model spins up from quiescent conditions. If the ramp function is invoked, forcing will be initiated at small magnitude and a hyperbolic tangent function applied to increase the forcing to full magnitude. The user specifies ramp duration. In typical applications, the ramp duration is 1 to 2 days.

Selection of tidal constituents is demonstrated in the example application.

EXAMPLE APPLICATION: This example illustrates the steps taken to assign tidal constituents to an ocean boundary on an ADCIRC grid within the SMS. A grid has been developed and requires specification of the ocean boundary and the tidal constituents. The steps are described in the following paragraphs.

1. Define a Nodestring for the Ocean Boundary. To set up a nodestring for the ocean boundary, click on the "Create Nodestring Tool" icon located on the left side of the screen in the ADCIRC module, as shown in Figure 1. Click the mouse on a boundary node that is located at the interface between land and ocean, as shown in Figure 1. Depress the Control key and double-click on the opposite land-water interface boundary node. SMS proceeds from the first boundary node counterclockwise around the grid boundary to the second and will display the newly created nodestring. If the ocean boundary is clockwise from the first boundary node, depress the Shift key as well as the Control key.

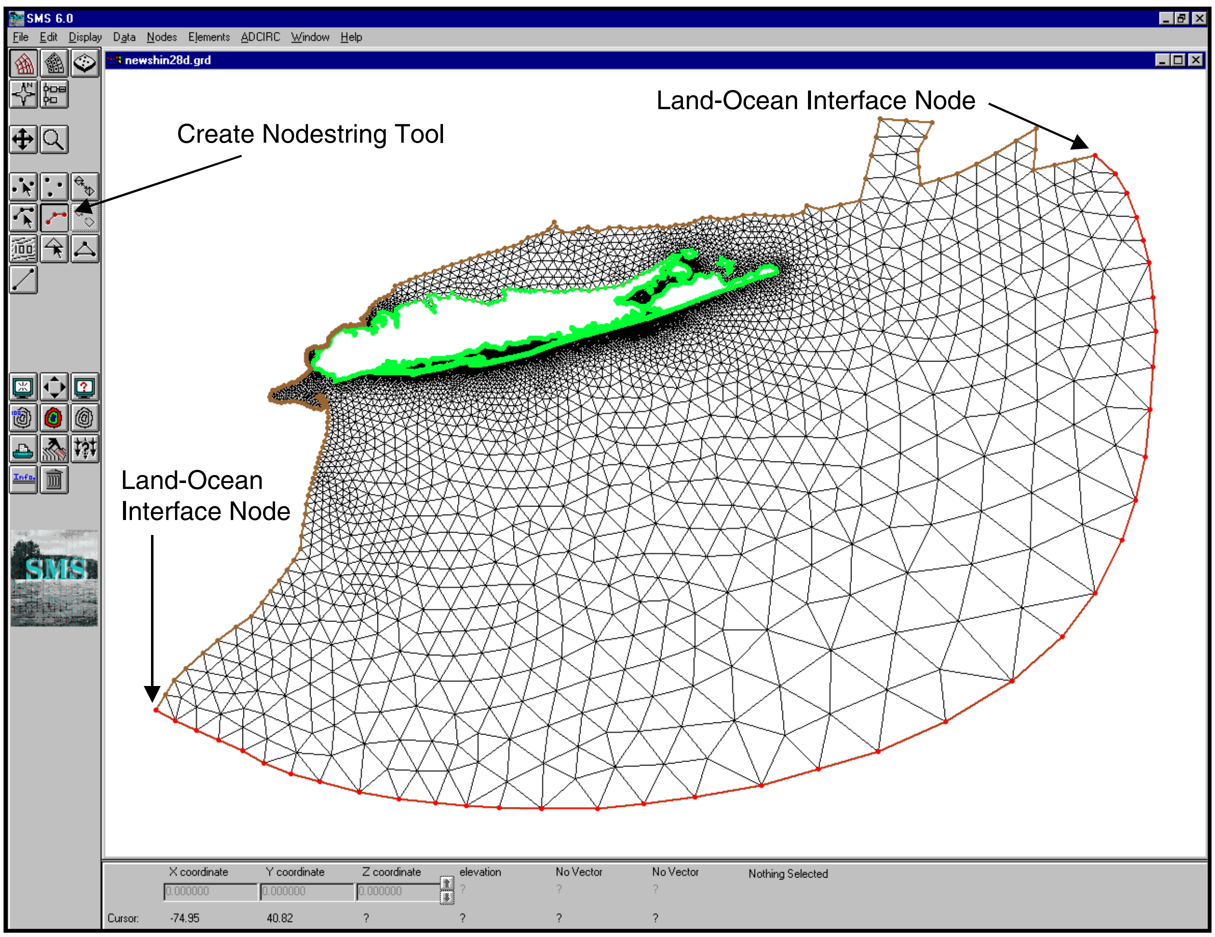

Figure 1. Graphical information for creating a nodestring on the ocean boundary

2. Specify Nodestring as an Ocean Boundary. Assigning the nodestring as an ocean boundary requires selecting the nodestring and specifying the boundary type. To select the nodestring, click on the "Select Nodestring Tool" (Figure 2). Boxes that represent each nodestring will appear on the grid, as shown in Figure 2. To select the ocean boundary nodestring, click on its box.

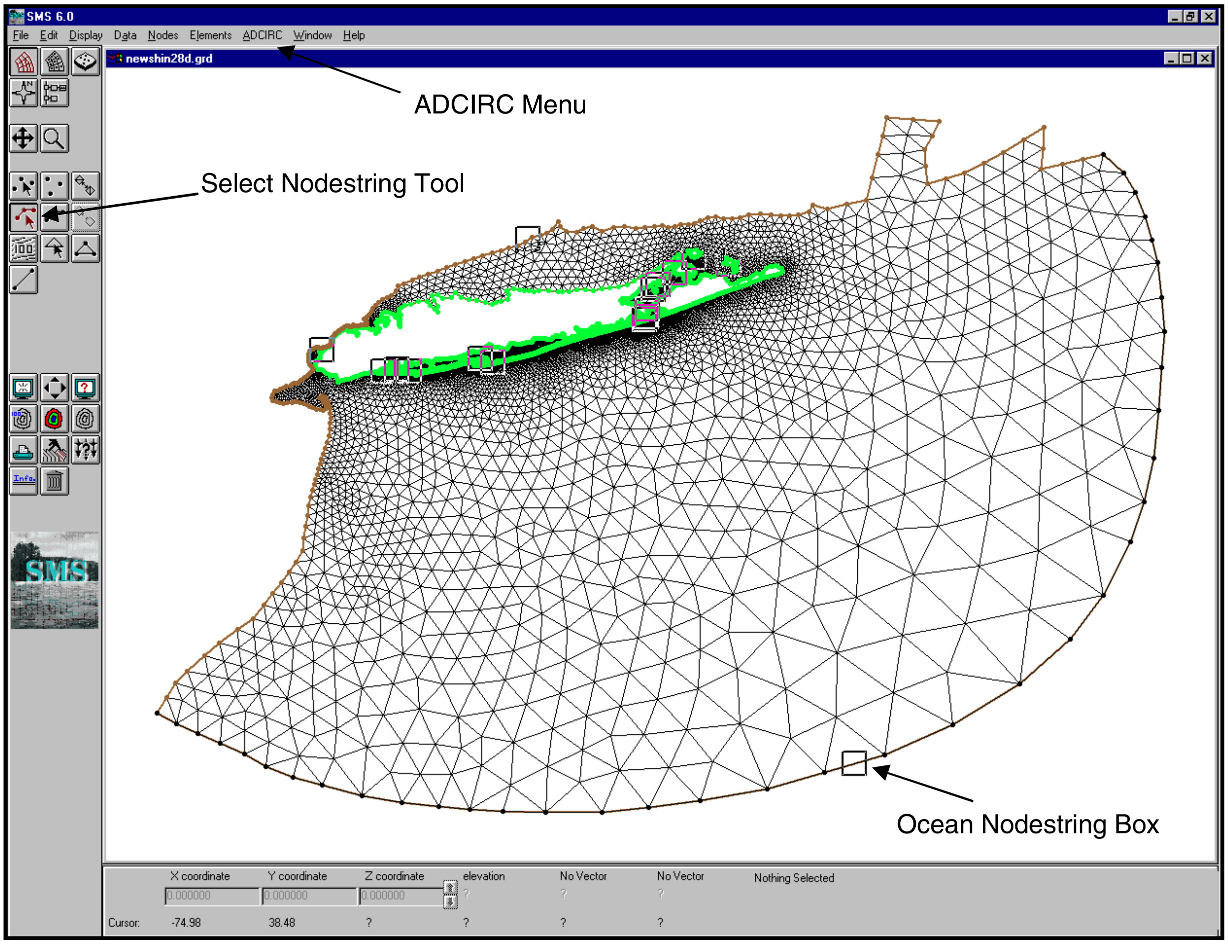

Figure 2. Graphical information for selecting a nodestring

To specify the boundary type, click on the “ADCIRC” menu at the top of the screen (Figure 2), then click on “Assign BC” in the drop-down menu. A dialog box entitled “ADCIRC Nodestring Atts” (Figure 3) will appear in which boundary condition types can be specified. Click on the “Ocean” selection, then click on “OK” to exit the dialog box.

3. Assign Tidal Constituents to Ocean Boundary Nodes. The Tidal Constituent Toolbox is accessed through the Model Control interface located under the “ADCIRC” menu. To access the Model Control interface, click on the “ADCIRC” menu, then click on “Model Control” in the drop-down menu. Click on “Tidal Forces,” as shown in Figure 4, to bring up the Tidal Constituent Toolbox. A dialog box will appear called “Tidal Functions” (Figure 5) in which tidal constituents can be specified.

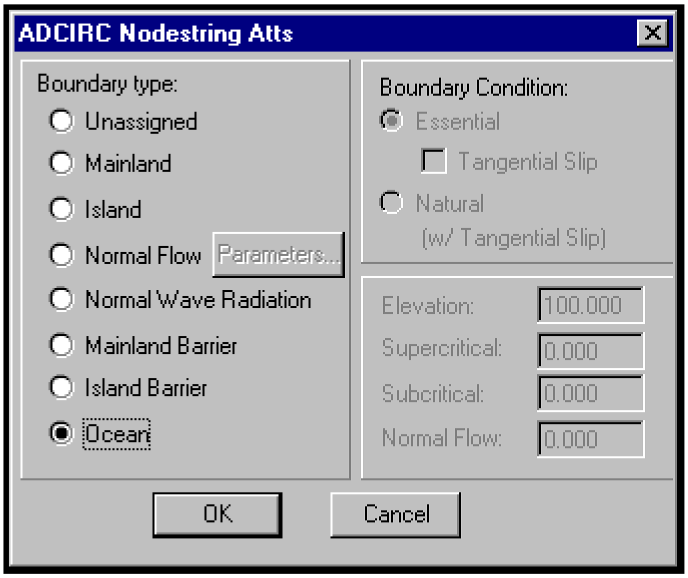

Figure 3. ADCIRC nodestring attribute dialog box

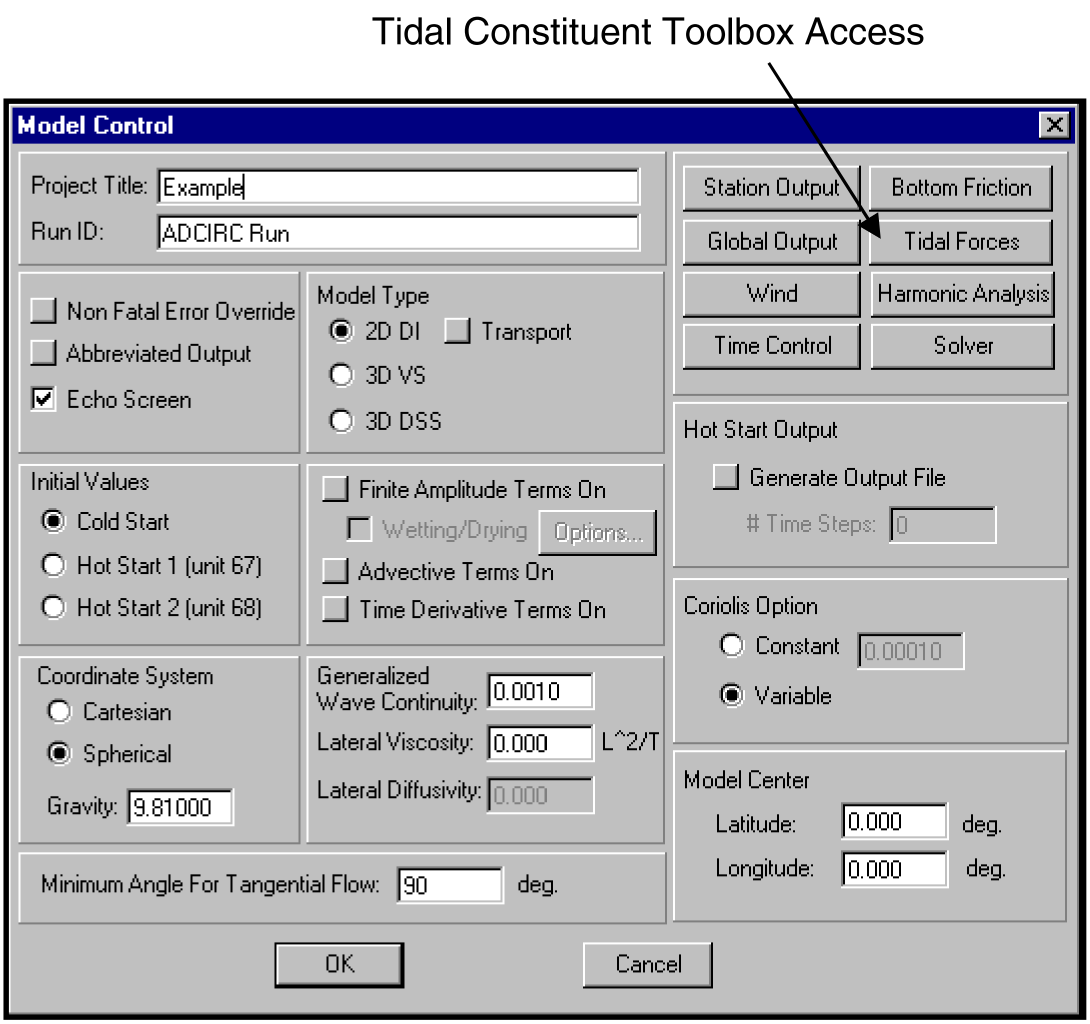

Figure 4. Model Control dialog box

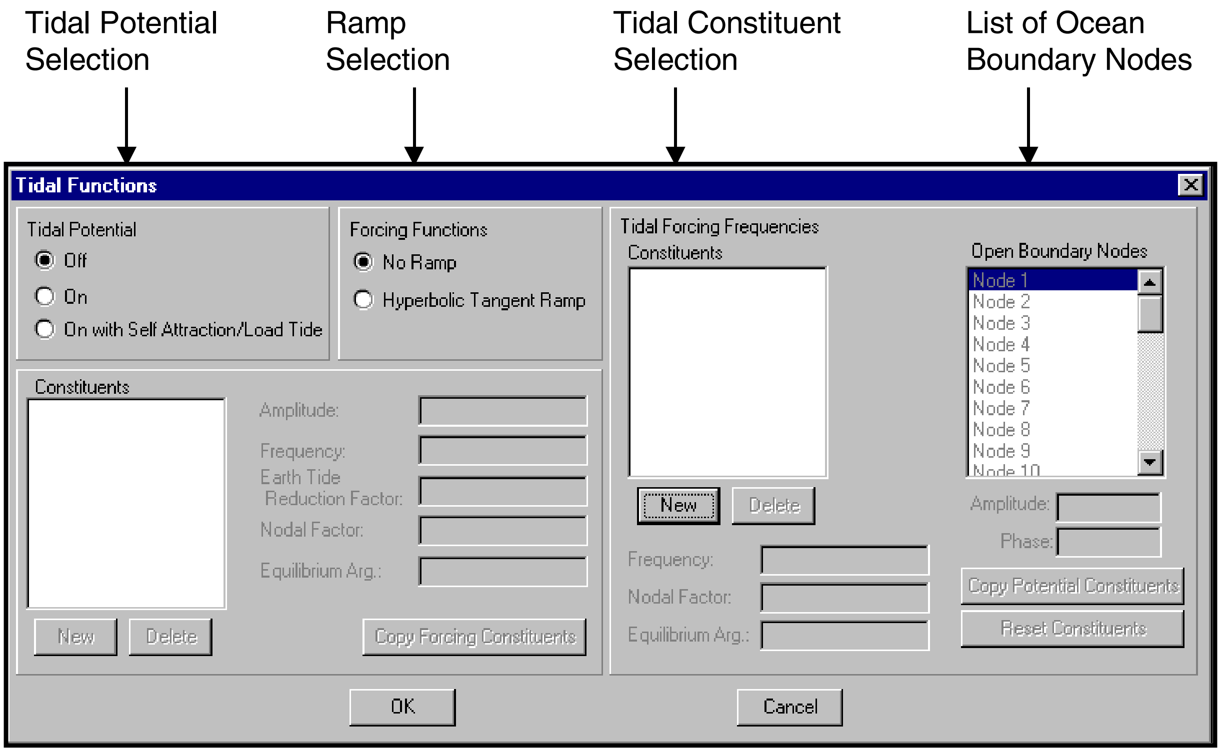

Figure 5. Tidal Functions dialog box

The "Tidal Functions" dialog box provides options for setting the Tidal Potential and Ramp options, as shown in Figure 5. To turn on each of these, click on "On" under "Tidal Potential" and "Hyperbolic Tangent Ramp" under "Forcing Functions."

Selection of tidal constituents for the open boundaries is done in the "Tidal Forcing Frequencies" section of the "Tidal Functions" dialog box (Figure 5). Boundary nodes for the ocean forcing are automatically listed on the right side of the dialog box. To select tidal constituents, click on "New," and a dialog box called "New Constituent" will appear (Figure 6). The user can select from a database list for the source of tidal constituents. At the time of this writing, the Le Provost database (Le Provost et al. 1994) has been implemented within the SMS. Constituents can be added to the ocean forcing by clicking on a particular constituent and specifying the time that the simulation will start. All time references in ADCIRC are in Greenwich Mean Time. To add the M_2 constituent for a simulation starting on 4 June 1998 at Hour 0, click on M2 in the "Constituents" windows and enter the time information under "Starting Day," as shown in Figure 6, then click "OK."

A warning may appear stating that SMS cannot find a file and ask if you want to search for it. This message refers to files containing the tidal constituent database information. If this message appears, click on "Yes" to specify where the database files are located. Multiple constituents can be added as forcing frequencies by entering the "New Constituent" dialog box as many times as is necessary. For instance, to include the K_1 constituent, enter the New Constituent dialog box and select that constituent. Once all constituents are selected, click "Copy Forcing Constituents" on the left side of the "Tidal Functions" dialog box. Figure 7 shows the "Tidal Functions" dialog box with M_2 and K_1 selected. Click "OK" to exit the Tidal Constituents Toolbox.

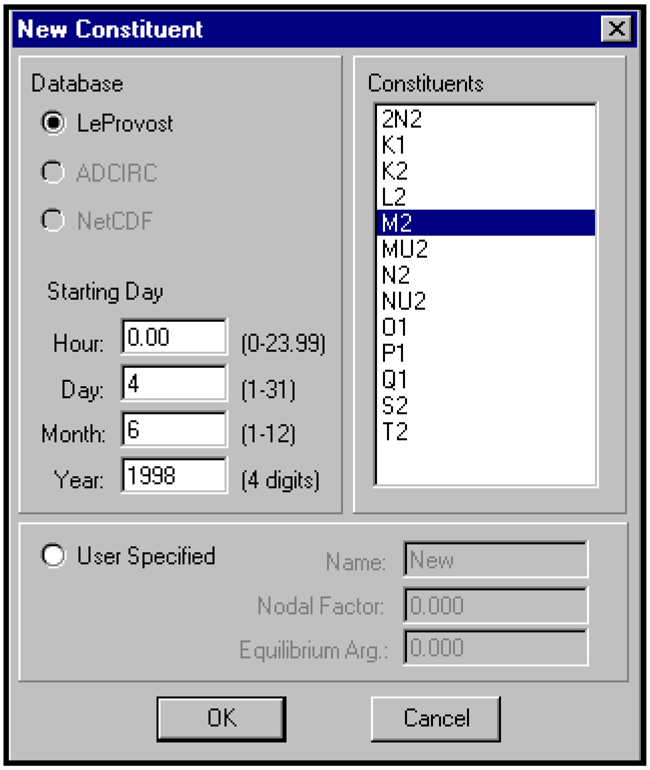

Figure 6. New Constituent dialog box

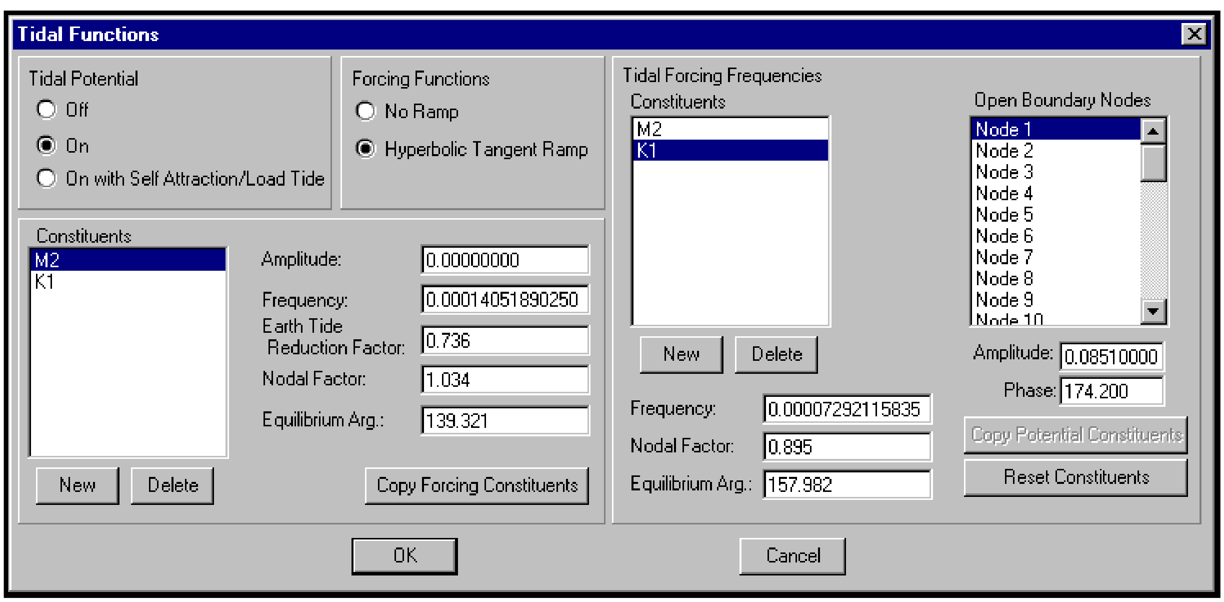

Figure 7. Tidal Functions dialog box with M2 and K1 constituents selected

ADDITIONAL INFORMATION: Questions about this technical note can be addressed to Dr. Adele Militello (Voice: 601-634-3099, e-mail: *militea@wes.army.mil*). For information about the Coastal Inlets Research Program, please contact the Program Manager, Mr. E. Clark McNair (Voice: 601-634-2070, e-mail: *mcnairc@wes.army.mil*). For information about the Surface-Water Modeling System (SMS), please contact Ms. Barbara Donnell (Voice: 601-634-2730, e-mail: *donnelb@ wes.army.mil)* or Mr. Bill Boyt (Voice: 601-634-3249, email: *boytw@wes.army.mil)*. This technical note should be cited as follows:

Militello, A., and Zundel, A. K. (1999). "Surface-water modeling system tidal constituents toolbox for ADCIRC," Coastal Engineering Technical Note CETN IV-21, U.S. Army Engineer Research and Development Center, Vicksburg, MS. *http://bigfoot.wes.army.mil/cetn.index.html*

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