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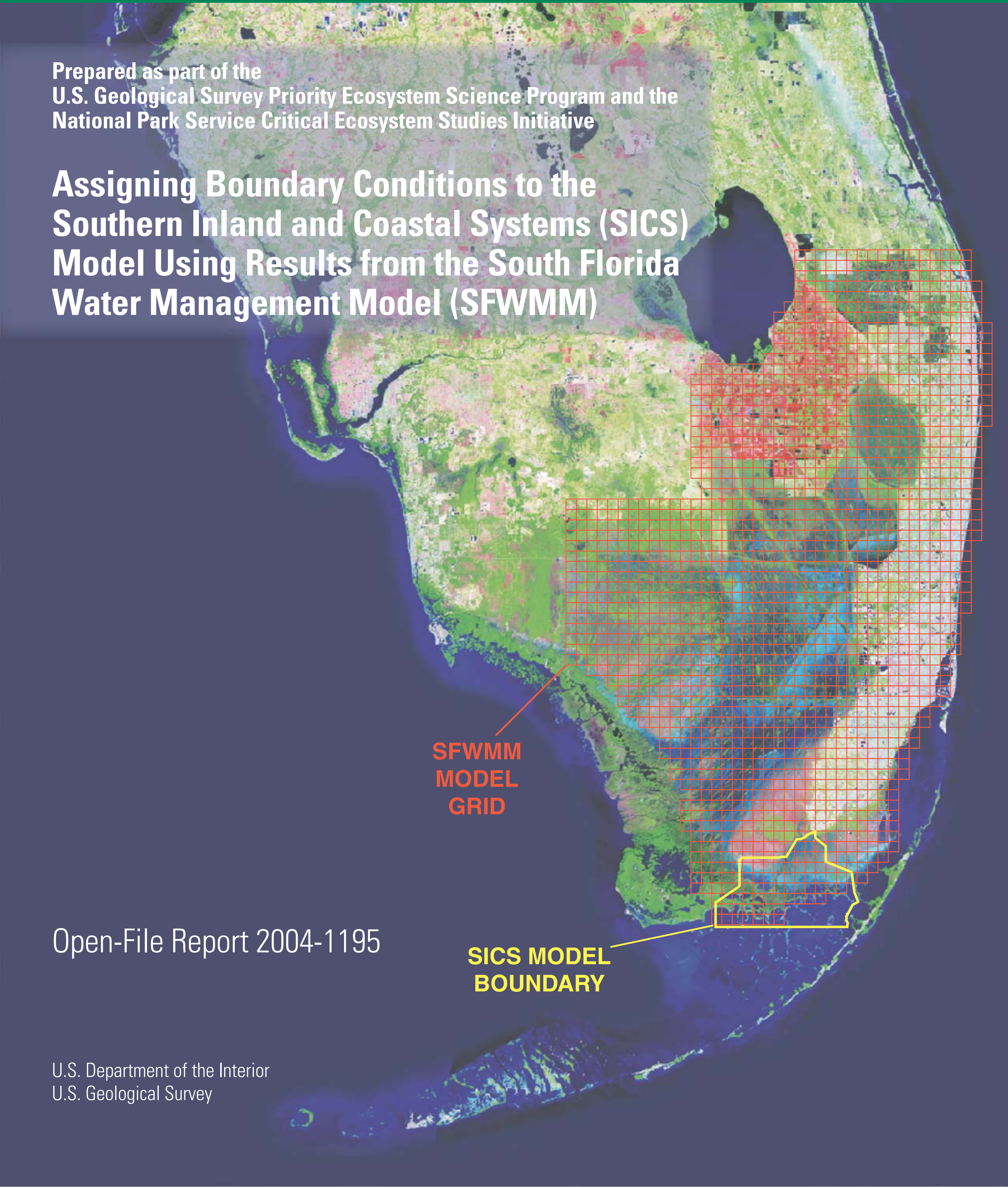
# Assigning Boundary Conditions to the Southern Inland and Coastal Systems (SICS) Model Using Results from the South Florida Water Management Model (SFWMM)




Open-File Report 2004-1195

U.S. Department of the Interior
U.S. Geological Survey

# Assigning Boundary Conditions to the Southern Inland and Coastal Systems (SICS) Model Using Results from the South Florida Water Management Model (SFWMM)

By Melinda A. Wolfert, Christian D. Langevin, and Eric D. Swain

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**U.S. Department of the Interior**
**U.S. Geological Survey**

**U.S. Department of the Interior**
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**U.S. Geological Survey**
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U.S. Geological Survey, Reston, Virginia: 2004

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# Conversion Factors, Acronyms, and Datums

| Multiply | By | To obtain |
|---|---|---|
| meter (m) | 3.281 | foot |
| kilometer (km) | 0.6214 | mile |
| square kilometer ($km^2$) | 0.3861 | square mile |
| gram per liter (g/L) | 1,000 | part per million |

| | |
|---|---|
| ADAPS | Automated Data Processing System |
| ATLSS | Across Trophic Level System Simulation |
| CERP | Comprehensive Everglades Restoration Plan |
| ENP | Everglades National Park |
| GHB | General Head Boundary |
| FTLOADDS | Flow and Transport in a Linked Overland Aquifer Density Dependent System |
| NSM | Natural Systems Model |
| SFNRC | South Florida Natural Resource Center |
| SFWMD | South Florida Water Management District |
| SFWMM | South Florida Water Management Model |
| SICS | Southern Inland and Coastal Systems |
| SOFIA | South Florida Information Access |
| SWIFT2D | Surface-Water Integrated Flow and Transport in Two Dimensions |
| UM | University of Miami |
| USGS | U.S. Geological Survey |

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88) unless otherwise noted. Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

# Assigning Boundary Conditions to the Southern Inland and Coastal Systems (SICS) Model Using Results from the South Florida Water Management Model (SFWMM)

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## Abstract

The Comprehensive Everglades Restoration Plan (CERP) requires the testing and evaluation of different water-management scenarios for southern Florida. As part of CERP, the South Florida Water Management District is using its regional hydrologic model, the South Florida Water Management Model (SFWMM), to evaluate different hydrologic scenarios. The SFWMM was designed specifically for the inland freshwater areas in southern Florida, and extends only slightly into Florida Bay. Thus, the U.S. Geological Survey developed the Southern Inland and Coastal Systems (SICS) model, which is an integrated surface-water and ground-water model designed to simulate flows, stages, and salinities in the southern Everglades and Florida Bay. Modifications to the SICS boundary conditions allow the local-scale SICS model to be linked to the regional-scale SFWMM. The linked model will be used to quantify the effects of restoration alternatives on flows, stages, and salinities in the SICS area. This report describes the procedure for linking the SICS model with the SFWMM. The linkage is shown to work by comparing the results of a linked 5-year simulation with the results from a simulation in which the model boundaries are assigned using field data.

The surface-water module of the SICS model is driven by areal influences and lateral boundaries. The areal influences (wind, rainfall, and evapotranspiration) remain the same when the SICS model is modified to link to the SFWMM. Four types of lateral boundaries (discharge, water level, no flow, and salinity) are used in the SICS model. Two of three discharge boundaries (at Taylor Slough Bridge and C-111 Canal) in the current SICS model domain are converted to water-level boundaries to increase accuracy. The only change to the third discharge boundary (at Levee 31W) is that the flow data are derived from SFWMM model output instead of using measured field data flows. Three water-level boundaries are modified only by receiving their data from SFWMM model output data. Additionally, two marine water-level boundaries remain the same because the SFWMM does not include Florida Bay and, therefore, this model cannot provide input data for these boundaries. The SICS no-flow boundaries remain intact because no additional data, provided by the SFWMM, suggest that any significant flow occurs along these boundaries. The Florida Bay salinity boundary is not modified because the SFWMM does not contain any salinity data that can be used to modify the model.

The ground-water module of the SICS model contains a general-head boundary and a no-flow boundary. The general-head boundary, which extends along the edges of the wetland part of the SICS model domain, is modified by acquiring stage values from SFWMM cells that correspond in location to the SICS model cells. Values from the SFWMM cells are bilinearly interpolated and assigned to the appropriate SICS general-head boundary cells in all layers of the ground-water model. The ground-water no-flow boundary in Florida Bay is unaltered because the SFWMM does not include this area.

A 5-year simulation was developed to test the linkage of the SICS model with the SFWMM. Results from the linked model are similar to those obtained from the original SICS model in which boundaries are assigned using field data. The simulated discharges at the coastal creeks along Florida Bay are about 5 percent lower than the field data simulation; water levels in the wetlands are about 4 percent lower, and salinities at the various coastal creeks are slightly higher.

## Introduction

As part of the Comprehensive Everglades Restoration Plan (CERP), the South Florida Water Management District (SFWMD) evaluates alternative water-management scenarios using the South Florida Water Management Model (SFWMM). This regional-scale model has 3.218 x 3.218-km (2- x 2-mi) grid cells and covers most of southern Florida (fig. 1), but does not include Florida Bay nor many of the Everglades coastal wetlands. Consequently, the SFWMM is not designed to simulate and/or predict local-scale effects of alternative water-management scenarios or the effects of alternatives on coastal wetland stages, salinities, and freshwater discharges to Florida Bay. A high-resolution local-scale model is required to more accurately evaluate the effects of alternatives on coastal wetlands and Florida Bay.

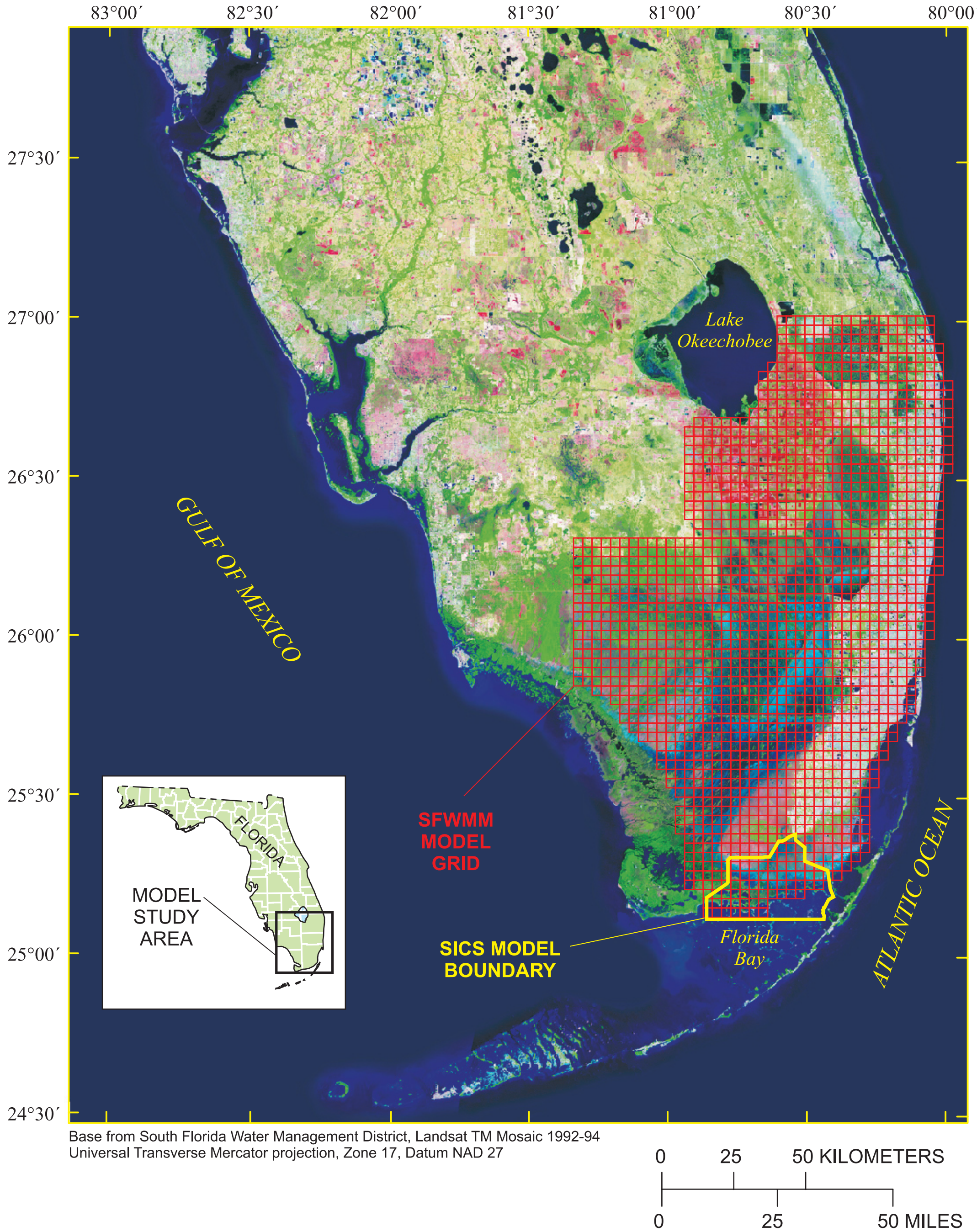


**Figure 1.** Location of the South Florida Water Management Model (SFWMM) grid and the outline of the Southern Inland and Coastal Systems (SICS) model boundary.

The U.S. Geological Survey (USGS) recently developed a local-scale model of the southern Everglades (fig. 2) that can simulate coastal wetland stages and salinities and freshwater discharge to Florida Bay. The model, known as the Southern Inland and Coastal Systems (SICS) model (Swain and others, 2003), is a hydrodynamic surface-water flow and transport model coupled with a ground-water flow and transport model (Langevin and others, 2002). The surface-water and ground-water models share the same finite-difference grid with a 304.8- x 304.8-m horizontal resolution. The ground-water model also contains a vertical three-dimensional 10 layer (each 3.2-m thick) grid that extends from land surface to a depth of 32 m.

Restoration scenarios proposed under CERP contain water-management system modifications that are far north from the SICS domain area, and a method was needed to evaluate the effects of these system modifications within the SICS area. The SFWMM was developed to represent many of the regional effects of the proposed modifications within most of southern Florida. However, to accomplish the goals of the CERP near the southern coastal area, which includes scenario testing, the local-scale SICS model had to be linked to the regional-scale SFWMM. The linking approach adopted for the SICS application is sequential and uses model results from the SFWMM as boundary conditions for the SICS model, with no feedback from the SICS model to the SFWMM.

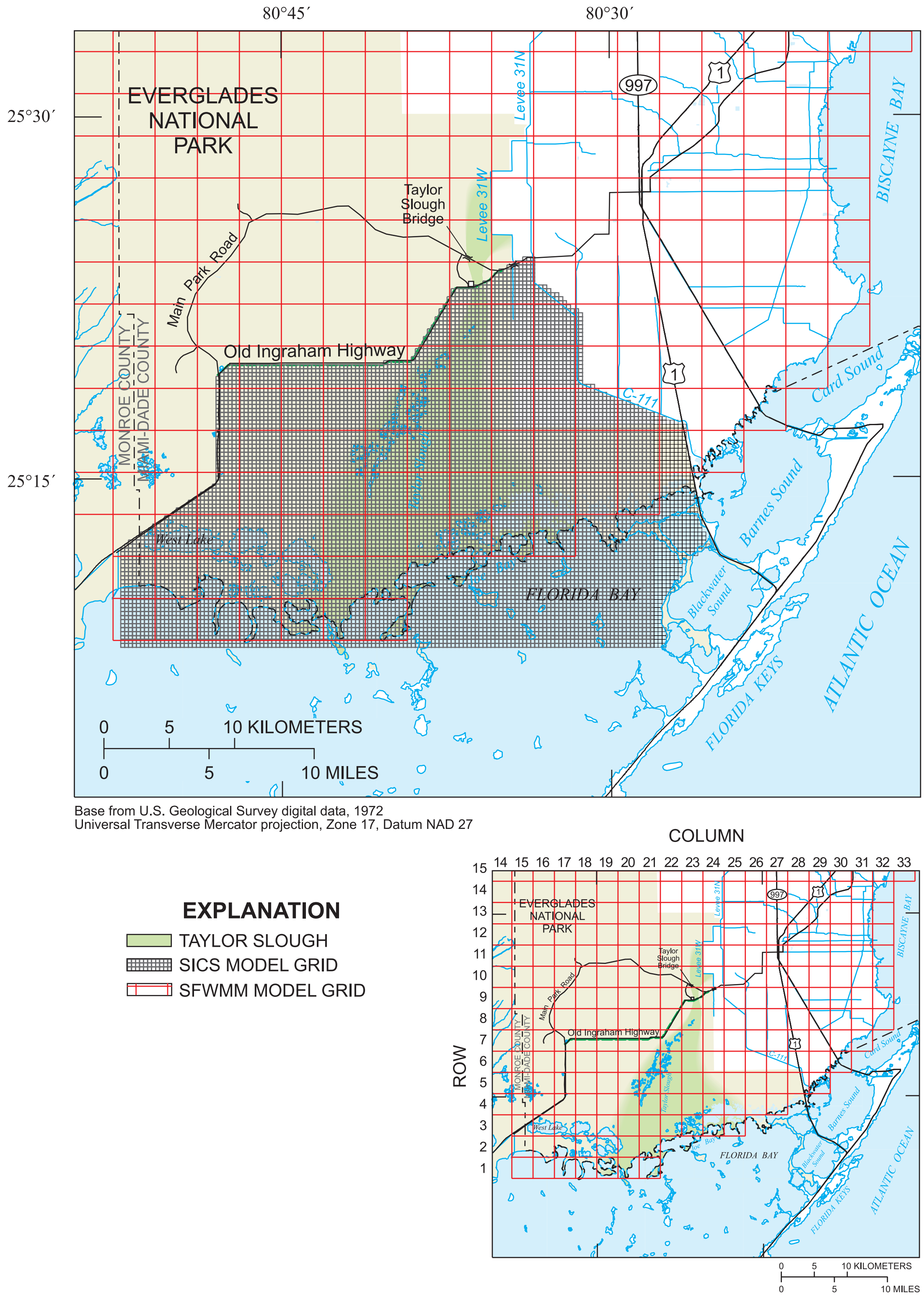


**Figure 2.** Overlay of the South Florida Water Management Model (SFWMM) grid on the Southern Inland and Coastal Systems (SICS) model grid. Inset displays the column and row numbering of the SFWMM grid, which covers the SICS model domain.

## Purpose and Scope

This report, prepared as part of the USGS Priority Ecosystem Science Program and the National Park Service Critical Ecosystem Studies Initiative, documents the SICS model boundaries developed using model results from the SFWMM. By specifying selected SICS model boundary conditions with SFWMM results, the local-scale effects of alternative water-management scenarios on coastal wetland stage, salinity, and freshwater flows to Florida Bay can be simulated. This report first presents an overview of the SFWMM and SICS models. The current method for assigning SICS model boundaries using field data then are described, followed by a description of designing SICS boundaries with SFWMM results. Finally, the results from a linked model are compared with those from a model that uses field data to assign the boundaries.

## Acknowledgments

The authors would like to express appreciation to SFWMD personnel, including Jayantha Obeysekera for his assistance in coordinating the review of the report, Randy VanZee for reviewing the report, and Ken Tarboton and Jennifer Barnes for providing information about (and data from) the SFWMM. USGS personnel Pamela Telis and Roy Sonenshein helped organize and coordinate the report; Jerad Bales coordinated and reviewed the report; Clinton Hittle and Arturo Torres reviewed the report; and Rhonda Howard, Mike Deacon, and Kim Swidarski helped prepare the report. Additional appreciation is extended to University of Miami professor John Wang for his technical assistance with the report.

# Overview of Models

The South Florida Water Management Model (SFWMM) originally was developed by the SFWMD in the late 1970’s and early 1980’s to simulate the hydrology and the highly managed water system in an approximately 19,700-km$^2$ area of southern Florida (fig. 1), but has since been substantially improved and updated. The SFWMM is currently used by the SFWMD to evaluate feasible water-supply alternatives for projected land use and water demand over the next decades (Bales and others, 1996). The SFWMM was designed specifically for the inland freshwater areas in southern Florida and does not cover Florida Bay and the coastal wetlands. The need for tools to scientifically examine the hydrology of the coastal wetlands in southeastern Everglades National Park (ENP) led the USGS to develop the SICS (Southern Inland and Coastal Systems) model (Swain and Langevin, 2001).

## South Florida Water Management Model

The SFWMM (South Florida Water Management District, 1997; and MacVicar and others, 1984) covers the southern Florida peninsula from about Lake Okeechobee to the southern tip of the Everglades at Florida Bay (fig. 1). Rainfall, evapotranspiration, infiltration, overland and ground-water flow, canal flow, seepage, ground-water pumping, and other such hydrologic components are simulated by the SFWMM. Additionally, the SFWMM simulates effects of SFWMD operational rules and the operation of water-management control structures. The regional-scale SFWMM attempts to simulate current conditions and also any operational changes proposed for southern Florida. As previously discussed, CERP relies on the SFWMM to test different operational and water-management scenarios. The SFWMM uses a 30-year dataset for calibration and verification with field measurements. Water-management scenarios are tested with the SFWMM by first simulating a 30-year base case with operational rules from one single year. The model is then modified to reflect proposed changes to the system and the 30-year simulation is repeated using the same set of climate data. Finally, a comparison is made between the alternative and the base-case scenario in order to quantify potential hydrologic changes.

The SFWMM was designed specifically for the inland freshwater areas in southern Florida, but not for coastal wetlands or adjacent estuaries; therefore, the model does not represent density-dependent flow nor the effects of winds and tides on water movement. Thus, a link between the coarse-grid SFWMM and a finer grid hydrodynamic model was required to better simulate changes in coastal wetlands hydrology resulting from different water-management scenarios. The SFWMM is important for representing the base-case and scenarios runs and for providing boundary conditions to local-scale models.

## Southern Inland and Coastal Systems Model

The SICS model is an integrated surface-water and ground-water model designed to simulate flows, stages, and salinities in the southern Everglades. This local-scale, fine-grid model uses the Flow and Transport in a Linked Overland Aquifer Density Dependent System (FTLOADDS) computer program to simulate coupled surface-water and ground-water flows (Langevin and others, 2002). Surface-water simulations are performed by using a modified version of the SWIFT2D code (Swain and others, 2003), and ground-water simulations are handled by using the SEAWAT code (Guo and Langevin, 2002).

The Surface Water Integrated Flow and Transport in Two Dimensions (SWIFT2D) code simulates overland surface-water flow and transport of dissolved salt in two dimensions (Leenderste, 1987; Swain and others, 2003). This fully dynamic circulation model uses the finite-difference method to solve the vertically averaged momentum and conservation of mass equations. The SWIFT2D code was originally designed to simulate flow and transport in vertically well-mixed estuaries, coastal embayments, lakes, rivers, and inland waterways. The code was modified for this study to include such processes as rainfall, evapotranspiration, and flow resistance of marsh vegetation.

Ground-water flow and transport of dissolved salt is simulated using the SEAWAT code (Guo and Langevin, 2002). The SEAWAT code was developed by combining MODFLOW (McDonald and Harbaugh, 1988) and MT3DMS (Zheng and Wang, 1998) to solve the variable-density ground-water flow equation formulated in terms of equivalent freshwater head, rather than pressure. This ground-water calculation considers all zones to be saturated. The finite-difference method is used to solve the flow equation.

FTLOADDS is a linked version of SWIFT2D and SEAWAT that allows information simulated at different time intervals to be passed seamlessly between the two programs. Transient ground-water flow is simulated by dividing stress periods, or periods of time when hydrologic stresses on the system remain constant, into many timesteps. A single ground-water stress period may contain many surface-water model timesteps. For example, the ground-water model may have daily stress periods, but the surface-water model may require timesteps that are only 15 minutes or less. In this case, there would be 96 surface-water model timesteps per ground-water model stress period.

The main linkage between SWIFT2D and SEAWAT is through a leakage quantity passed between the two models. First, SWIFT2D simulates conditions for the current stress period and then SEAWAT does the same. In SWIFT2D, leakage is calculated using a variable-density form of Darcy's law, the current surface-water stage, the ground-water head from the end of the previous stress period, and a leakage coefficient. SEAWAT then evenly applies the average leakage rate over the entire stress period. The transfer of salt mass between surface water and ground water is based on the leakage volume and salinity of the donor cell. Upward leakage to the surface-water system is assumed to have the concentration of the underlying ground-water cell from the end of the previous stress period. Downward leakage is assumed to have the concentration of the surface-water cell, which is averaged over each stress period. At the end of the stress period, the cumulative salt flux is divided by the leakage rate to calculate the average leakage concentration. This average concentration and average leakage rate is then applied in the current stress period to the ground-water model. Using this approach, salt and fluid mass is conserved within the system.

Several other enhancements were programmed in FTLOADDS for the case when a surface-water cell becomes dry. In this case, recharge and evapotranspiration, which are calculated by the surface-water model (Swain and others, 2003), are applied to the cells in the uppermost layer in the ground-water model. The model code also includes the capability for upward leakage to rewet a surface-water cell, which can be important to adequately represent isolated depressions in the land surface.

# Boundary Conditions Assigned Using Field Data

This section describes the use of field data to specify the SICS model boundary conditions. The integrated SICS model was calibrated using a wide range of field data, and results from the model have been used for various purposes, including use as input for biological models. An example of this is the ALFISHES model (an ecological model created under the USGS Across Trophic Level System Simulation (ATLSS) program, which uses water levels and salinity output data from the SICS model (Cline and Swain, 2002). For integrated simulations, SICS model boundaries are specified using field data. Information and documentation about the field data sites and the sources of the data are presented in appendix I. The classification of the data collected at field stations or calculated from other physical characteristics is presented in appendix II.

## Surface-Water Boundaries

The surface-water part of the SICS model has areal influences and lateral boundaries. Three areal influences (wind, rainfall, and evapotranspiration) are used in the SICS model. Wind is included in the model as a term applied to the momentum equation for each cell computation. In the present model, wind conditions are spatially uniform over the entire model grid (Swain and others, 2003). Scalar wind speeds and vector wind directions were obtained from the ENP Joe Bay weather station (fig. 3, JBWS) to describe the wind field in the model domain, owing to a lack of spatial data.

Volumes for rainfall and evapotranspiration boundaries are prescribed for each cell and for each timestep. These volumes are then removed as evapotranspiration or added as rainfall to the cells. The rainfall data have been spatially represented by using data collected at 14 field stations (fig. 3 and app. I). The data from most of the stations are collected at hourly intervals and interpolated to a 15-minute timestep. These data are then kriged over the model domain for each 15-minute timestep to calculate a rainfall value for each cell. The evapotranspiration data are calculated by using a modified Priestley-Taylor equation (Swain and others, 2003) that is dependent on water depth and solar radiation. The model simulates the water depth for each timestep, and the solar radiation data are obtained from pyranometer measurements at the USGS Old Ingraham Highway station and the ENP Joe Bay weather station (fig. 3, OIH and JBWS). The 15-minute pyranometer data are used to represent spatially uniform solar radiation values over the entire model domain.

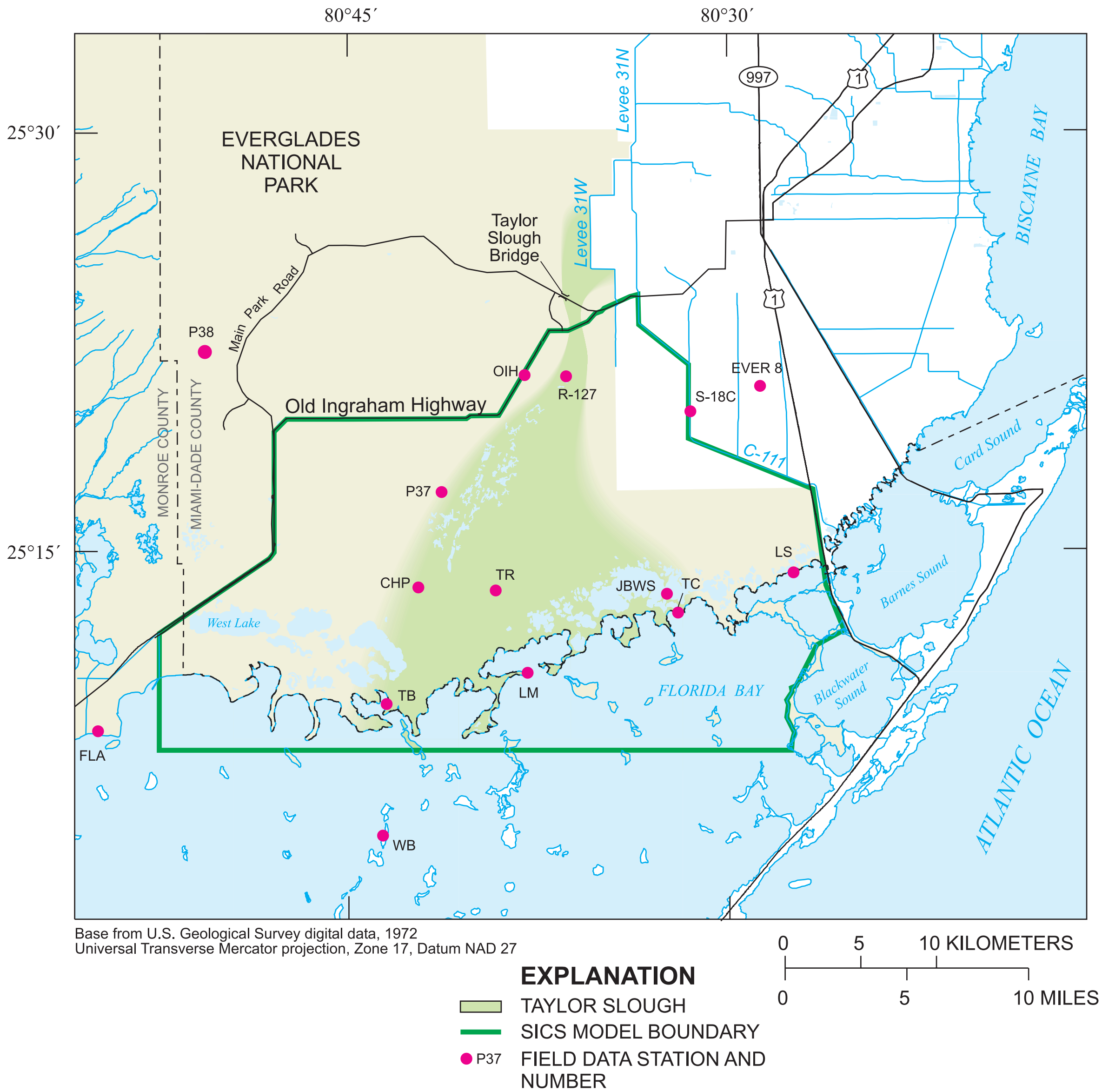


**Figure 3.** Stations used for determination of wind, rainfall, and solar radiation in the Southern Inland and Coastal Systems (SICS) model. All sites are rainfall stations, except for OIH (solar radiation and rainfall) and JBWS (wind and solar radiation). Site names and identifiers are listed in appendix 1.

Lateral boundaries are defined as open (having free exchange of water and salt across the boundary) or closed (having no flow across the boundary). Open boundaries can be described by a time series of discharge or water levels. Four types of lateral boundaries (discharge, water level, no flow, and salinity) are used in the SICS model (fig. 4).

The SICS model contains three discharge boundaries (fig. 4 and table 1, SW8, SW11, and SW12). Boundary SW8 is located between structures S-18C and S-197 on the C-111 Canal (fig. 4). The discharge released into the wetlands along the SW8 discharge boundary is assumed to be the difference in releases measured at structures S-18C and S-197. Normally, the gate at structure S-197 is closed; however, when structure S-197 is opened, flow data are obtained and provided by the SFWMD. The boundary flows are created by uniformly distributing the discharge along an artificial topographic low along the entire section of the C-111 Canal between structures S-18C and S-197. The boundary is defined in this manner in order to ensure that the cells where the discharge is applied do not become dry during any timestep. This topographic low simulates the removal of the levee on the southern part of the C-111 Canal, which promotes delivery of additional water to the easternmost part of the Everglades wetlands.

Discharge data for boundary SW11 (fig. 4) is provided by the SFWMD at structure S-175 (fig. 4) using a stage-discharge

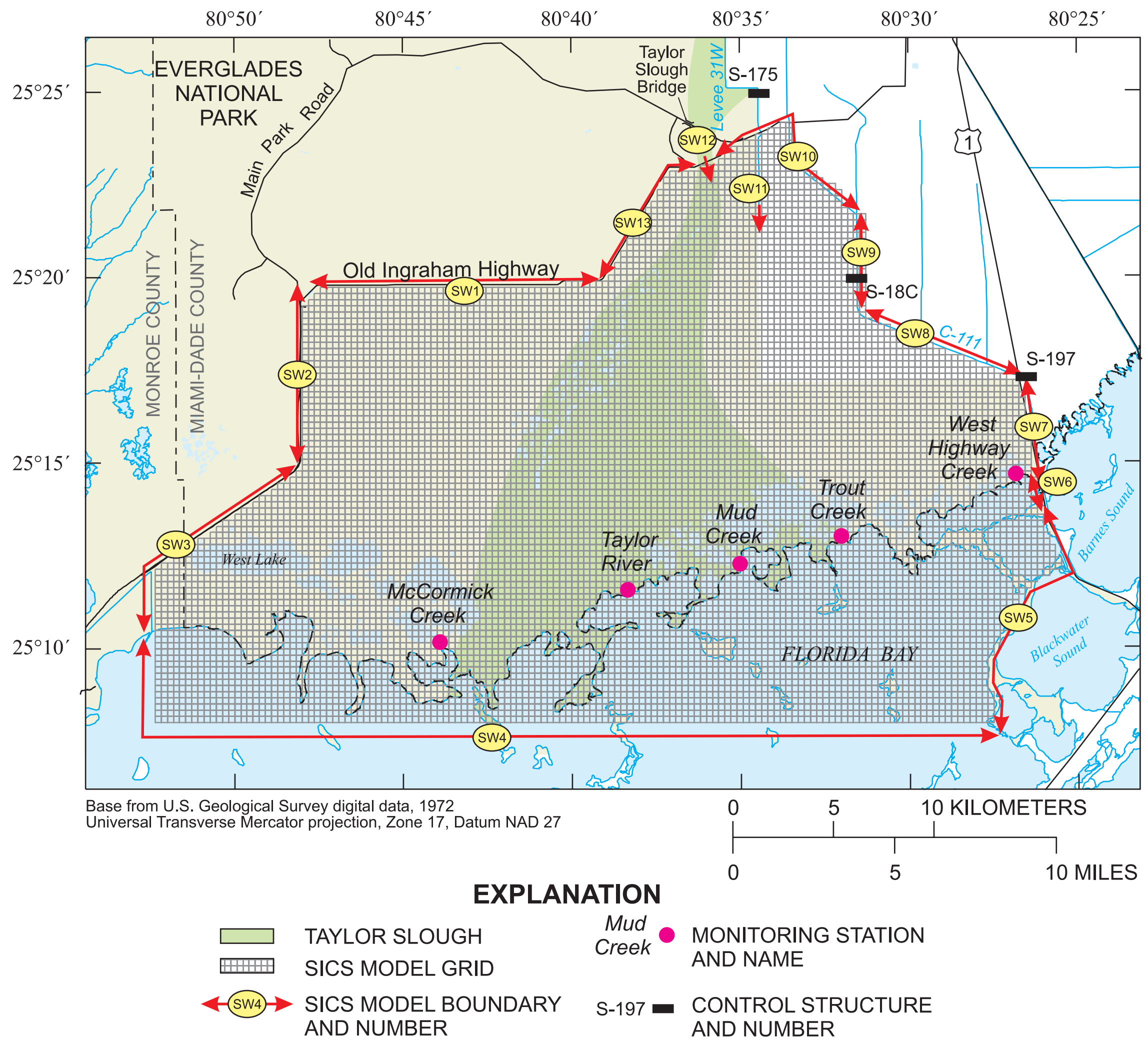


**Figure 4.** Finite-difference model grid and location of boundary conditions specified for the Southern Inland and Coastal Systems (SICS) surface-water model. Descriptions for boundary conditions are given in table 1.

rating. The discharge through the structure enters the northern section of the SICS model through Levee 31W Canal at cell (100,88), which is located in the northern part of the model. Levee 31W extends south into the SICS model area about 6 km where it terminates. Water entering the model domain at cell (100,88) flows southward along Levee 31W, which is a topographic low in the model, and is subsequently distributed into adjacent wetlands.

Boundary SW12 (fig. 4) uses inflow provided by ENP using a stage-discharge relation at Taylor Slough Bridge (fig. 5, TSB). The discharge is specified at cell (90,90) just inside the SICS model boundary (fig. 4, SW12).

The SICS model contains five water-level boundaries (fig. 4 and table 1, SW1, SW2, SW4, SW6 and SW9). Boundaries SW1 and SW2 are located along Old Ingraham Highway and the southern part of Main Park Road, respectively (fig. 4). Both boundaries experience periodic culvert flow and overtopping. Because very little actual flow data exist along these boundaries, water-level data from four ENP field stations were used to create the model boundaries. Each station, located just within the model boundaries, provides good representation of stage along Old Ingraham Highway and Main Park Road. Boundary SW1 is actually divided into two segments within the SICS model. The first segment extends between stations P67 and CY3, and the second segment extends between stations CY3 and P46 (fig. 5). Boundary SW2 is a single segment that extends from station P46 to NMP (fig. 5). The water-level boundary is specified by linearly interpolating daily mean stage between each pair of adjacent stations.

**Table 1.** Description of the current and modified boundary conditions for the Southern Inland and Coastal Systems (SICS) surface-water model

[Model boundary locations are shown in figure 4. Boundary type: D, discharge boundary; NF, no-flow boundary; S, salinity boundary; SFWMM, South Florida Water Management Model; WL, water-level boundary; --, not applicable]

| Boundary number | Description | Boundary conditions | | SFWMM cells used for source data (row,column) |
|---|---|---|---|---|
| | | Field data model | Linked model | |
| SW1 | Old Ingraham Highway (north) | WL, S | WL, S | (7,17) (7,18) (7,22) |
| SW2 | Old Ingraham Highway (west) | WL, S | WL, S | (5,17) (7,17) |
| SW3 | Old Ingraham Highway (southwest) | NF | NF | -- |
| SW4 | Florida Bay | WL, S | WL, S | -- |
| SW5 | Florida Bay islands | NF | NF | -- |
| SW6 | US-1 culverts | WL, S | WL, S | -- |
| SW7 | C-111 tidal canal | NF | NF | -- |
| SW8 | C-111 (S-18C to S-197) | D, S | WL, S | (7,26) (6,27) (6,26) (6,28) |
| SW9 | C-111 (north of S-18C) | WL, S | WL, S | (7,26) |
| SW10 | C-111/Park Road | NF | NF | -- |
| SW11 | Levee 31W | D | D | -- |
| SW12 | Taylor Slough inflow | D, S | WL, S | (9,23) |
| SW13 | Old Ingraham Highway (northeast) | NF | NF | -- |

Water-level boundaries SW4 and SW6 (fig. 4) are specified using measured water-level values from nearby creeks. Boundary SW4, located along the southern part of the model boundary, uses an average of daily mean stage values from McCormick Creek, Taylor River, and Trout Creek. The average is used across the entire boundary to avoid any numerical oscillations that can occur when small lateral water-level differences are forced along a long open boundary. Boundary SW6 uses daily mean stage values from West Highway Creek due to the lack of available flow data for the culverts under US Highway 1.

Boundary SW9, located along the northeastern part of the C-111 Canal, is defined using measured daily mean water-level values from the upstream measuring station at structure S-18C (figs. 4 and 5). The stage from the S-18C upstream station is applied along the entire boundary, unlike boundaries SW1 and SW2 (fig. 4), where water levels between two stations are interpolated. When water levels in the C-111 Canal are greater than the land-surface elevation west of the levee, the model permits leakage beneath and through the levee into the wetlands. A friction coefficient is defined to represent flow resistance equivalent to the resistance of the levee, so leakage through the levee is actually represented as flow through this boundary even though this boundary is designated as a water-level boundary.

Boundaries SW3, SW5, SW7, SW10, and SW13 (fig. 4 and table 1) are no-flow boundaries. Field measurements for boundary SW3 obtained by Stewart and others (2000) indicate that the culverts in this area along Old Ingraham Highway south of station NMP (fig. 5) may not have any significant flow.

Salinity values, in 15-minute intervals, were defined along all of the lateral boundaries. The inland water-level and discharge boundaries (fig. 4, SW1, SW2, SW8, SW9, SW11 and SW12) are essentially freshwater inputs to the model and have an assigned salinity value of zero. No salinity value is required at the no-flow boundaries (fig. 4, SW3, SW5, SW7, SW10, and SW13). Salinity measured at offshore ENP stations BK, WB, and BN (fig. 6) are linearly interpolated between adjacent stations and applied along the southern open-water boundary (fig. 4, SW4). Salinity west of BK at SW4 is set equal to the value at BK, and salinity east of BN is set equal to

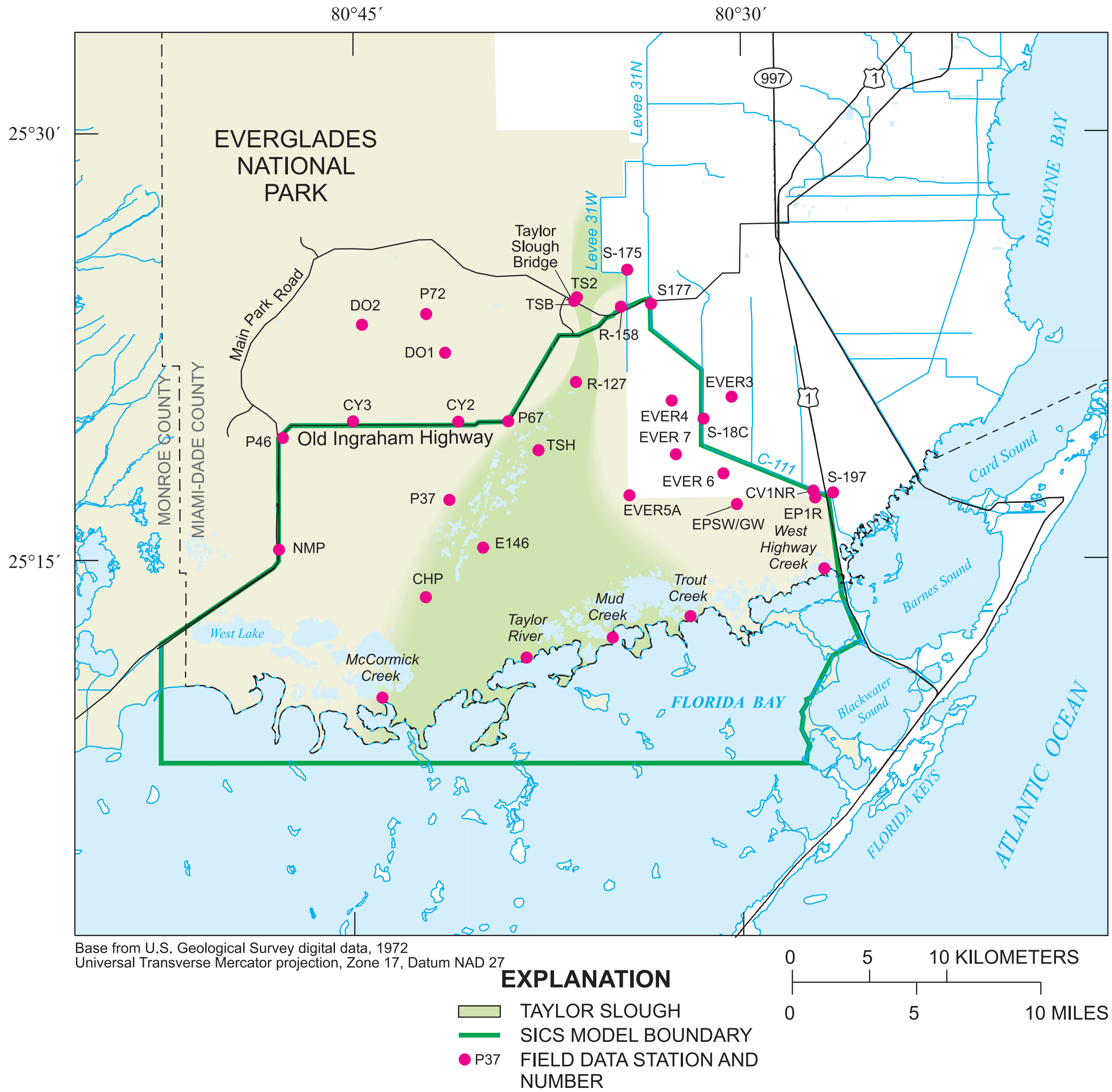


**Figure 5.** Surface-water stations used for determination of water level and discharge in the Southern Inland and Coastal Systems (SICS) model. All sites are water-level stations, except for McCormick, Trout, West Highway Creeks and Taylor River (water level and discharge) and S-18C, S-197, S-175, TSB, and Mud Creek (discharge). Site names and identifiers are listed in appendix 1.

measurements at BN. Salinity recorded at station LS (fig. 6) is applied to boundary SW6 (fig. 4), which represents flow through the culverts beneath US Highway 1.

## Ground-Water Boundaries

The ground-water part of the SICS model contains general-head boundaries (GHBs) and no-flow boundaries (table 2). The GHBs are head-dependent boundaries where the volumetric flux is proportional to the head difference between the boundary and the attached model cell. The GHB cells in the SICS ground-water model are aligned in the horizontal direction, although they can be vertically aligned as well. Due to the coupling method between the surface-water and ground-water models, vertical GHBs are not necessary. The GHBs are represented by boundary GW1, which includes Old Ingraham Highway, the southern part of Main Park Road to the west, and the southern reach of C-111 Canal to the east (fig. 7). The southern part of boundary GW1 ends at the Florida Bay coastline.

Boundary GW1 extends vertically downward into the Biscayne aquifer to include cells representing the aquifer. At

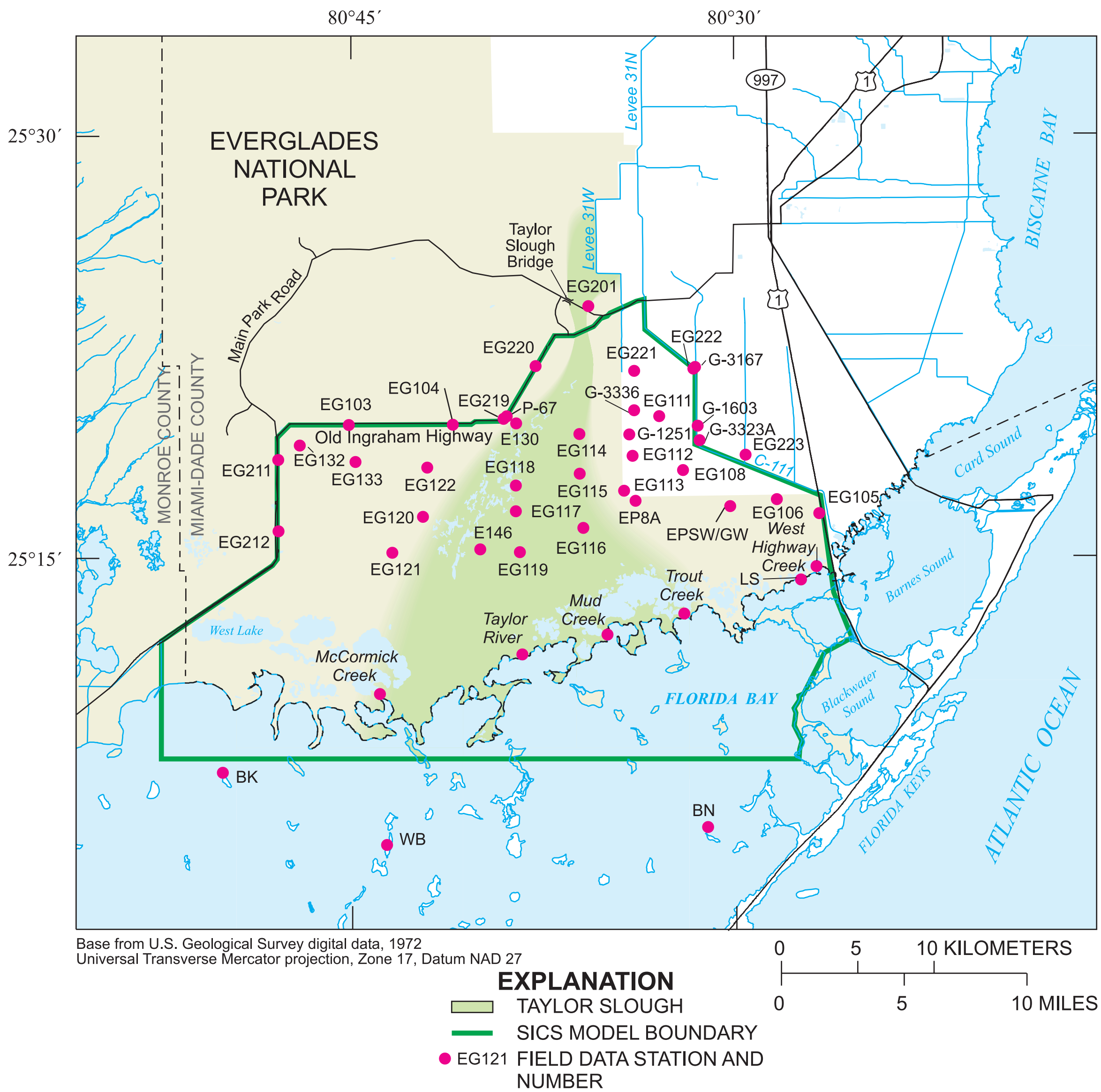


**Figure 6.** Sites used for determination of salinity in the Southern Inland and Coastal Systems (SICS) model. Site names and identifiers are listed in appendix 1.

**Table 2.** Description of the current and modified boundary conditions for the Southern Inland and Coastal Systems (SICS) ground-water model

[Model boundary locations are shown in figure 7. SFWMM, South Florida Water Management Model; --, not applicable]

| Boundary number | Description | Boundary conditions | | SFWMM cells used for source data (row, column) |
|---|---|---|---|---|
| | | Field data model | Linked model | |
| GW1 | Land portion of model boundary | General head, salinity | General head, salinity | (2,15) (3,15) (3,16) (4,16) (4,17) (5,17) (5,28) (6,17) (6,26) (6,27) (6,28) (7,17) (7,18) (7,19) (7,20) (7,21) (7,22) (7,26) (8,22) (8,26) (9,22) (9,23) (9,24) (9,25) |
| GW2 | Florida Bay boundary | No flow | No flow | -- |

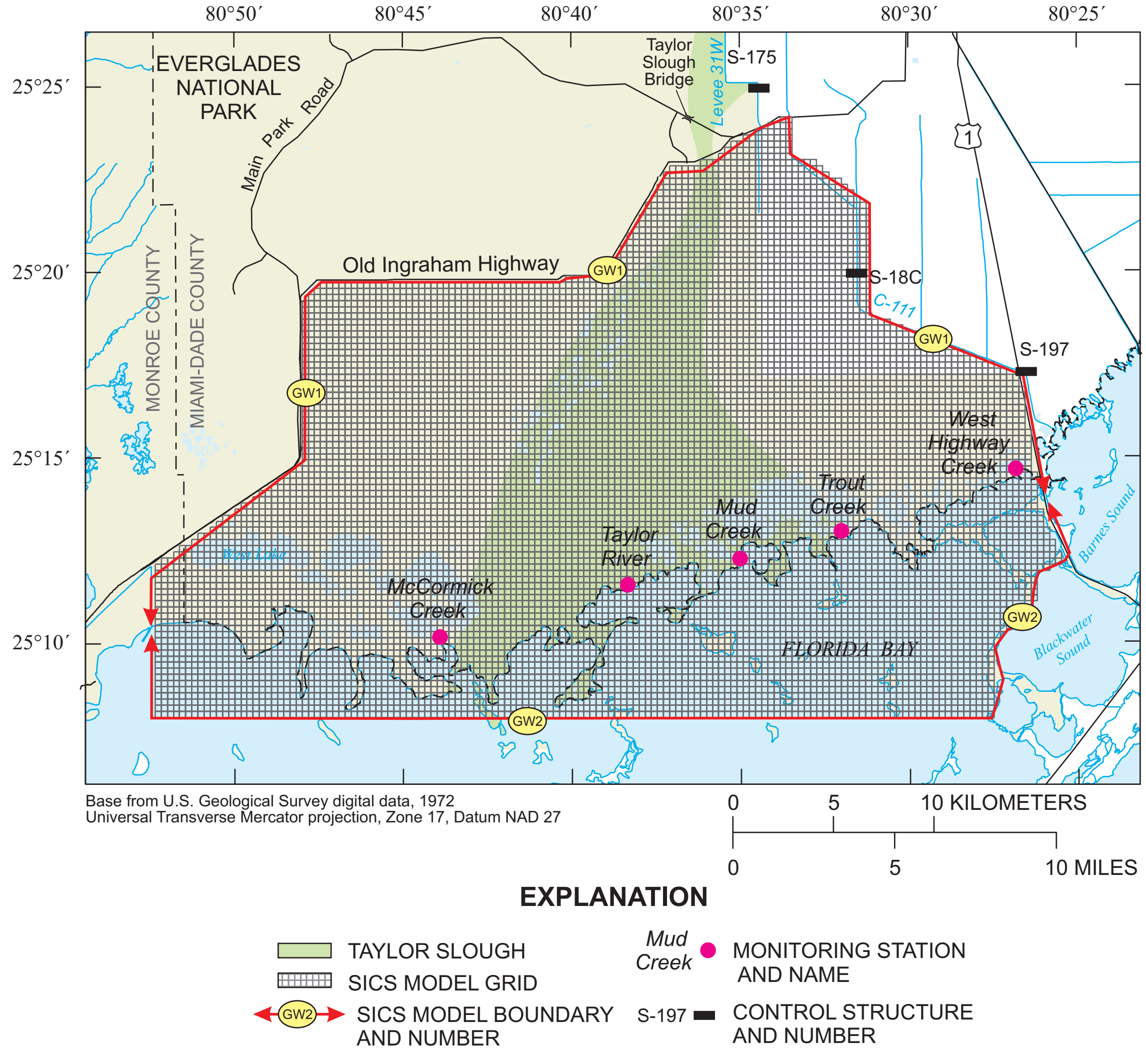


**Figure 7.** Finite-difference model grid and location of boundary conditions specified for the Southern Inland and Coastal Systems (SICS) ground-water model. Descriptions for boundary conditions are given in table 2.

cells where the elevation of the center of the cell is below the estimated bottom elevation of the Biscayne aquifer (fig. 8), a GHB cell is not used and the model cell is assigned as inactive in that layer and all lower layers. The equivalent freshwater head values for the GHBs are calculated by using time-varying stage and salinity from a simulation model using only the surface-water component of the SICS model and the distance to the center of the ground-water cell. The GHB cells in layers 2 to 10 also use the stage and salinity from the corresponding layer 1 GHB cell to calculate the freshwater head values. The only difference between layer 1 head values and the heads from lower layers is the freshwater head correction based on the depth to the center of the ground-water cell. In the surface-water model along no-flow and discharge boundaries, the surface-water cell does not have a defined stage value and can be intermittently dry. If the surface-water cell became dry during the simulation period, a head value at each dry cell then was interpolated from kriged grids of time-varying measured water levels. These water levels were attained from the surface-water stations shown in figure 5 and from the ground-water wells shown in figure 9. The salinity for the GHBs was defined by the salinity input from the surface-water model at each cell for each timestep.

Boundary GW2 (fig. 7) represents a no-flow condition, which indicates that no horizontal flow occurs across this boundary. Unfortunately, field data are lacking to evaluate the appropriateness of this prescribed no-flow condition. An advantage of using a no-flow condition is that there is no need to specify a boundary salinity concentration, which could be problematic for the evaluation of restoration scenarios if the scenario itself were to change salinity values in the Biscayne aquifer beneath Florida Bay.

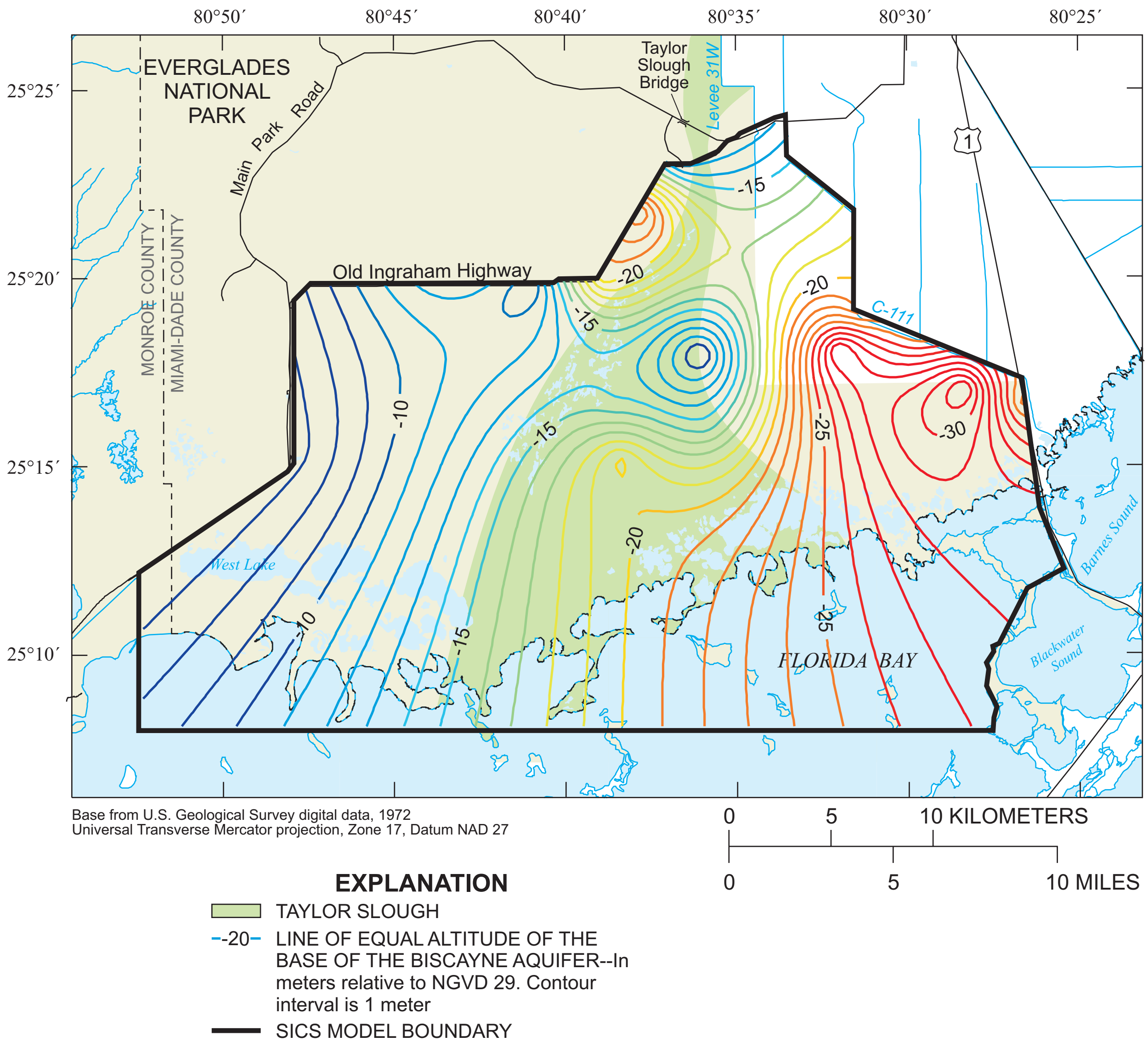


**Figure 8.** Estimated altitude of the base of the Biscayne aquifer. Altitude is given in meters relative to NGVD 29. Data used to construct the map were obtained from Fish and Stewart (1991) and modified using data from Fitterman and others (1999).

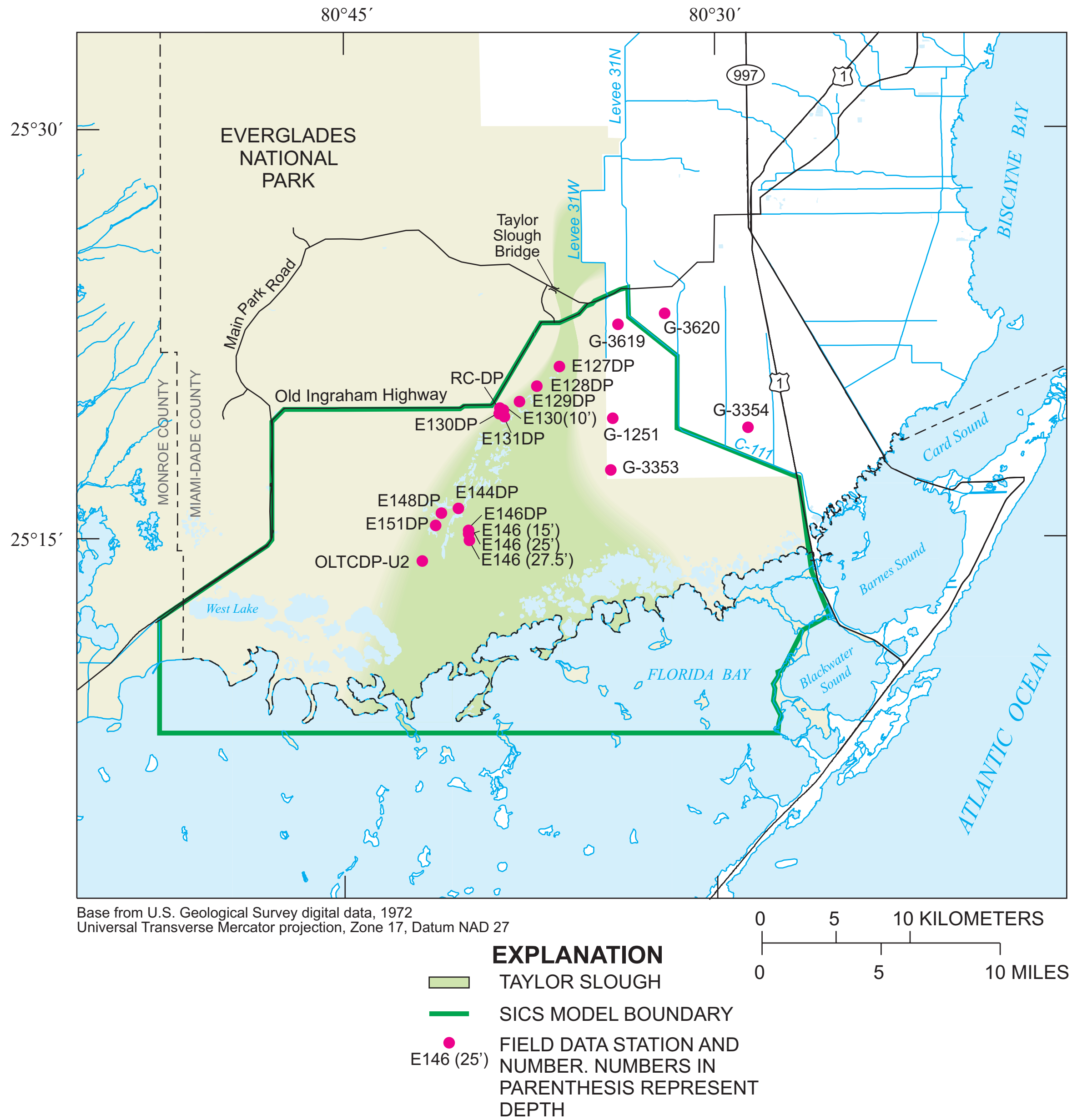


**Figure 9.** Ground-water stations and sites where ground-water head difference was measured in the Southern Inland and Coastal Systems (SICS) model. All sites are head-difference stations, except for G-1251, G-3353, and G-3619 (water level). Site names and identifiers are listed in appendix 1.

# Linked Model Boundary Conditions

In developing the method for “driving” the SICS model with output from the SFWMM, decisions were made regarding the most accurate and defensible method for assigning spatially variable hydrologic input to SICS boundaries. Perhaps the most important decision was determining whether to use simulated stages from the SFWMM as hydrologic input for SICS boundaries, or whether to utilize simulated flows from the SFWMM. In a previous endeavor by the SFWMD, the SFWMM model was modified to simulate hydrologic conditions in southern Florida without the presence of water-management canals or other anthropogenic influences. At the request of SFWMD, this model, called the SFWMD’s Natural Systems Model (NSM), was technically reviewed by the USGS (Bales, and others, 1997). After evaluating the NSM, the USGS concluded that: “In general, reasonable simulations of water depth are easier to obtain in all hydraulic simulation models than reasonable simulations of flow” (Bales, and others, 1997). Thus, from this evaluation of the NSM, it was decided that the most accurate method for driving the SICS model would be to convert discharge boundaries to water-level boundaries and assign stages based on output from the SFWMM. This procedure then allowed for the SFWMM to supply reasonable water levels as input to the SICS model.

Several SICS model boundary conditions, prescribed by field data, were modified in order to link the SICS model and the SFWMM. The three areal influences (wind, rainfall, and evapotranspiration) in the SICS model were not altered. The SFWMM does not simulate effects of wind on flow, and therefore, does not provide the data required by the SICS model for the boundary. Rainfall and evapotranspiration data in the SFWMM model, like the SICS model, are based on measured data and would not provide any new information for the SICS boundaries. The subsequent sections describe the procedures used to assign the remaining boundary conditions for surface-water and ground-water components of the SICS model from the SFWMM.

## Surface-Water Boundaries

Discharge boundaries SW8, SW11, SW12 and water-level boundaries SW1, SW2, and SW9 were modified in order to couple the SFWMM to the SICS model. No-flow and salinity boundaries SW3-7, SW10, and SW13 were not modified. Discharge boundaries SW8 and SW12 in the current SICS model domain were converted to water-level boundaries (table 1). These boundaries are in the southeastern part of the C-111 Canal (fig. 4, SW8) and at Taylor Slough Bridge (fig. 4, SW12). The flows into the model through Levee 31W from structure S-175 (fig. 5) remain a discharge boundary (fig. 4, SW11) in the linked model. The source of the data for this boundary, however, comes from the discharge values calculated by the SFWMM at structure S-175 rather than from measured data at this control structure.

Discharge boundary SW12 at Taylor Slough Bridge (fig. 4 and table 1) was modified by converting SICS model cells (88,92), (89,92), (90,92) along the boundary to represent water levels, and removing previous discharge input from a single cell just inside the model boundary. Taylor Slough Bridge is located outside of the actual SICS model boundary; however, because of a developed stage-discharge relation, flow was entered as a direct discharge input into the model designated cell. This relation does not correspond to the input of stages at the boundary. Stages reflect land-surface elevations; therefore, a comparison between the different elevations at Taylor Slough Bridge and the location of the three boundary cells precludes the direct use of stage values. The elevation difference is made larger in the SFWMM because each cell spans about 3.2 km, and land-surface elevations increase northward. A reason for the larger difference is that the SFWMM outputs values for each cell as water levels. In order to transform these values to stages for input into the SICS model, they must be corrected for land-surface elevation. The elevation that the SFWMM uses is the average land-surface elevation of the entire 3.218- x 3.218-km (2- x 2-mi) cell, which can overlook smaller scale elevation changes that show up in the SICS model. Even though these elevation changes are small, slight differences in land-surface elevation observed in southern Florida can create substantial differences in water levels. The SFWMM cell (10,23) that represents Taylor Slough Bridge is about 2.6 km away from the location of the SICS boundary cells, which can cause even larger elevation discrepancies. To represent the stages at the boundary more accurately, the SFWMM cell (9,23) directly south of the SFWMM cell (10,23) that includes Taylor Slough Bridge was used. The SFWMM cell (9, 23) also overlaps SICS boundary cells (88,92), (89,92), (90,92) where the stage is defined.

For the restoration effort, one proposed change is the removal of the southeastern part of C-111 Canal between structures S-18C and S-197 (fig. 5). To test this scenario, boundary SW8 (fig. 4) in the SICS model was changed from a discharge boundary to a water-level boundary. This modification involved applying simulated SFWMM stage values to corresponding SICS cells for structures S-18C and S-197, and linearly interpolating a water-level boundary along C-111 Canal for the SICS model water-level boundary condition.

Boundaries SW1 and SW2 (fig. 4) represent water levels in the original SICS model, so the boundary type does not change with the linkage—only the source of the data input is changed. These data are acquired from SFWMM cells (7,22) at station P67, (7,18) at CY3, (7,17) at P46, and (5,17) at NMP (fig. 5). Once the stages are input, the SICS model then linearly interpolates between the stations to create the water-level boundaries SW1 and SW2 (fig. 4).

Water-level boundary SW9 is located along the northern part of C-111 Canal (fig. 4). Like boundaries SW1 and SW2, the only modification for SW9 is in the source of its data. Water levels are acquired from the SFWMM at cell (7,26), which corresponds to the upstream location of the upstream S-18C gaged water-level station. The stage is then applied to the SICS model along the entire boundary, unlike boundaries SW1 and SW2, where stages are interpolated along the canal reach.

Boundaries SW3 to SW7, SW10, and SW13 (fig. 4 and table 1) are not modified. The specified water levels and salinities along Florida Bay and at West Highway Creek (fig. 4, SW4 and SW6) are not altered because the southern SFWMM boundaries are north of the southern SICS model boundaries and, therefore, do not provide any input information for the SICS model. No-flow boundaries SW3, SW5, SW7, SW10 and SW13 also are not modified.

## Ground-Water Boundaries

Boundary GW1 (fig. 7 and table 2) for the SICS ground-water model is modified by acquiring stage values from all of the SFWMM cells that surround each of the SICS boundary cells. Table 2 gives the SFWMM cells in which the SICS model cells overlap. Ground-water boundary heads are spatially interpolated using the bilinear interpolation method. These interpolated values are assigned to the appropriate SICS boundary GW1 cell in all layers of the SICS ground-water model.

Boundary GW2 (fig. 7 and table 2), which represents a no-flow condition along Florida Bay, is unaltered. The SFWMM does not include this area; therefore, no SFWMM simulation data are available to modify the boundary.

# Model Comparison

To verify the linkage procedure, a test simulation was performed. The test simulation covered the time period from January 1, 1996, to December 31, 2000. Data were acquired from the SFWMD for that simulation period from the SFWMM 2000B1 Existing Conditions simulation. The data were applied to the SICS model by using the procedure previously described in this report. Results from this linked model simulations then were compared with the SICS field data model results (C.D. Langevin and others, U.S. Geological Survey, written commun., 2004).

In general, the error stastistics for the two models are within reasonable ranges (table 3). For coastal creek discharges, the overall flow difference between the two models for the entire simulation period is about 5 percent, and the overall stage difference in the wetlands is only 4 percent lower in the linked model than in the field data model. The largest difference between the two simulations occurs in the salinities. The linked model predicts salinities that are higher than the field data model. This difference ranges from 1 to 5 g/L, though the larger differences occur only in the smaller creeks, which carry a minimal portion of the overall flow through the model area.

**Table 3.** Error statistics for model simulations using the linked and base field data models

[RMSE, root mean square error]

| Station | Count | Linked model | | | Base field data model | | |
|---|---|---|---|---|---|---|---|
| | | Mean error | Mean absolute error | RMSE | Mean error | Mean absolute error | RMSE |
| Discharge | | | | | | | |
| McCormick Creek | 1,827 | 0.22 | 1.50 | 2.00 | 0.29 | 1.56 | 2.03 |
| Mud Creek | 1,828 | .36 | 1.81 | 3.89 | .39 | 1.76 | 3.55 |
| Trout Creek | 1,797 | -1.11 | 5.22 | 7.23 | -1.35 | 4.97 | 6.97 |
| Taylor River | 1,826 | -.29 | 1.14 | 2.59 | -.08 | 1.20 | 3.24 |
| West Highway Creek | 1,753 | -.66 | 1.11 | 1.63 | -.25 | 1.16 | 1.68 |
| Stage/Head | | | | | | | |
| Nine Mile Pond | 1,561 | -0.07 | 0.07 | 0.09 | 0.02 | 0.02 | 0.02 |
| Cypress No. 3 | 1,581 | -.13 | .14 | .18 | -.07 | .07 | .07 |
| ENP-P46 | 1,751 | -.08 | .09 | .12 | -.01 | .06 | .08 |
| ENP-P67 | 1,813 | -.02 | .07 | .10 | .01 | .06 | .08 |
| Cypress No. 2 | 1,521 | -.09 | .10 | .14 | -.03 | .04 | .05 |
| Taylor Slough Hilton | 1,806 | -.02 | .06 | .08 | .00 | .05 | .07 |
| ENP-E146 | 1,755 | .03 | .05 | .08 | .04 | .06 | .08 |
| Craighead Pond | 1,761 | -.04 | .07 | .09 | -.03 | .06 | .08 |
| Everglades EPSW | 1,751 | .09 | .09 | .12 | .08 | .08 | .10 |
| Everglades 6 | 1,665 | -.06 | .08 | .09 | -.04 | .05 | .07 |
| Everglades 7 | 1,739 | -.02 | .05 | .06 | -.03 | .05 | .06 |
| ENP-127 | 1,770 | -.02 | .07 | .09 | .01 | .06 | .09 |
| ENP-P37 | 1,736 | -.02 | .05 | .07 | .00 | .05 | .07 |
| G-3619 | 1,736 | -.05 | .11 | .15 | -.03 | .07 | .10 |
| G-3353 | 1,795 | .16 | .16 | .19 | .14 | .15 | .17 |
| G-1251 | 1,362 | .04 | .11 | .13 | .05 | .07 | .09 |
| Salinity | | | | | | | |
| McCormick Creek | 1,823 | 6.76 | 7.50 | 8.83 | 3.28 | 8.31 | 10.59 |
| Mud Creek | 1,828 | 3.93 | 4.65 | 5.86 | 2.12 | 3.89 | 5.02 |
| Trout Creek | 1,805 | 3.81 | 5.17 | 6.60 | 2.44 | 4.78 | 6.32 |
| Taylor River | 1,817 | 8.33 | 8.50 | 10.15 | 5.83 | 6.46 | 7.97 |
| West Highway Creek | 1,786 | 4.19 | 6.39 | 8.00 | -.86 | 4.52 | 5.54 |

Figures 10 and 11 display results of the linked SICS and SFWMM model simulation in comparison to the field data model simulation and actual measured values at selected sites in the model area. Discharges and salinities at Trout Creek from August 1, 1997, to July 31, 1998, are shown in figure 10. Stages for the entire simulation at ENP-P37 (P37) and Taylor Slough Hilton (TSH) are shown in figure 11. In general, these plots show close agreement between the SICS model linked with the SFWMM and the SICS field data model.

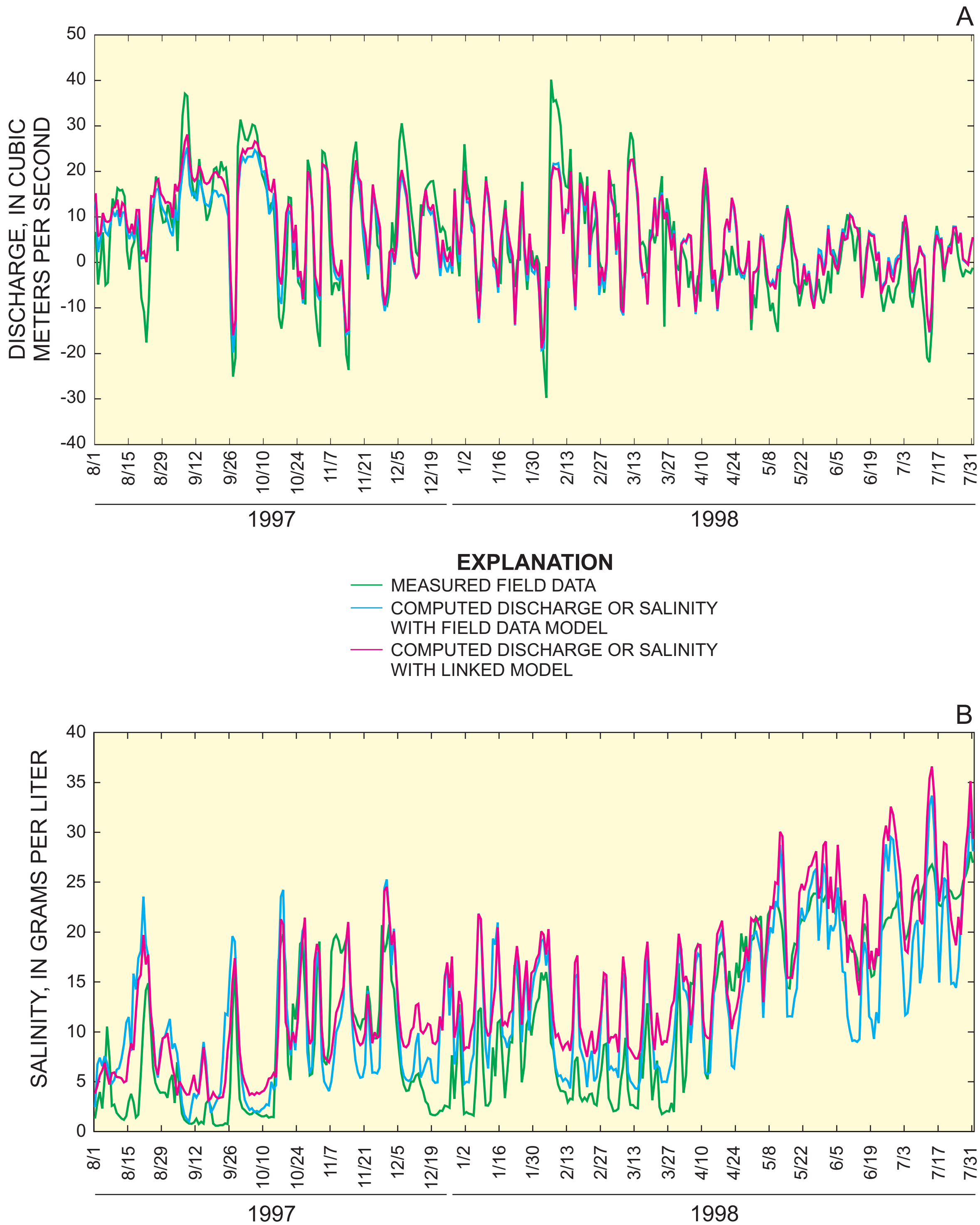


**Figure 10.** (A) Discharge and (B) salinity values at Trout Creek, August 1, 1997, to July 31, 1998. Plots display the measured field data values relative to the computed values from the field data model and the linked model. The location of the Trout Creek site is shown in figure 5.

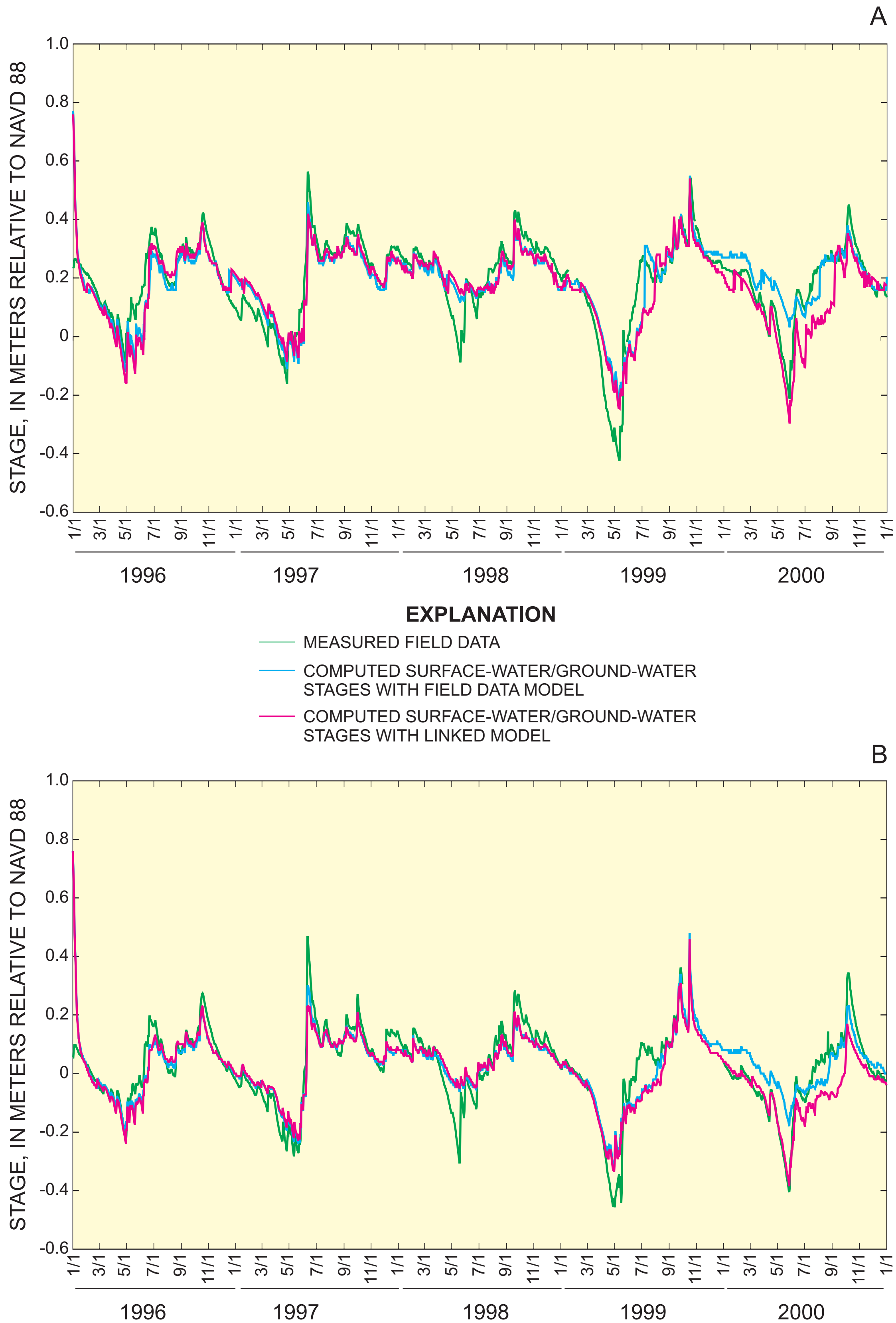


**Figure 11.** Stages at (A) Taylor Slough Hilton (TSH) and (B) P37, January 1, 1996, to November 1, 2000. Plots display the measured stages relative to the computed stages from the field data model and the linked model. The locations of TSH and P37 are shown in figures 5 and 3, respectively.

## Summary

This report describes the general procedure for performing simulations with the SICS integrated surface-water/ground-water model using boundary data generated by the SFWMM. Boundary conditions were defined for both surface- and ground-water parts of the SICS model. The surface-water model contains two types of boundaries: areal (wind, rainfall, and evapotranspiration) and lateral boundaries (discharge, water level, no flow, and salinity). The ground-water model contains two types of boundaries: general head and no flow. In the linkage of the SFWMM and SICS models, areal boundaries were not changed; however, the lateral and general-head boundaries were changed. Once the appropriate changes were implemented, a 5-year test simulation using data from the SFWMM 200B1 Existing Conditions simulation was run to verify the linkage procedure.

Results from the test simulation indicate that the linkage procedure works well, and the linked model runs with the new boundaries. The test simulation also shows that the results produced by the linked model are reasonable and within plausible error ranges. This demonstrates that the linkage procedure is applicable for testing future CERP scenarios.

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# Appendixes I and II

# Appendix I. Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

Latitude/longitude is in degrees, minutes, and seconds (ddmmss). Terminology: Field station name refers to the name of the station at which data were collected. Model component refers to which model regime the data were applied to. Purpose refers to how the collected data were used in the model; boundary refers to data that are used to create the model boundaries for each model run—these data will change with scenario runs; comparison refers to data from field stations that are used to verify how well the model is simulating the real system. Timestep refers to the interval in which the data were collected at the field sites—this is not necessarily the interval in which the data were applied to the model; point data refers to a measuring point that was only sampled a few times.

Acronyms and symbols:

| | |
|---|---|
| ADAPS | automated data processing system |
| ENP | Everglades National Park |
| GW | ground water |
| SOFIA | South Florida Information Access |
| SFNRC | South Florida Natural Resource Center |
| SFWMD | South Florida Water Management District |
| SW | surface water |
| UM | University of Miami |
| USGS | U.S. Geological Survey |
| -- | not applicable |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| Solar Radiation (station locations shown in figure 3) | | | | | | | | | | |
| ENP Joe Bay Weather Station | JBWS | IX714 | 251328 | 803224 | SW | Boundary | 15 minute | 1991-Present | SFWMD | SFWMD DBHYDRO |
| USGS Old Ingraham Highway | OIH | 252112080380700 | 252111 | 803802 | SW | Boundary | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| Wind (station location shown in figure 3) | | | | | | | | | | |
| ENP Joe Bay Weather Station | JBWS | IX718 | 251328 | 803224 | SW | Boundary | 15 minute | 1991-Present | SFWMD | SFWMD DBHYDRO |
| Rainfall (station locations shown in figure 3) | | | | | | | | | | |
| USGS Old Ingraham Highway | OIH | 252112080380700 | 252111 | 803802 | SW | Boundary | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| ENP-127 | R127 | R127:Rainfall-3 | 252115 | 803624 | SW | Boundary | Hourly | 1994-Present | ENP | SFNRC ENP data website |
| Flamingo | FLA | FLA:Rainfall-83 | 250829 | 805453 | SW | Boundary | Hourly | 1962-Present | ENP | SFNRC ENP data website |
| Craighead Pond | CHP | CP:Rainfall-24 | 251344 | 804215 | SW | Boundary | Hourly | 1994-Present | ENP | SFNRC ENP data website |
| S-18C_R | S-18C | S18C:rain-3 | 251950 | 803130 | SW | Boundary | Hourly | 1967-Present | ENP | SFNRC ENP data website |
| P37 | P37 | P37:Rainfall-60 | 251708 | 804119 | SW | Boundary | Hourly | 1982-Present | ENP | SFNRC ENP data website |
| P38 | P38 | P38:Rainfall-62 | 252209 | 805036 | SW | Boundary | Hourly | 1983-Present | ENP | SFNRC ENP data website |
| Everglades 8 | EVER8 | EVER8:Rainfall-41 | 252046 | 802844 | SW | Boundary | Hourly | 1992-Present | ENP | SFNRC ENP data website |
| Little Madeira | LM | LM:Rainfall-289 | 251031 | 803756 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Terrapin Bay | TB | TB:Rainfall-350 | 250924 | 804330 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Long Sound | LS | LS:Rainfall-305 | 251405 | 802727 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Trout Cove | TC | TC:Rainfall-354 | 251239 | 803160 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Taylor River | TR | TR:Rainfall-366 | 251328 | 803911 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Whipray Basin | WB | WB:Rainfall-370 | 250441 | 804339 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface-Water Level (station locations shown in figure 5) | | | | | | | | | | |
| McCormick Creek | McCormick-Creek | 251003080435500 | 251003 | 804355 | SW/GW | Boundary/Comparison | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| Taylor River | Taylor River | 251127080382100 | 251127 | 803821 | SW/GW | Boundary/Comparison | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| Trout Creek | Trout Creek | 251253080320100 | 251253 | 803201 | SW/GW | Boundary/Comparison | 15 minute | 1996-Present | USGS | USGS SOFIA website |
| West Highway Creek | West Highway Creek | 251433080265000 | 251433 | 802650 | SW/GW | Boundary/Comparison | 15 minute | 1996-Present | USGS | USGS SOFIA website |
| Nine Mile Pond | NMP | NMP:Stage-46 | 251515 | 804754 | SW | Boundary/Comparison | Daily | 1996-Present | ENP | SFNRC ENP data website |
| Cypress No. 3 | CY3 | CY3:Stage-29 | 251946 | 804502 | SW | Boundary/Comparison | Daily | 1996-Present | ENP | SFNRC ENP data website |
| ENP-P46 | P46 | NP46:Stage-64 | 251911 | 804745 | SW | Boundary/Comparison | Daily | 1966-Present | ENP | SFNRC ENP data website |
| ENP-P67 | P67 | NP67:Stage-66 | 251950 | 803902 | SW | Boundary/Comparison | Daily | 1962-Present | ENP | SFNRC ENP data website |
| Upstream S18C_H | S-18C | 05776 | 251950 | 803130 | SW | Boundary | Daily | 1985-Present | SFWMD | SFWMD DBHYDRO |
| Taylor Slough Bridge 2 | TS2 | TS2:Stage-101 | 252359 | 803625 | SW | Boundary | Daily | 2000-Present | ENP | SFNRC ENP data website |
| Cypress No. 2 | CY2 | CY2:Stage-28 | 251945 | 804058 | SW/GW | Boundary/Comparison | Daily | 1996-Present | ENP | SFNRC ENP data website |
| Taylor Slough Hilton | TSH | TSH:Stage-76 | 251844 | 803752 | SW/GW | Boundary/Comparison | Daily | 1994-Present | ENP | SFNRC ENP data website |
| ENP-E146 | E146 | E146:Stage-4 | 251518 | 804001 | SW/GW | Boundary/Comparison | Daily | 1994-Present | ENP | SFNRC ENP data website |
| Craighead Pond | CHP | CP:Stage-23 | 251344 | 804215 | SW/GW | Boundary/Comparison | Daily | 1978-Present | ENP | SFNRC ENP data website |
| Everglades EPSW | EPSW/GW | EPSW:Stage-36 | 251649 | 803012 | SW/GW | Boundary/Comparison | Daily | 1986-Present | ENP | SFNRC ENP data website |
| Everglades CV1NR | CV1NR | CV1NR:Stage-1 | 251725 | 802714 | GW | Boundary | Daily | 1989-Present | ENP | SFNRC ENP data website |
| Everglades Donut No. 1 | DO1 | DO1:Stage-30 | 252218 | 804128 | GW | Boundary | Daily | 1989-Present | ENP | SFNRC ENP data website |
| Everglades Donut No. 2 | DO2 | DO2:Stage-31 | 252317 | 804440 | GW | Boundary | Daily | 1996-Present | ENP | SFNRC ENP data website |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| Everglades EP1R | EP1R | EP1R:Stage-33 | 251709 | 802711 | GW | Boundary | Daily | 1985-Present | ENP | SFNRC ENP data website |
| Everglades 3 | EVER3 | 252043080302400 | 252043 | 803024 | GW | Boundary | Daily | 1985-Present | USGS | ADAPS |
| Everglades 4 | EVER4 | 252036080324300 | 252036 | 803243 | GW | Boundary | Daily | 1985-Present | USGS | ADAPS |
| Everglades 5A | EVER5A | 251716080342100 | 251716 | 803421 | GW | Boundary | Daily | 1985-Present | USGS | ADAPS |
| ENP-P72 | P72 | NP72:Stage-67 | 252339 | 804211 | GW | Boundary | Daily | 1966-Present | ENP | SFNRC ENP data website |
| S-177 | S177 | 13154 | 252359 | 803330 | GW | Boundary | Daily | 1981-Present | SFWMD | SFWMD DBHYDRO |
| Everglades 6 | EVER6 | EVER6:Stage-38 | 251754 | 803043 | SW/GW | Boundary/ Comparison | Daily | 1991-Present | ENP | SFNRC ENP data website |
| Everglades 7 | EVER7 | EVER7:Stage-39 | 251835 | 803234 | SW/GW | Boundary/ Comparison | Daily | 1991-Present | ENP | SFNRC ENP data website |
| ENP-127 | R127 | R127:Stage-2 | 252115 | 803624 | SW/GW | Boundary/ Comparison | Daily | 1984-Present | ENP | SFNRC ENP data website |
| ENP-158 | R158 | R158:Stage-5 | 252346 | 803440 | SW/GW | Boundary/ Comparison | Daily | 1983-Present | ENP | SFNRC ENP data website |
| ENP-P37 | P37 | P37:Stage-59 | 251708 | 804119 | SW/GW | Boundary/ Comparison | Daily | 1953-Present | ENP | SFNRC ENP data website |
| Discharge (stations locations shown in figure 5) | | | | | | | | | | |
| S-18C | S-18C | 00718 | 251950 | 803130 | SW | Boundary | Daily | 1968-Present | SFWMD | SFWMD DBHYDRO |
| S-197_C | S-197 | 15763 | 251713 | 802629 | SW | Boundary | Daily | 1970-Present | SFWMD | SFWMD DBHYDRO |
| S-175_C | S-175 | 15752 | 252504 | 803425 | SW | Boundary | Daily | 1970-Present | SFWMD | SFWMD DBHYDRO |
| Taylor Slough Bridge | TSB | H3153 | 252406 | 803624 | SW | Boundary | Daily | 1960-1999 | SFWMD | SFWMD DBHYDRO |
| McCormick Creek | McCormick Creek | 251003080435500 | 251003 | 804355 | SW | Comparison | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| Taylor River | Taylor River | 251127080382100 | 251127 | 803821 | SW | Comparison | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| Mud Creek | Mud Creek | 251209080350100 | 251209 | 803501 | SW | Comparison | 15 minute | 1995-Present | USGS | USGS SOFIA website |
| Trout Creek | Trout Creek | 251253080320100 | 251253 | 803201 | SW | Comparison | 15 minute | 1996-Present | USGS | USGS SOFIA website |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| West Highway Creek | West Highway Creek | 251433080265000 | 251433 | 802650 | SW | Comparison | 15 minute | 1996-Present | USGS | USGS SOFIA website |
| Salinity (stations locations shown in figure 6) | | | | | | | | | | |
| BUOY KEY | BK | BK:salinity-8 | 250716 | 805001 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| BUTTERNUT KEY | BN | BN:salinity-8 | 250518 | 803107 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Long Sound | LS | LS:salinity-8 | 251405 | 802727 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| Whipray Basin | WB | WB:salinity-8 | 250441 | 804339 | SW | Boundary | Hourly | 1993-Present | ENP | SFNRC ENP data website |
| G-1603 | G-1603 | 251949080313102 | 251949 | 803131 | GW | Comparison | Point data | -- | UM | Price (2001) |
| E130-(10') | E130 | ENP--E130 | 251960 | 803873 | GW | Comparison | Point data | -- | UM | Price (2001) |
| E130-(52.5') | E130 | ENP--E130 | 251960 | 803873 | GW | Comparison | Point data | -- | UM | Price (2001) |
| E146-(15') | E146 | ENP--E146 | 251518 | 804001 | GW | Comparison | Point data | -- | UM | Price (2001) |
| E146-(25') | E146 | ENP--E146 | 251518 | 804001 | GW | Comparison | Point data | -- | UM | Price (2001) |
| E146-(27.5') | E146 | ENP--E146 | 251518 | 804001 | GW | Comparison | Point data | -- | UM | Price (2001) |
| NP-67 | P67 | ENP--P67 | 251944 | 803902 | GW | Comparison | Point data | -- | UM | Price (2001) |
| EPGW | EPSW/GW | EPSW/EPGW | 251648 | 803012 | GW | Comparison | Point data | -- | UM | Price (2001) |
| EP8A | EP8A | EP8A | 251715 | 803421 | GW | Comparison | Point data | -- | UM | Price (2001) |
| G-1251 | G-1251 | 251922080340701 | 251922 | 803407 | GW | Comparison | Point data | -- | UM | Price (2001) |
| G-3323A | G-3323A | 251902080312402 | 251902 | 803124 | GW | Comparison | Point data | -- | UM | Price (2001) |
| G-3336 | G-3336 | 252007080335701 | 252007 | 803357 | GW | Comparison | Point data | -- | UM | Price (2001) |
| G-3167 | G-3167 | 252138080313301 | 252138 | 803133 | GW | Comparison | Point data | -- | UM | Price (2001) |
| McCormick Creek | McCormick Creek | 251003080435500 | 251003 | 804355 | SW | Comparison | Daily | 1995-Present | USGS | USGS SOFIA website |
| Taylor River | Taylor River | 251127080382100 | 251127 | 803821 | SW | Comparison | Daily | 1995-Present | USGS | USGS SOFIA website |
| Mud Creek | Mud Creek | 251209080350100 | 251209 | 803501 | SW | Comparison | Daily | 1995-Present | USGS | USGS SOFIA website |
| Trout Creek | Trout Creek | 251253080320100 | 251253 | 803201 | SW | Comparison | Daily | 1996-Present | USGS | USGS SOFIA website |
| West Highway Creek | West Highway Creek | 251433080265000 | 251433 | 802650 | SW | Comparison | Daily | 1996-Present | USGS | USGS SOFIA website |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| EG221 | EG221 | EG221 | 252131 | 803355 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG223 | EG223 | EG223 | 251831 | 802935 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG222 | EG222 | EG222 | 252135 | 803136 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG220 | EG220 | EG220 | 252141 | 803748 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG219 | EG219 | EG219 | 251954 | 803856 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG212 | EG212 | EG212 | 251550 | 804753 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG211 | EG211 | EG211 | 251822 | 804753 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG201 | EG201 | EG201 | 252349 | 803544 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG133 | EG133 | EG133 | 251818 | 804451 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG132 | EG132 | EG132 | 251853 | 804702 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG122 | EG122 | EG122 | 251804 | 804203 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG121 | EG121 | EG121 | 251504 | 804325 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG120 | EG120 | EG120 | 251621 | 804213 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG119 | EG119 | EG119 | 251505 | 803826 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG118 | EG118 | EG118 | 251727 | 803835 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG117 | EG117 | EG117 | 251632 | 803835 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG116 | EG116 | EG116 | 251557 | 803556 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG115 | EG115 | EG115 | 251752 | 803604 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG114 | EG114 | EG114 | 251916 | 803605 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| EG113 | EG113 | EG113 | 251654 | 803352 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG112 | EG112 | EG112 | 251830 | 803401 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG111 | EG111 | EG111 | 251954 | 803258 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG108 | EG108 | EG108 | 251759 | 803202 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG106 | EG106 | EG106 | 251657 | 802822 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG105_EP12R | EG105 | EG105_EP12R | 251626 | 802643 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG104_CYP2 | EG104 | EG104_CYP2 | 251944 | 804059 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG103_CYP3 | EG103 | EG103_CYP3 | 251944 | 804503 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| EG107_EPGW/SW | EPSW/GW | EG107_EPGW/SW | 251648 | 803012 | GW | Comparison | Point data | -- | USGS | Fitterman and others (1999) |
| Ground-Water Level and Head Difference (stations locations shown in figure 9) | | | | | | | | | | |
| E127DP | E127DP | E127DP | 252110 | 803616 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E128DP | E128DP | E128DP | 252026 | 803712 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E129DP | E129DP | E129DP | 251953 | 803754 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E130 (10’) | E130 (10’) | E130(10’) | 251940 | 803834 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E130DP | E130DP | E130DP | 251940 | 803842 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E131DP | E131DP | E131DP | 251919 | 803831 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E144DP | E144DP | E144DP | 251559 | 804024 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E146 (15’) | E146 (15’) | E146(15’) | 251511 | 803959 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E146 (25’) | E146 (25’) | E146(25’) | 251511 | 803959 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |

**Appendix I.** Temporal Data-Collection Stations Used in the Southern Inland and Coastal Systems Model

| Field station name[1] (this report) | Map identifier | Site identifier | Latitude (ddmmss) | Longitude (ddmmss) | Model component | Purpose | Timestep | Period of record | Agency | Website or data source[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| E146 (27.5’) | E146 (27.5’) | E146(27.5’) | 251458 | 803958 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E146DP | E146DP | E146DP | 251511 | 803959 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E148DP | E148DP | E148DP | 251549 | 804106 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| E151DP | E151DP | E151DP | 251404 | 804151 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| OLTCDP-U2 | OLTCDP-U2 | OLTCDP-U2 | 251522 | 804119 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| RC-DP | RC-DP | RC-DP | 251927 | 803844 | GW | Comparison | Point data | -- | USGS | Harvey and others (2000) |
| G-3354 | G-3354 | 251855080283401 | 251855 | 802834 | GW | Boundary | Daily | 1985-Present | USGS | ADAPS |
| G-3619 | G-3619 | 252243080335501 | 252243 | 803355 | GW | Boundary/ Comparison | Daily | 1996-Present | USGS | ADAPS |
| G-3620 | G-3620 | 252312080320301 | 252312 | 803203 | GW | Boundary | Daily | 1996-Present | USGS | ADAPS |
| G-3353 | G-3353 | 251724080341401 | 251724 | 803414 | GW | Boundary/ Comparison | Daily | 1985-Present | USGS | ADAPS |
| G-1251 | G-1251 | 251922080340701 | 251922 | 803407 | GW | Boundary/ Comparison | Daily | 1965-Present | USGS | ADAPS |

[1]A “DP” suffix indicates drop point at station listed. A number in parenthesis in a site name refers to the depth of the listed station, in feet (values are not converted to meters for identification purposes). The depth values are approximate at ground-water wells

[2]The USGS SOFIA website can be accessed at http://sofia.usgs.gov. The SFNRC ENP data website can be accessed at http://www.sfnrc.ever.nps.gov/physical/data_physical_form. The SFWMD DBHYDRO website can be accessed at http://glades.sfwmd.gov/pls/dbhydro_pro_plsql/show_dbkey_info.main_page. Contact the Data Section Chief for the South Florida USGS Florida Integrated Science Center office (http://fl.water.usgs.gov) for information from ADAPS.

# Appendix II. Sources Used to Develop Model Spatial Information

[Model component: SW, surface water; GW, ground water]

| Data type | Model component | Data source[1] |
|---|---|---|
| Peat thickness | SW, GW | Harvey and others (2000) |
| Peat hydraulic conductivity | SW, GW | Harvey and others (2000) |
| Hydraulic conductivity | GW | Fish and Stewart (1991) |
| Biscayne aquifer depth | GW | Fish and Stewart (1991) |
| Florida Bay bottom types | SW, GW | Halley (1997) |
| Salinity interface | GW | Fitterman and others (1999) |
| Specific yield | GW | Merritt (1996) |
| Porosity | GW | Merritt (1996) |
| Land-surface elevation | SW | Desmond and others (2000) |
| Bay bathymetry | SW | Hansen and Dewitt (2000) |
| Vegetation | SW | Lee and others (1999); Jones (1999) |
| Evapotranspiration | SW | German (2000) |
| Wind-sheltering term | SW | H.L Jenter (U.S. Geological Survey, written commun., 1999) |

[1]Most data available under the investigator's name at http://sofia.usgs.gov.