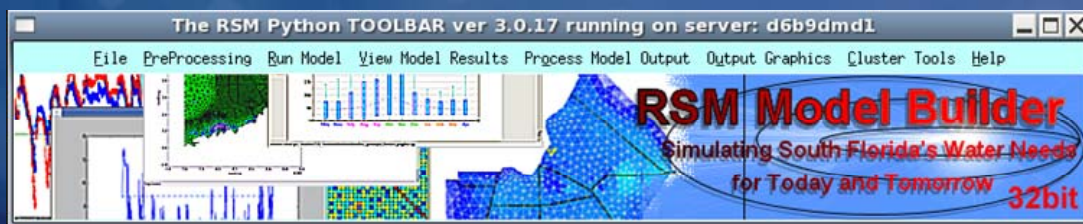


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## RSM Post-Processing

### Using the RSM Graphical User Interface (RSM GUI) Part II



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## Lecture 8: RSM Post-Processing—Using the RSM Graphical User Interface (RSM GUI) Part II

This Regional Simulation Model (RSM) lecture introduces you to the RSM Graphical User Interface (RSM GUI). The RSM GUI organizes a collection of utilities and applications that make it easier to set up and run the RSM.

After this training session, you will know how to:

- Access the RSM GUI
- Run the model
- Use the post-processing tools

**NOTE:****Prerequisite:**

**This training, and the tools used in this session, requires basic familiarity with the Regional Simulation Model output.**

**The RSM GUI is designed to work in a Linux Redhat 5.x environment.**

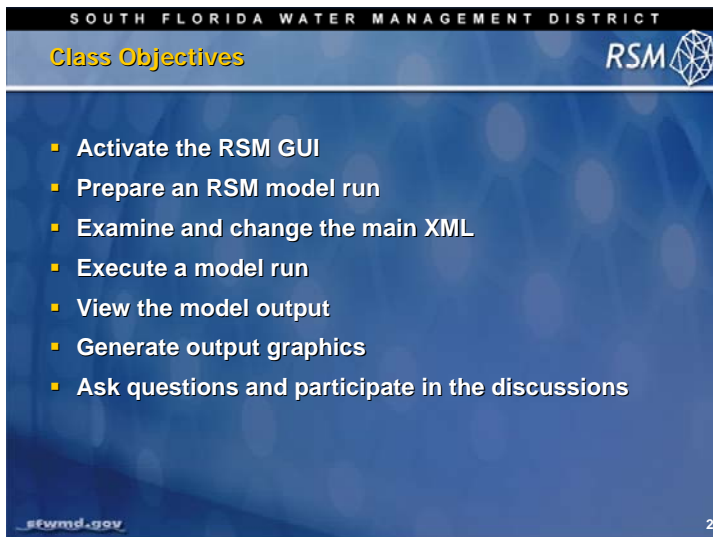
**Although some features require access to the South Florida Water Management District's (SFWMD) network server, this documentation explains the features in detail. The screen captures included on the lecture slides will enable you to see many of the features described in this discussion.**

**Configuration:**

**Ideally, users will be on the SFWMD network or have remote VPN access. Installing the RSM locally from the training DVDs provides most capabilities to perform the exercises in Lab 8.**

**Additional Resources**

**RSM GUI User Manual**



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Class Objectives

- Activate the RSM GUI
- Prepare an RSM model run
- Examine and change the main XML
- Execute a model run
- View the model output
- Generate output graphics
- Ask questions and participate in the discussions

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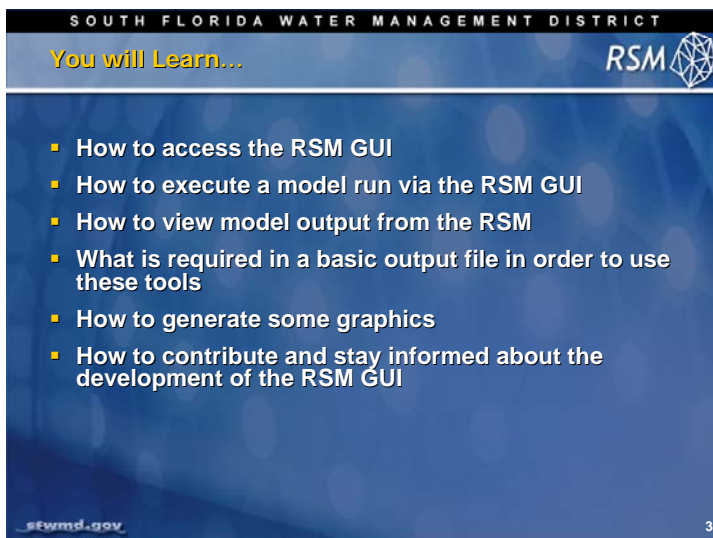
There are a few tools created to support RSM developers and calibrators.

A number of tools are currently available to help visualize the RSM output and other tools that help generate performance measure graphics to support new implementations of the RSM.

The RSM also includes several output options. Not all model output from the RSM is the same. Some output is suitable for certain tools while some tools will only work with specific elements in the output. The **Help** icon associated with each tool in

the RSM GUI, links to additional information about the files necessary to run each tool.

The RSM GUI is an ongoing project. New features are added as new scenarios are implemented.



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You will Learn...

- How to access the RSM GUI
- How to execute a model run via the RSM GUI
- How to view model output from the RSM
- What is required in a basic output file in order to use these tools
- How to generate some graphics
- How to contribute and stay informed about the development of the RSM GUI

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Although this training module introduces the basic features in the RSM GUI, it does not present every tool in the RSM GUI.

The *RSM GUI User Manual*, available under the **Help** drop-down Menu in the RSM GUI, describes each tool in detail and directs users to sample data to help demonstrate each tool.

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**What Makes it an RSM Scenario?**

**RSM**

**obs\_data dir**

**Output Dir**

**DTD file**

**Geo-database**

**GMS .2dm file**

4


An RSM scenario consists of a model input directory containing many files, which typically include:

- Boundary condition files
- Topo files
- Historical DSS data files
- Bottom elevation files
- Initial condition files
- Canal index files
- Landuse index files
- Hydrologic conductivity files
- Parameter zone files
- Public water supply files

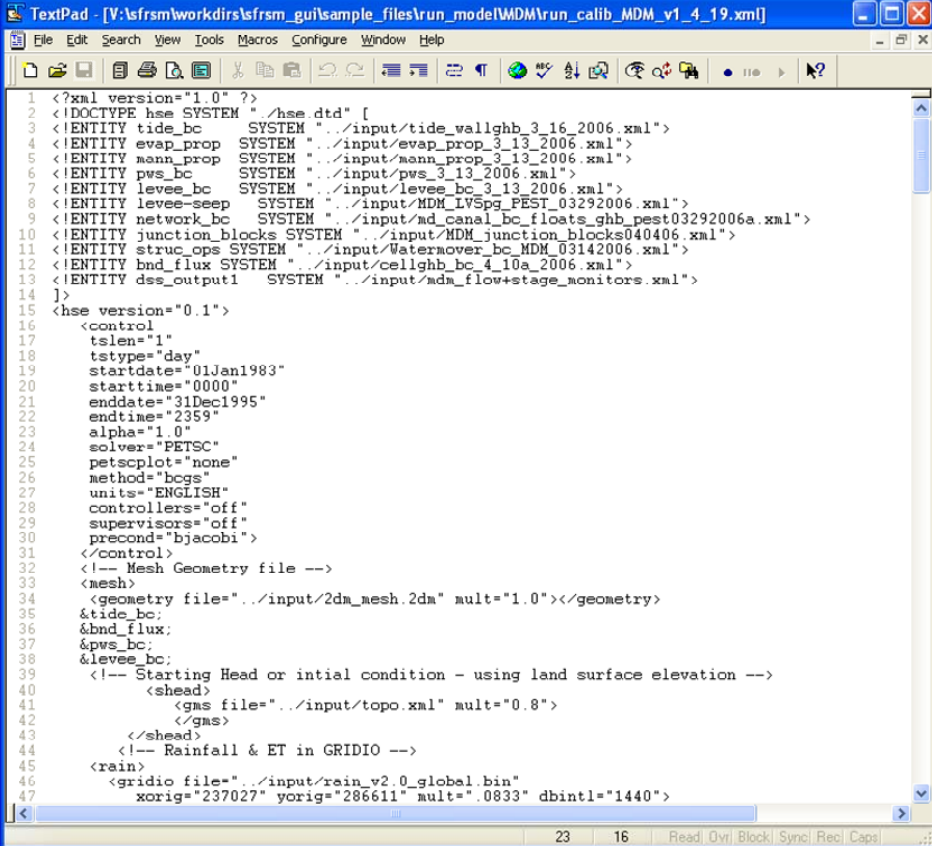
A scenario also contains an output directory, a copy of the DTD and observation files. Ideally it will contain a GMS .2DM file and a geodatabase.



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RSM 

## What's the "Main XML"?



<Entity>

<Control>

<Mesh>

<Network>

<Watermovers>

<Output>


5

### The RSM Main XML:

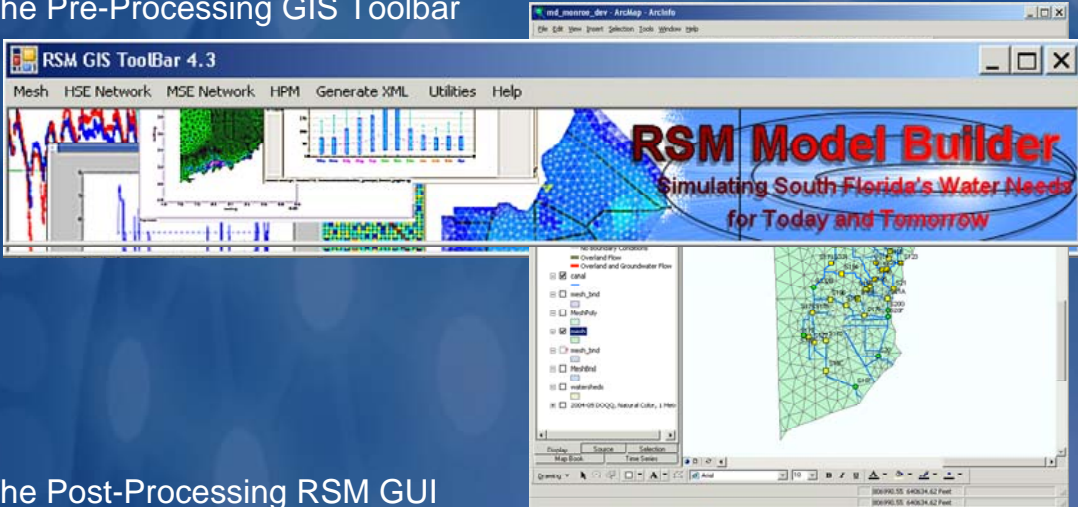
- Contains all the information to describe the model parameters and run a scenario, including references to secondary files and paths to output files
- The main XML (usually called run\*.xml) documents the run and should be kept as part of the implementation documentation
- Blocks can be copied from another scenario or created from scratch. (The *RSM GUI User Manual* contains instructions on how to create this file and the DTD contains the definition for each parameter.)
- Keeps your specifications for the output choices from the model. (The output files you specify in your model run will be important when you begin using the post-processing tools.)

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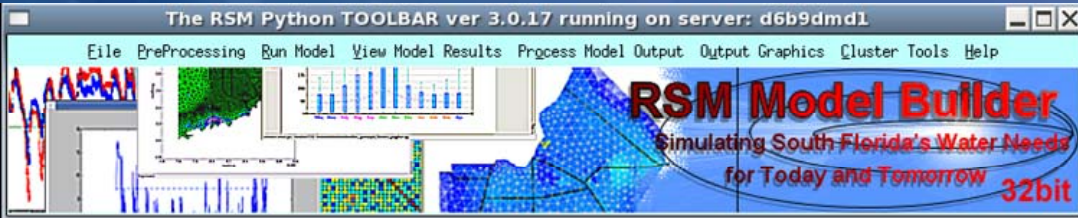
## What is the RSM GUI?

**RSM** 

The Pre-Processing GIS Toolbar



The Post-Processing RSM GUI



6

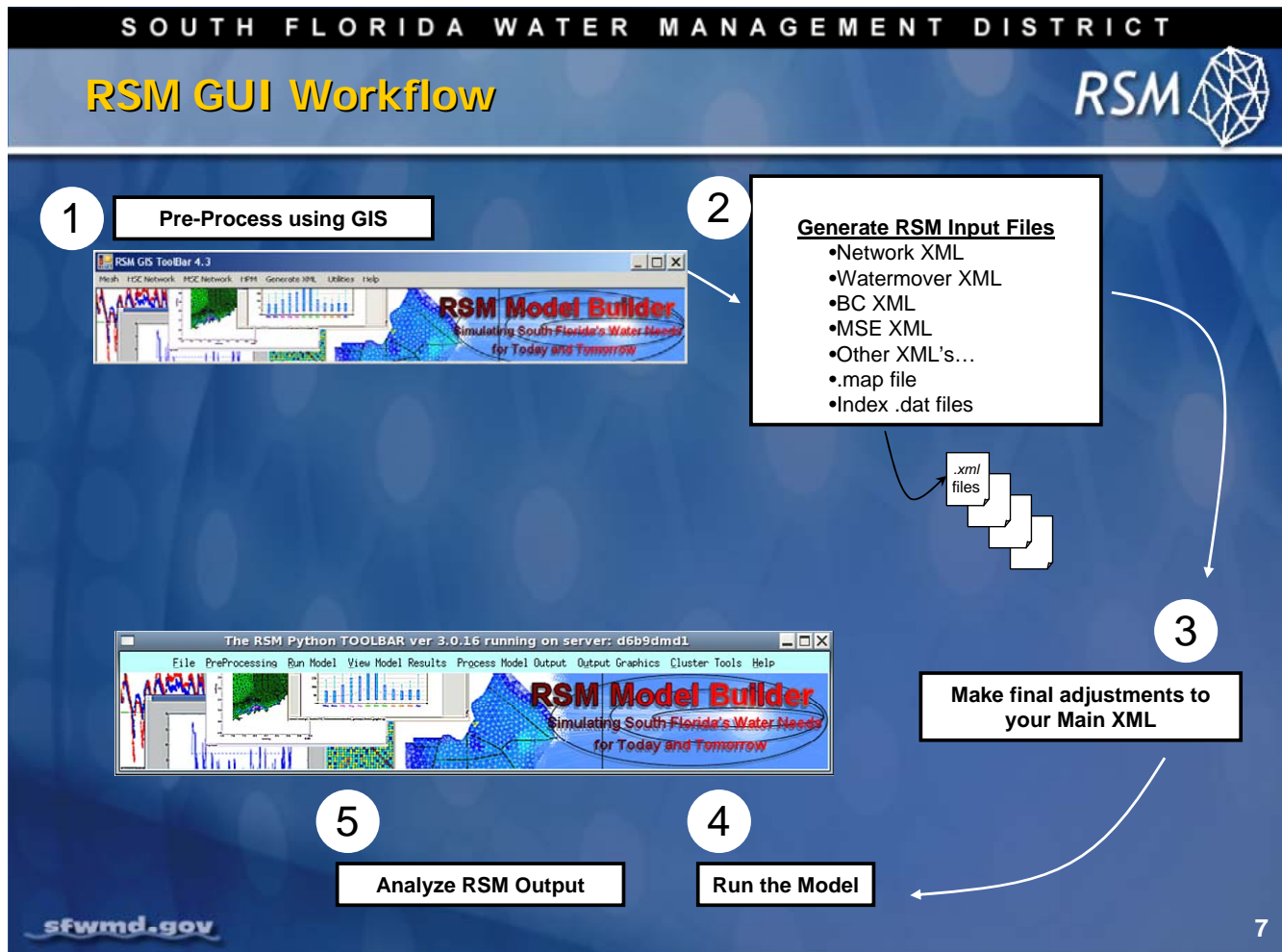
The RSM Graphical User Interface (GUI) currently consists of two toolbars:

1. The GIS ToolBar
2. The RSMGUI Python Toolbar

The Geographic Information System (GIS) ToolBar organizes a set of tools developed to run inside ArcGIS (9.2) to assist with generating input files for the Regional Simulation Model. The ArcGIS software is the South Florida Water Management District HESM's designated (spatial) database for storing RSM geographic features: structures, canals, boundaries, mesh.

The RSMGUI Toolbar organizes a set of tools developed to execute the RSM and post-process the output from the model. The RSMGUI uses Python, a platform independent programming language that can be deployed on any operating system.

Both toolbars are intended to help simplify some of the repetitive steps for setting up an RSM scenario in a self-documenting environment. The HESM team plans to complete a set of tools that will help build a scenario from beginning to end.



### Basic workflow for how tools are used to set-up an RSM scenario:

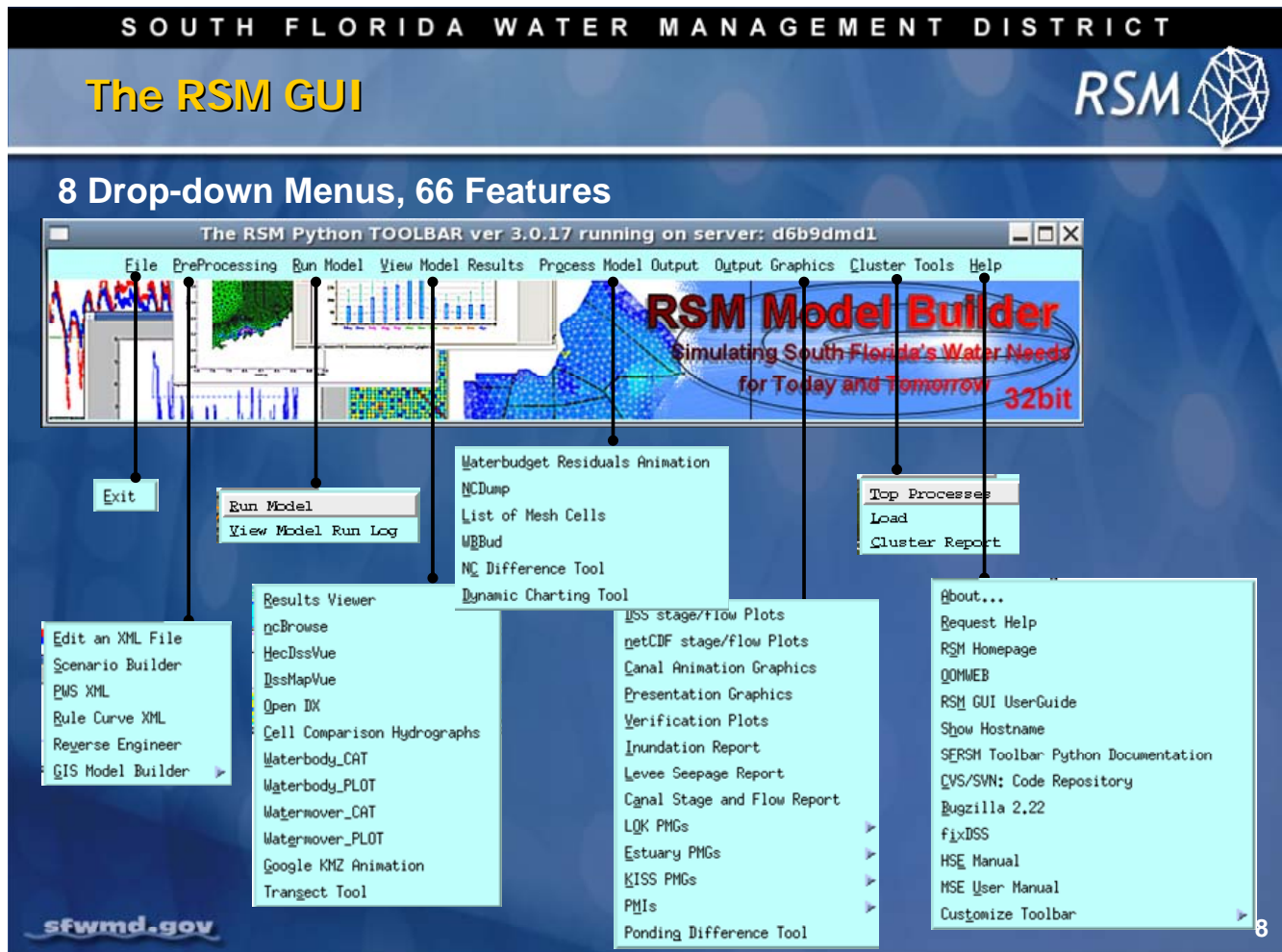
- Generate a mesh using GMS

### The GIS Toolbar

- Import the .2DM into the GIS to generate a GIS mesh layer
- Combine the mesh layer with an RSM geodatabase template
- Configure the model features in the GIS
- Generate the RSM input files from the GIS Toolbar

### The Python Model Builder RSM GUI

- Make adjustments to the Main XML
- Run the Model
- View the RSM output
- Process the Model output
- Produce graphics for presentations and analysis



The RSM GIS Toolbar contains tools to:

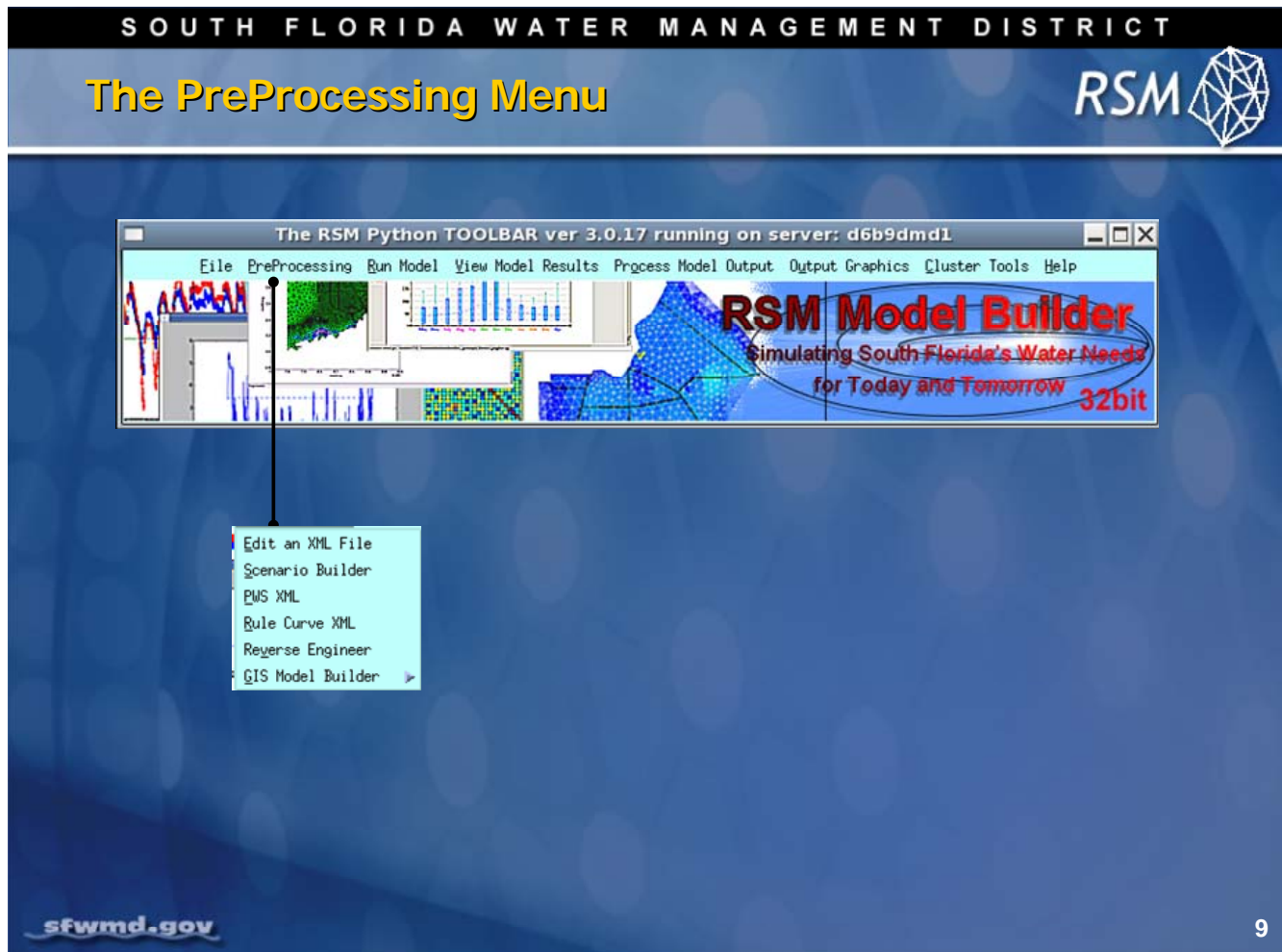
- Help configure the Main XML
- Run the model that self-documents the run
- View and process the model output
- Generate graphics
- Help monitor the server

The geodatabase is significant because it contains all of the data used to specify the physical features being represented in the model. This helps you to visualize your scenario when you are setting it up and it helps document what was modeled when you are presenting post-processing analysis from your run. Eventually the geodatabase from your run is used for post-processing the model results.

Options available within several of the tools offer some flexibility in how the tool can be used and how the output generated will be formatted. This flexibility enables you use some tools to perform multiple tasks and to generate a variety of output.

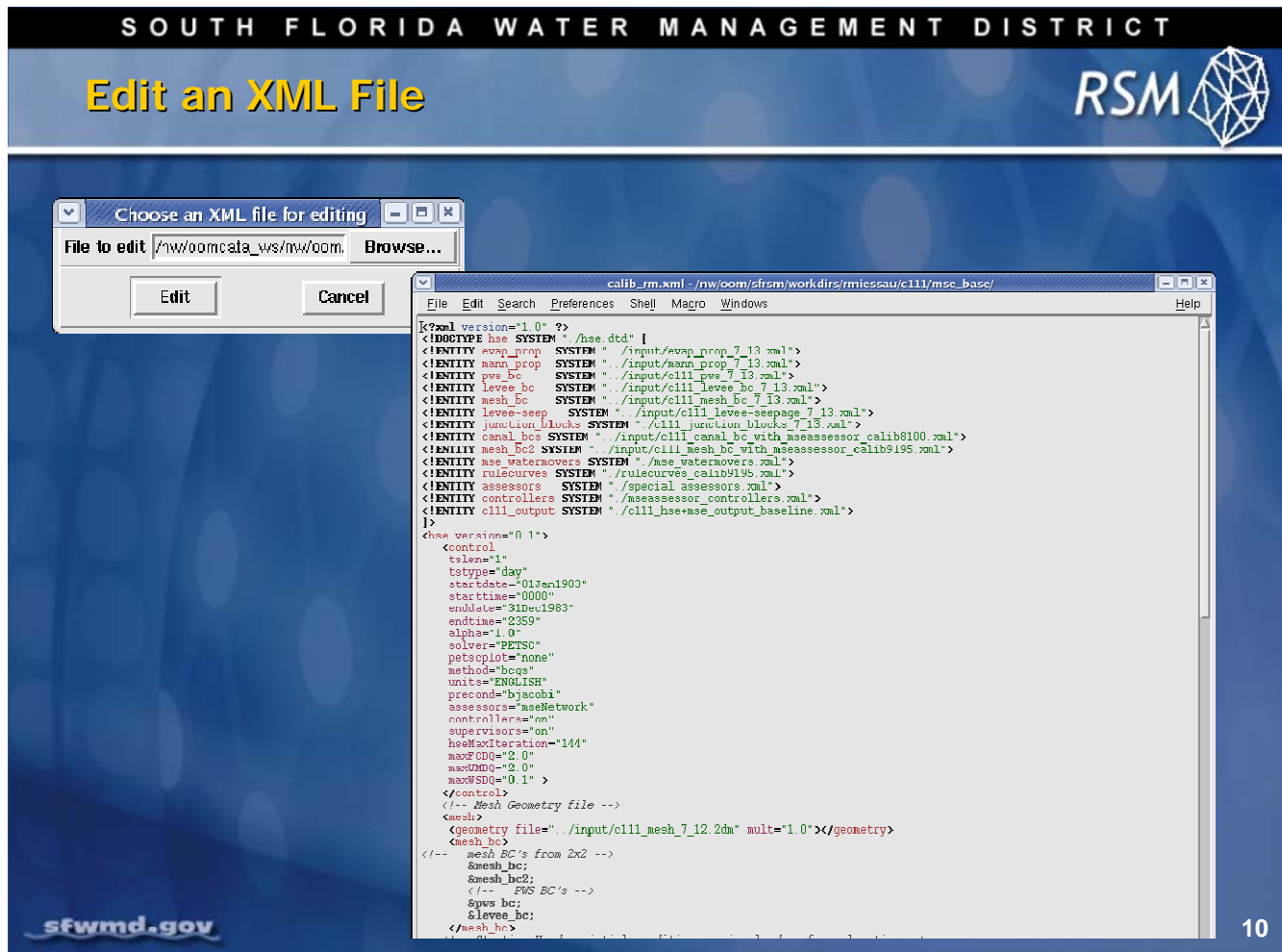
The tools are organized in order of the phases you follow preparing, running and analyzing your run.





The RSM GUI contains tools to aid in making final changes and help set-up your RSM run. The GUI tools facilitate modifying the XMLs used to configure and execute the model.

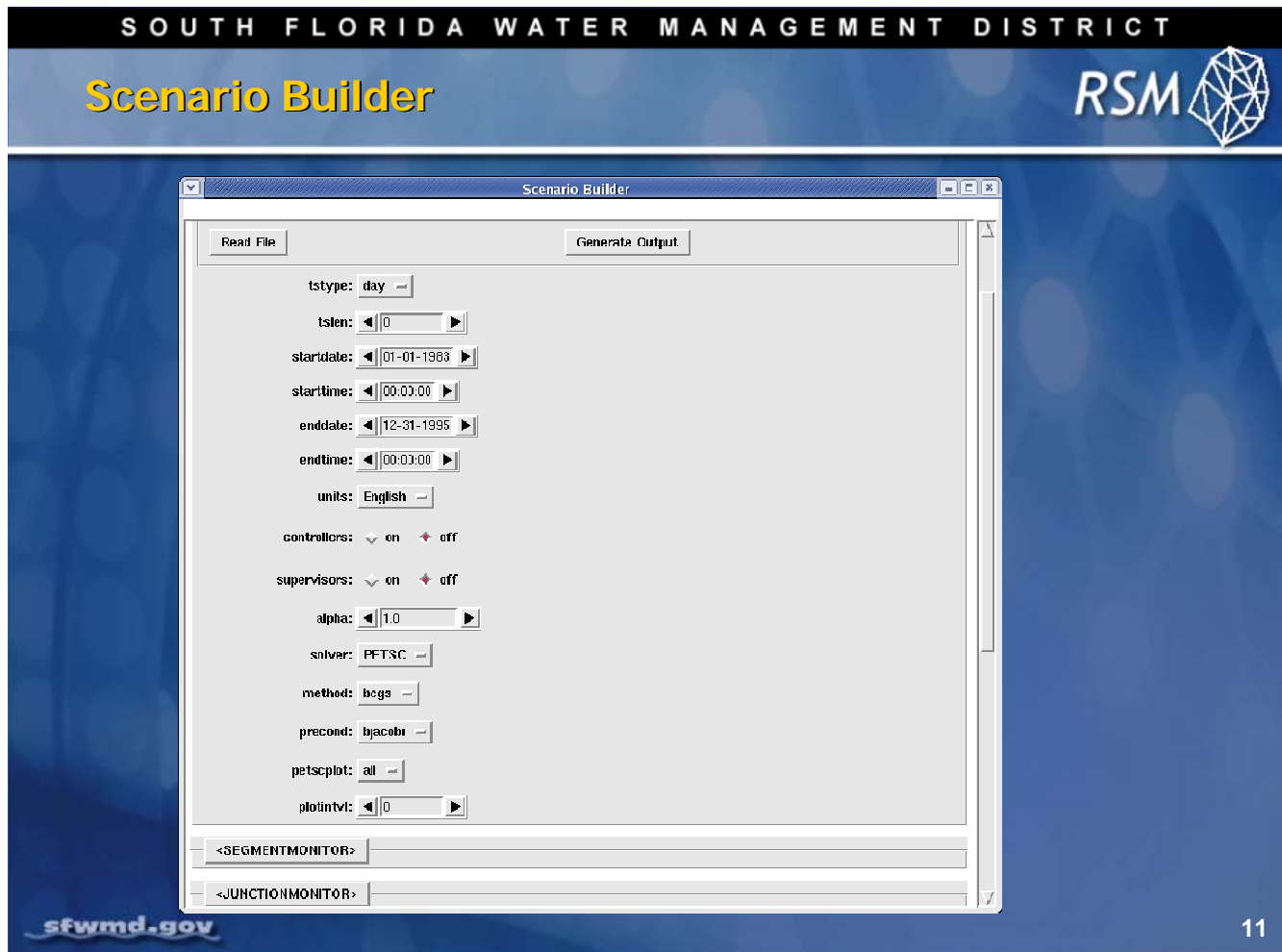
Final pre-processing steps are organized under the pre-processing menu on the RSM GUI.



10

The **Edit** tool offers a method to edit an XML file with XML indenting and syntax recognition. On a Linux desktop an edit window will open displaying colorized XML, making it easier to review the proper syntax.

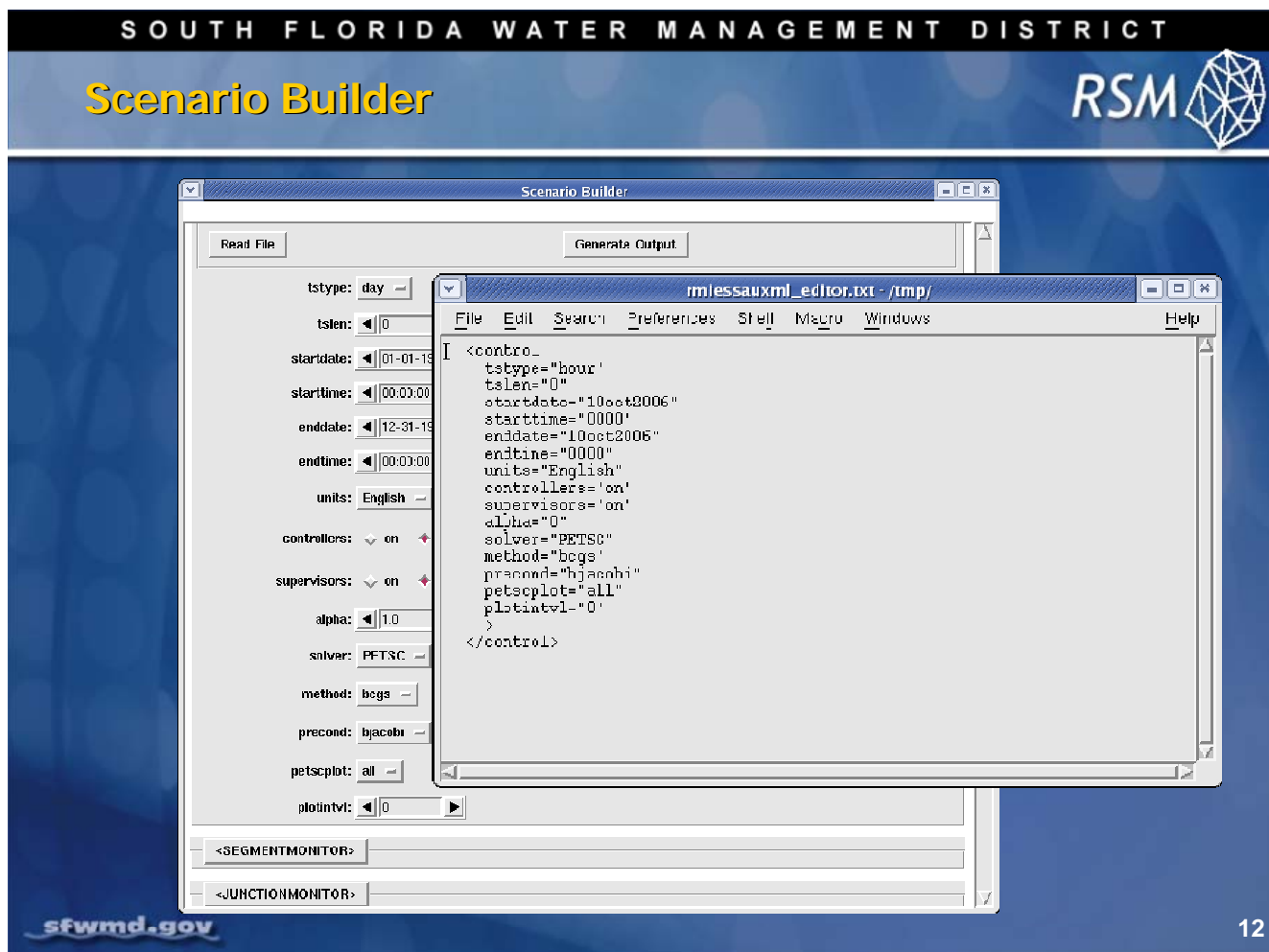




The **Scenario Builder** tool offers several options to help build blocks of XML which then can be inserted into the Main XML to run the RSM. These tools provide some automation for creating consistently formed XML blocks, including the default options often left out to save typing when creating an XML manually. The blocks help generate repetitive portions of the Main XML, such as monitors, conveyance and conductivity sections.

The Entity tool utilizes explicit paths to files referenced in the XML in order to better document the run being made.

When an XML block is generated it can be saved, or copied and pasted into your Main XML.




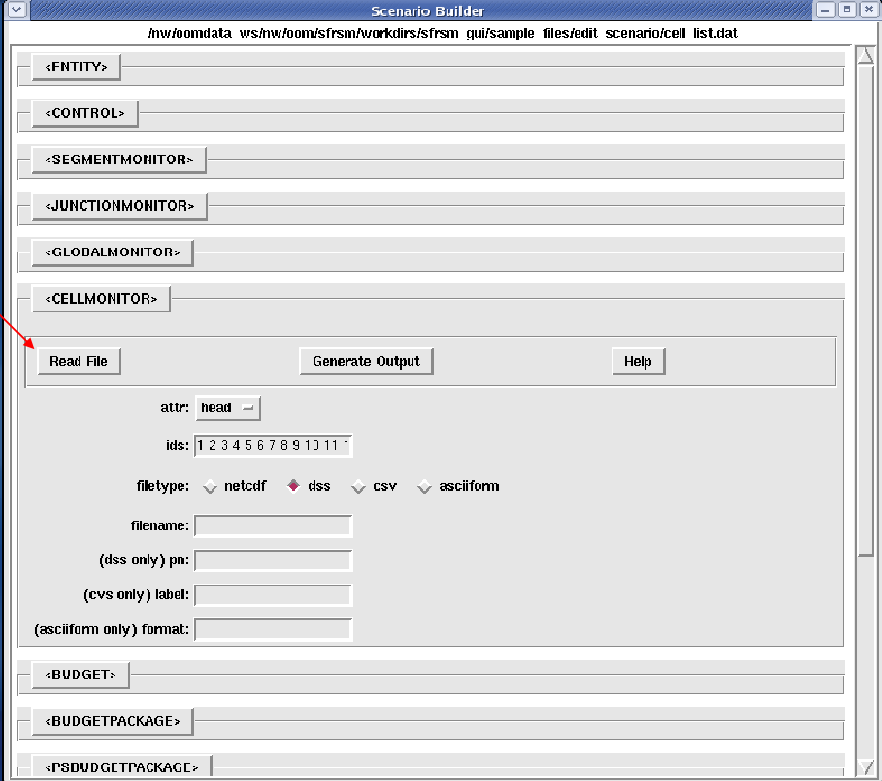
12

Control Block output from the Scenario Builder.

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## Scenario Builder Cell Monitors

RSM 



Reads a list of cell IDs


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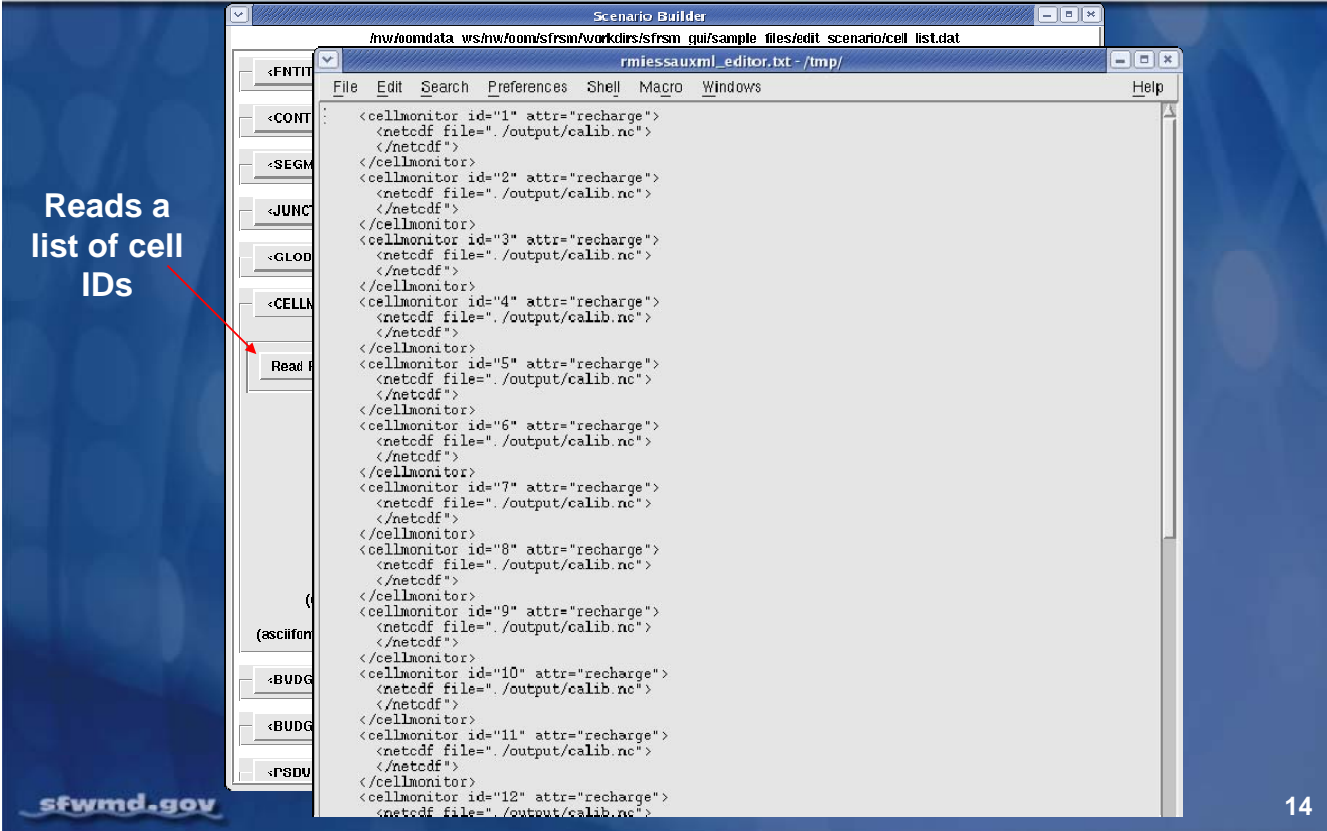
13

An example of building a **Cell Monitor Block** of XML using the Scenario Builder. A file containing a list of cell IDs can be 'read in' or manually entered.

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## Scenario Builder Cell Monitors

RSM 

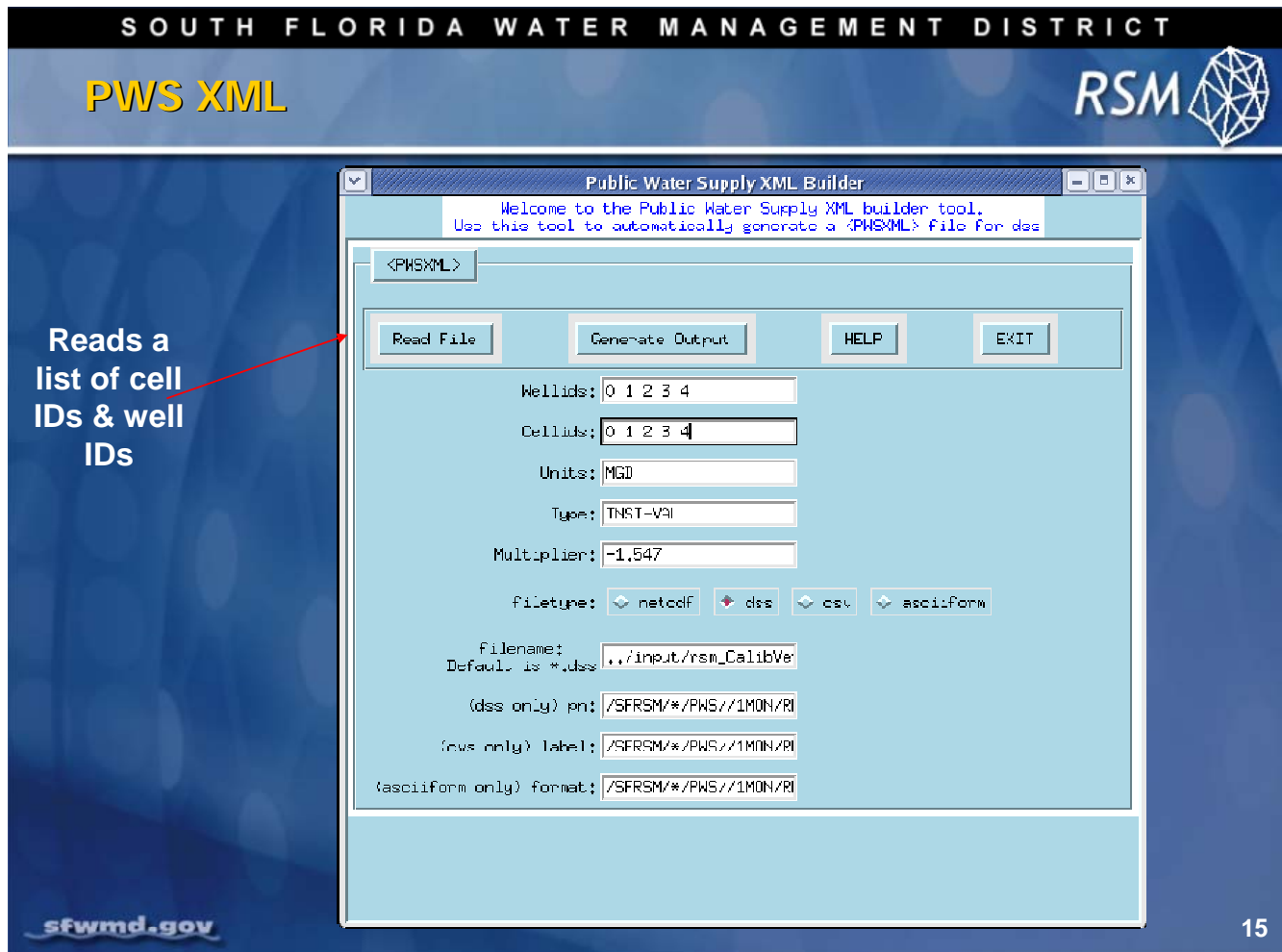


Reads a list of cell IDs

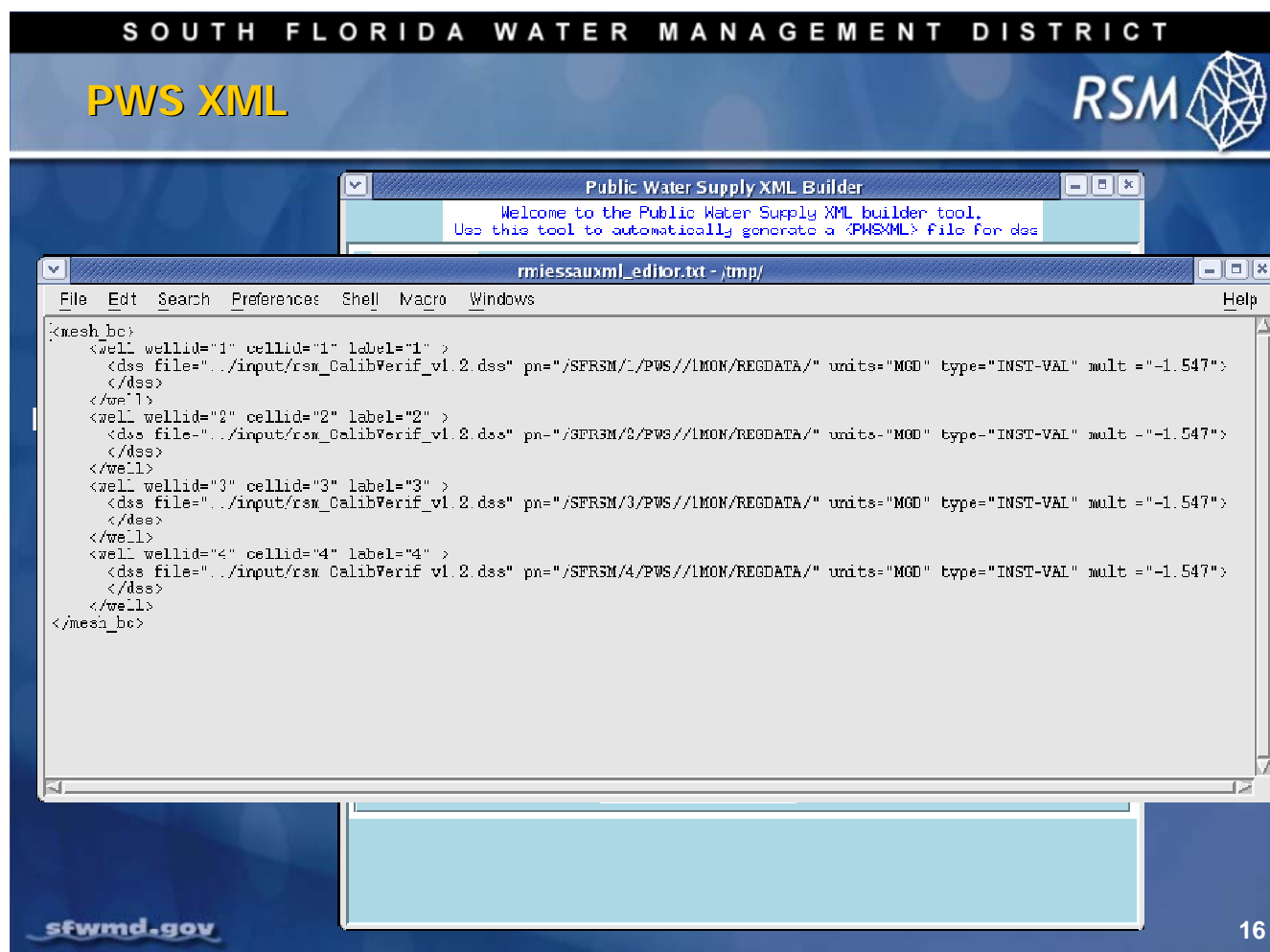
```
<cellmonitor id="1" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="2" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="3" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="4" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="5" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="6" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="7" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="8" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="9" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="10" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="11" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
<cellmonitor id="12" attr="recharge">
<netcdf file=". /output/calib.nc"
</netcdf"
</cellmonitor>
```

14

Cell Monitor output from the Scenario Builder.

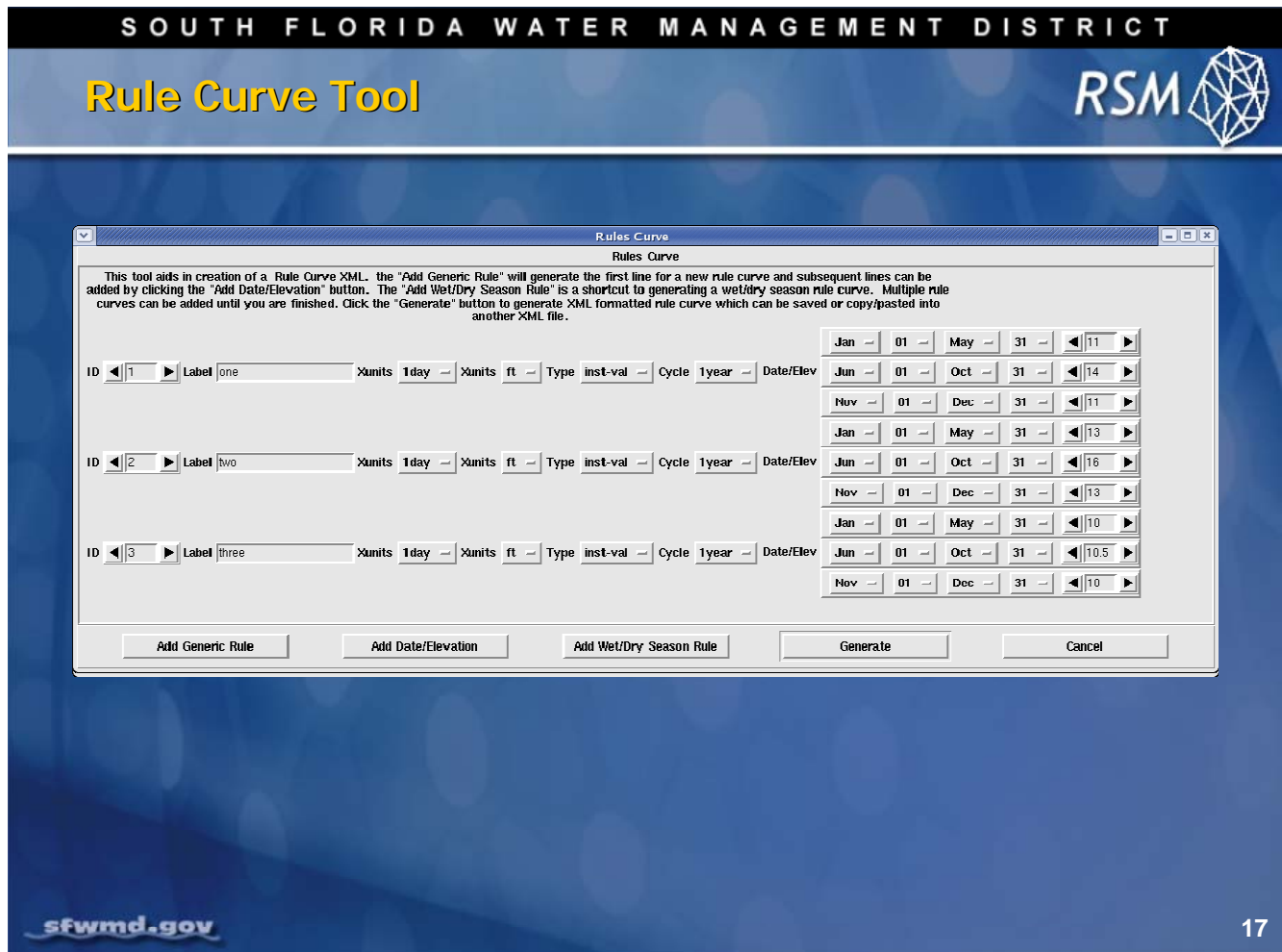


The **Public Water Supply (PWS) XML** tool offers a means to build a public water supply block of XML. The tool reads in a list of IDs and corresponding labels. Default values are offered to populate the other attributes or they can be edited by the user. And, hints for creating different formatted output types are also provided. The resulting block of XML can then be edited, or copied and pasted into your Main XML. It's important to realize the first ID and label are ignored if the values are entered by hand. When utilizing an input file, a header is expected which also will be ignored when the block of XML is generated.



Output from the PWS tool.





The **Rule Curve** tool assists in building the Rule Curve block of XML which can then be copied and pasted into your XML.

### Add Generic Rule

- Generates a new generic rule curve and inserts one line of rule curve text (startdate/enddate/elevation), which can then be modified to reflect the values desired
- Generates multiple rule curves in a single XML

### Add Date/Elevation

- Adds a new generic line (startdate/enddate/elevation) to the rule curve being created

### Add Wet/Dry Season Rule


- Generates a new Wet/Dry Season rule curve
- Fields can be modified to reflect the desired values
- Generates multiple rule curves in a single XML

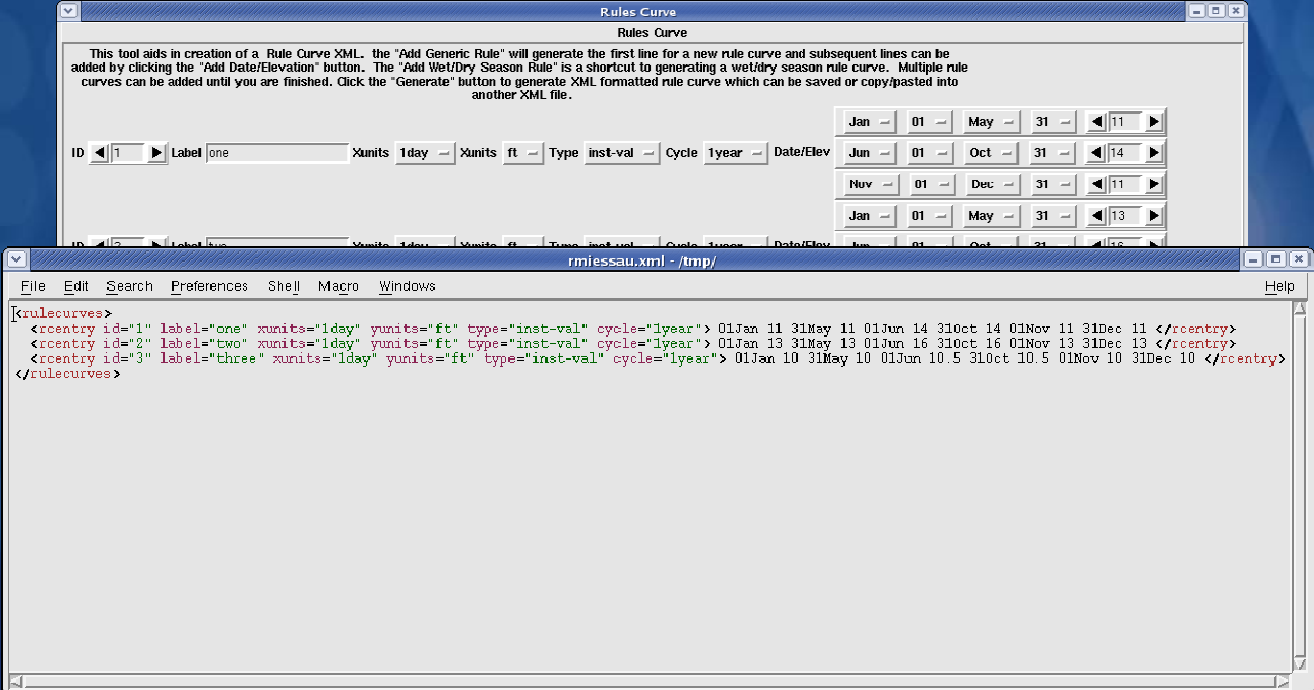
### Generate

- Produces block of XML which can be copied and pasted into your XML

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## Rule Curve Tool

**RSM** 



The screenshot displays the 'Rule Curve Tool' interface. The top window, titled 'Rules Curve', contains a text box with instructions: 'This tool aids in creation of a Rule Curve XML. The "Add Generic Rule" will generate the first line for a new rule curve and subsequent lines can be added by clicking the "Add Date/Elevation" button. The "Add Wet/Dry Season Rule" is a shortcut to generating a wet/dry season rule curve. Multiple rule curves can be added until you are finished. Click the "Generate" button to generate XML formatted rule curve which can be saved or copy/pasted into another XML file.'

Below the instructions are several input fields: 'ID' (set to 1), 'Label' (set to one), 'Xunits' (set to 1day), 'Yunits' (set to ft), 'Type' (set to inst-val), and 'Cycle' (set to 1year). To the right, there are four date selection buttons: 'Jan 01 May 31 11', 'Jun 01 Oct 31 14', 'Nov 01 Dec 31 11', and 'Jan 01 May 31 13'.

The bottom window, titled 'rmiessau.xml - /tmp/', shows the XML output generated by the tool:

```
[rulecurves]
<rcentry id="1" label="one" xunits="1day" yunits="ft" type="inst-val" cycle="1year"> 01Jan 11 31May 11 01Jun 14 31Oct 14 01Nov 11 31Dec 11 </rcentry>
<rcentry id="2" label="two" xunits="1day" yunits="ft" type="inst-val" cycle="1year"> 01Jan 13 31May 13 01Jun 16 31Oct 16 01Nov 13 31Dec 13 </rcentry>
<rcentry id="3" label="three" xunits="1day" yunits="ft" type="inst-val" cycle="1year"> 01Jan 10 31May 10 01Jun 10.5 31Oct 10.5 01Nov 10 31Dec 10 </rcentry>
</rulecurves>
```

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Output from the **Rule Curve** tool.



The **Run Model** Menu.

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Run Model Tool

Run locally on the computer used to run the RSM GUI

20

The **Run Model** tool offers added value to running the model from the command line. Special features include:

- Fields for the user to browse to the Main XML and Hydrologic Simulation Engine chosen to execute the model.
- Two optional fields collect information about the run and its purpose.
- A drop-down list or text field is used to capture the region name for the run.
- An email option will email one specified recipient when the run is completed.
- Buttons to simplify execution of the RSM on the local server where the RSM GUI has been executed.

These Run Model features provide a means for documenting and cataloging the model run in the **Model Log**. The Model Log captures the information entered by the user and also captures statistics from the server hosting the run.

Run the model by browsing to:

- \$RSM/data/C111/hse\_test
- \$RSM/data/C111/run\_c111\_mse\_sr5\_sss.xml

A text window appears showing the model run's progress. The C-111 example run took 13 minutes.

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**Model Log**

**RSM**

**Display model log**

All Users

Users Single User

Region Name

Enter Single User ID  Or Select Region Name C111

Display Cancel

runmodel.py region 'C111'

Region: C111

User rmiessau

Execution Start Time: Mon Oct 9 18:07:30 2006

Execution End Time: Mon Oct 9 18:14:09 2006

Execution Elapsed Time: 0 Days 0 Hours 6 Minutes 39 Seconds

Where Executed: ooserv.sfwmd.gov

+++ MODEL DETAILS +++

Model Executable Path: /nw/oow/sfrsm/workdirs/rmiessau/c111/hse

Version: RSM-2-6-1

Model File: /nw/oow/sfrsm/workdirs/rmiessau/c111/wse\_base/calib\_m.xml

Model Start Date: 01JAN1983

Model Start Time: 0000

Model End Date: 31DEC1983

Model End Time: 2359

Has Budget Package: Y

Region Name: C111

-----

User rmiessau

Execution Start Time: Mon Oct 9 18:20:55 2006

Execution End Time: Mon Oct 9 18:27:15 2006

Execution Elapsed Time: 0 Days 0 Hours 7 Minutes 2 Seconds

Where Executed: ooserv.sfwmd.gov

+++ MODEL DETAILS +++

Model Executable Path: /nw/oow/sfrsm/workdirs/rmiessau/c111/hse

Version: RSM-2-6-1

Model File: /nw/oow/sfrsm/workdirs/rmiessau/c111/wse\_base/calib\_m.xml

Model Start Date: 01JAN1983

Model Start Time: 0000

Model End Date: 31DEC1983

Model End Time: 2359

Has Budget Package: Y

Region Name: C111

-----

User rmiessau

Execution Start Time: Wed Oct 11 13:32:24 2006

Execution End Time: Wed Oct 11 13:37:05 2006

Execution Elapsed Time: 0 Days 0 Hours 4 Minutes 41 Seconds

Where Executed: ooserv.sfwmd.gov

+++ MODEL DETAILS +++

Model Executable Path: /nw/oow/sfrsm/workdirs/rmiessau/c111/hse

Version: RSM-2-6-1

Model File: /nw/oow/sfrsm/workdirs/rmiessau/c111/wse\_base/calib\_m.xml

Model Start Date: 01JAN1983

Model Start Time: 0000

Model End Date: 31DEC1983

Model End Time: 2359

Has Budget Package: Y

Region Name: C111

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21

The **Model Log** contains information about each run executed through the RSM GUI. This feature automates documentation of model runs. It can assist with determining:


- When a run was made
- The server the model was run on
- Which HSE version was used
- The location of the input files
- The performance of the server used to make the run


The Main XML can also be parsed to capture settings information from the run, e.g. the duration and which output options were included.

The Model Log can be searched by user name or region name.

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## The View Model Results Menu

**RSM** 

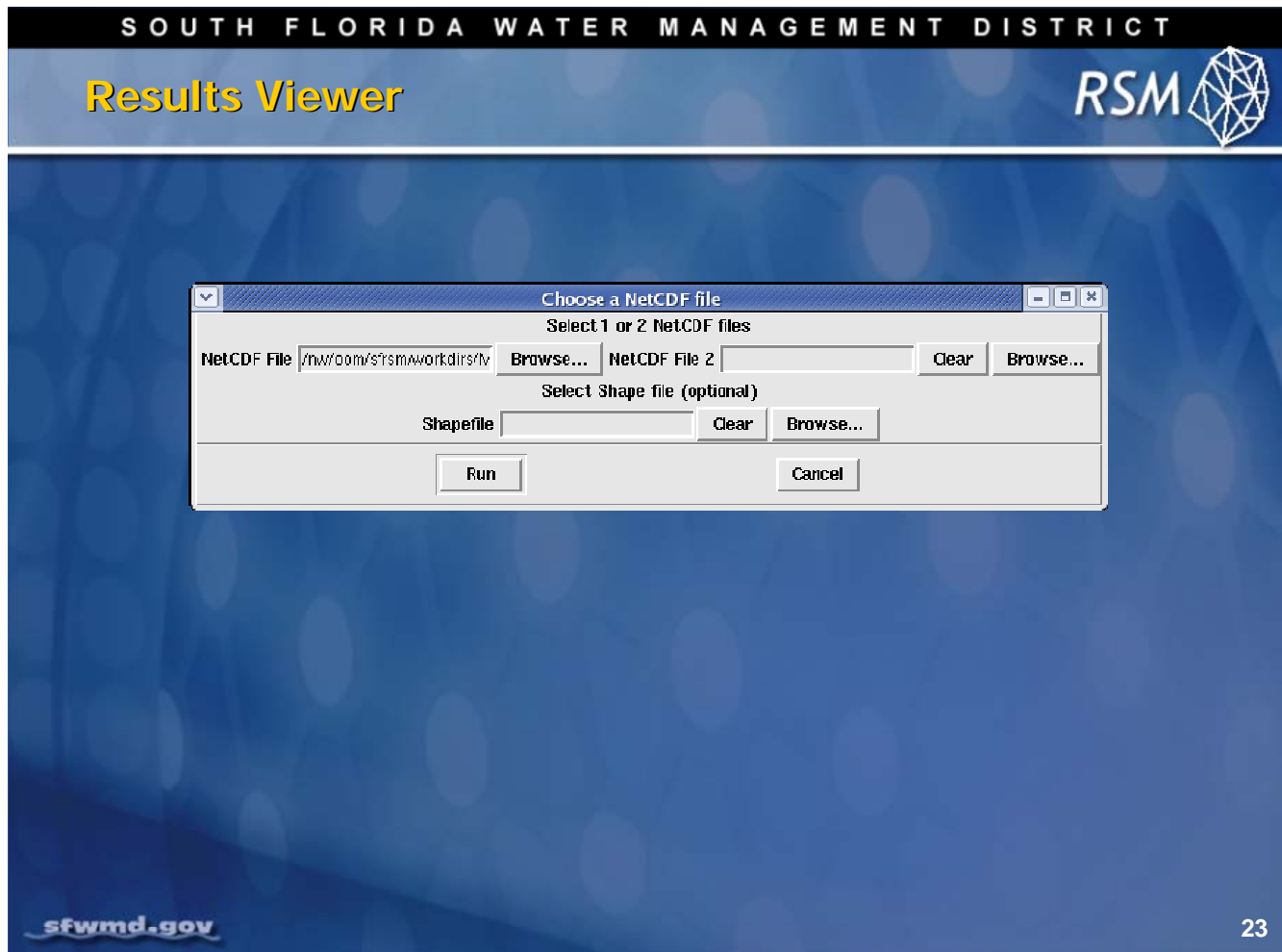


The screenshot displays the RSM Model Builder software interface. The title bar reads "The RSM Python TOOLBAR ver 3.0.17 running on server: d6b9dmd1". The menu bar includes "File", "PreProcessing", "Run Model", "View Model Results", "Process Model Output", "Output Graphics", "Cluster Tools", and "Help". The main window shows a 3D map of a watershed with a blue grid, overlaid with a red and blue hydrograph. A black arrow points from the "View Model Results" menu item to a light blue dropdown menu. The dropdown menu contains the following options: Results Viewer, ncBrowse, HecIssVue, IssMapVue, Open IXX, Cell Comparison Hydrographs, Waterbody\_CAT, Waterbody\_PLOT, Watermover\_CAT, Watermover\_PLOT, Google KMZ Animation, and Transect Tool. The text "RSM Model Builder" is prominently displayed in red, with the tagline "Simulating South Florida's Water Needs for Today and Tomorrow" and "32bit" below it. The "sfwmd.gov" logo is visible in the bottom left corner.

22

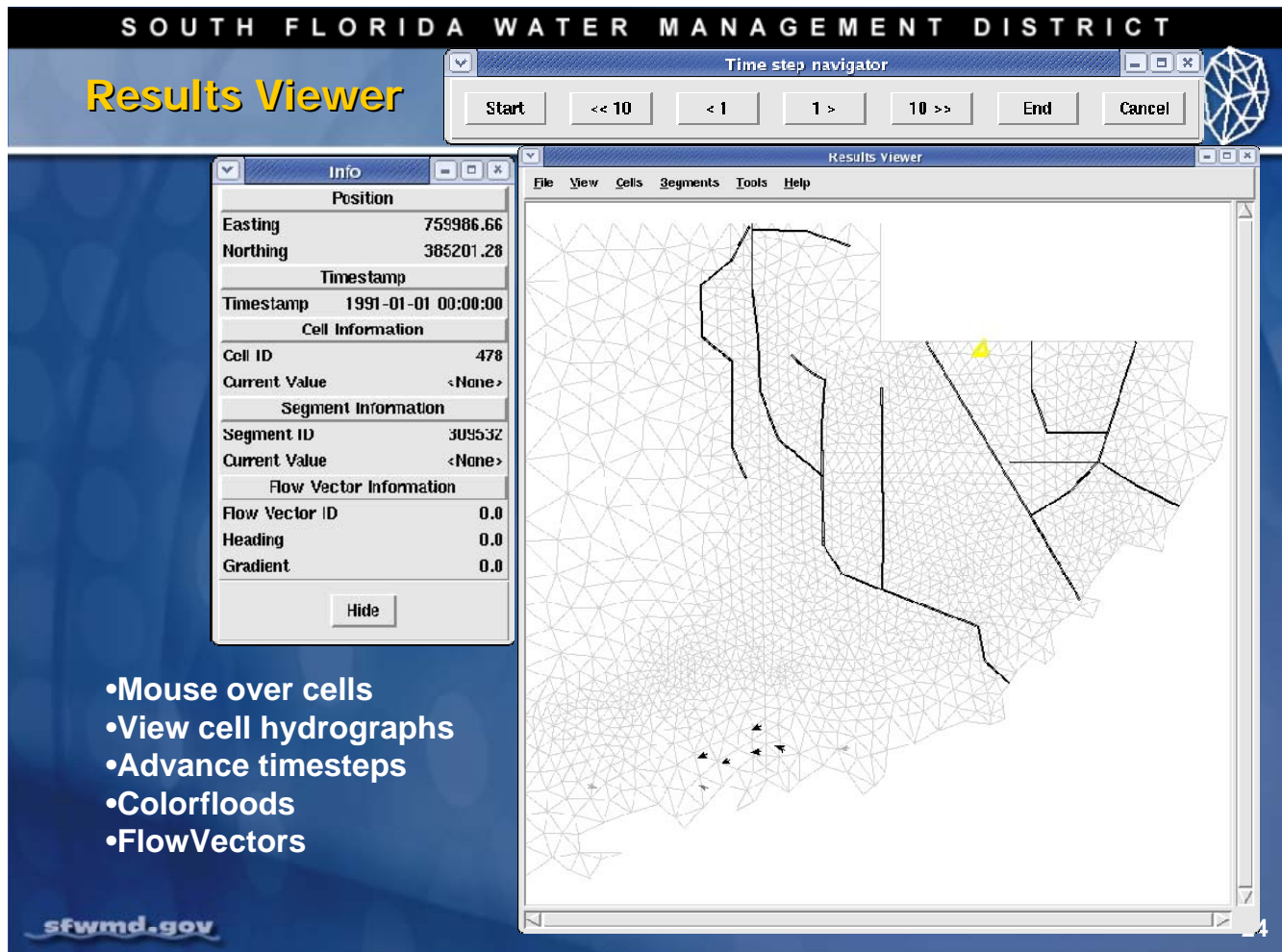
The **View Model Results** Menu.





The **Results Viewer** is actually a collection of tools unto itself. The tool offers an option to import two netCDF files from similar model regions (no demo is available at this time). A GIS shapefile can also be imported to be displayed along with the model output.

The file for running the Results Viewer is: \$RSM/labs/lab8\_RSMtoolbar/c111\_base.nc



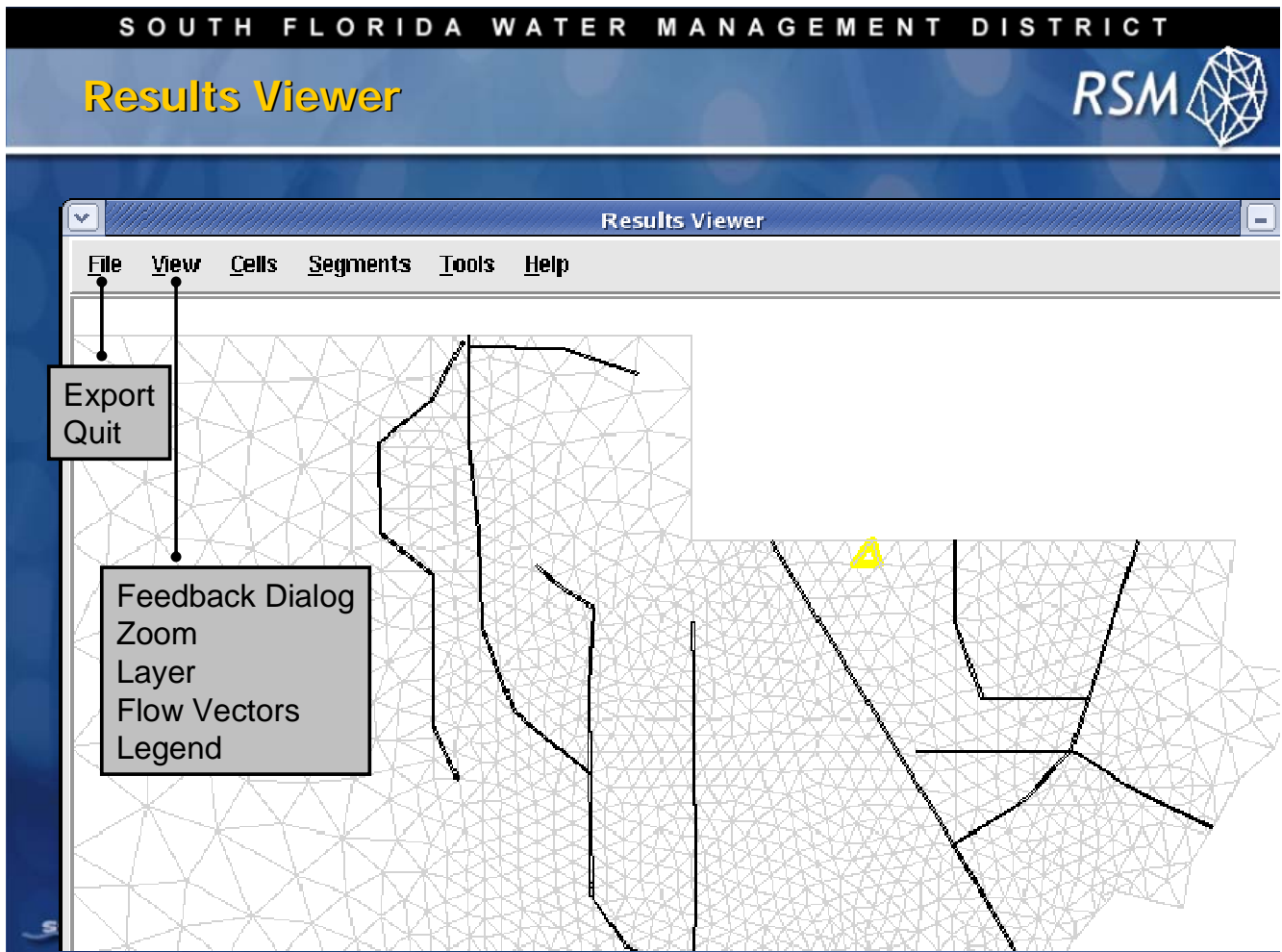
When the netCDF file initially opens, three display windows appear:

- A canvas used to visually display the mesh, waterbodies and optional shapefile
- A timestep window to move forward and backward through the model timesteps
- An INFO window used to display waterbody information for the moused-over cell.

Display options are available by right-clicking a waterbody.



**NOTE:** Only runs containing mesh cells and canal networks can be visually displayed in the Results Viewer.



Menu choices along the top of the **Results Viewer** offer a variety of features.

The first menu offers options to:

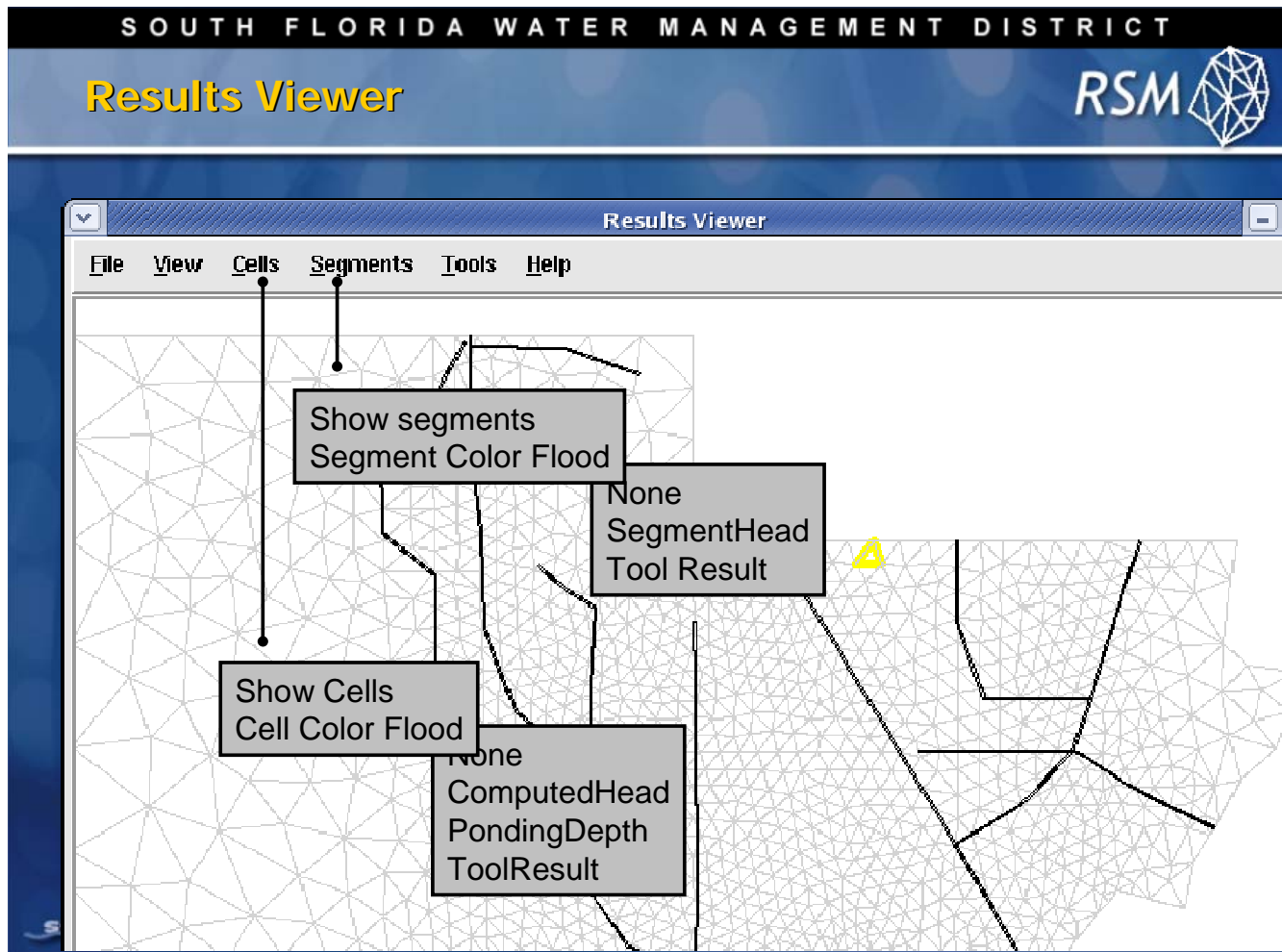
- Exit the tool
- Export the current view to a PNG image file

The second menu offers options to:

- Zoom in and zoom out
- Display or deactivate display of the flow vectors
- Turn-on a legend

Page Up and Page Down also offer zoom capability.

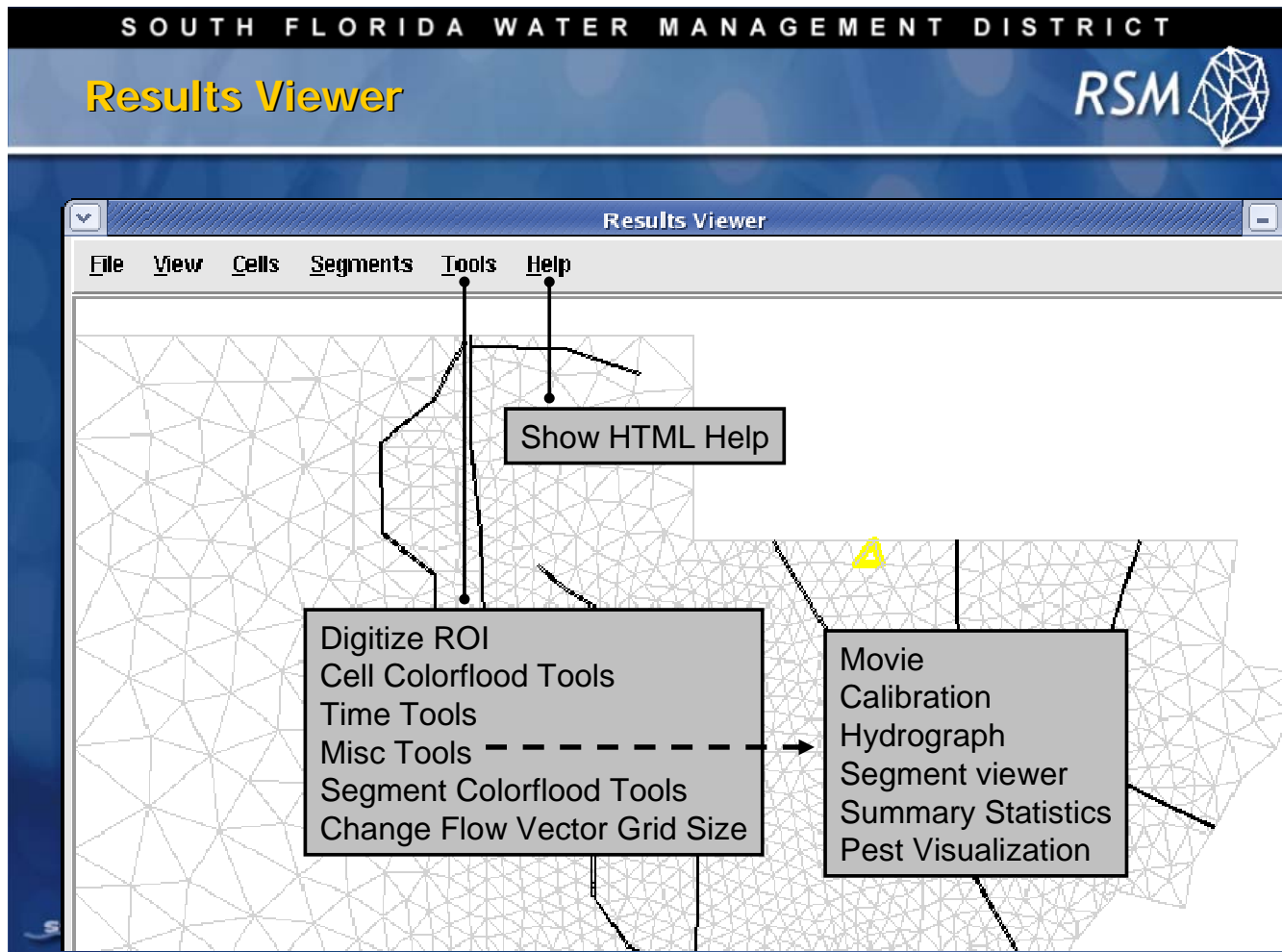
And, waterbodies display yellow highlighting upon mouse over.



The **Cells** Menu offers a means to color-shade the mesh cells. The attribute used to color-flood the cells can be **ComputedHead** or **PondingDepth**. Optional means offer the ability to select other attributes output by each model.

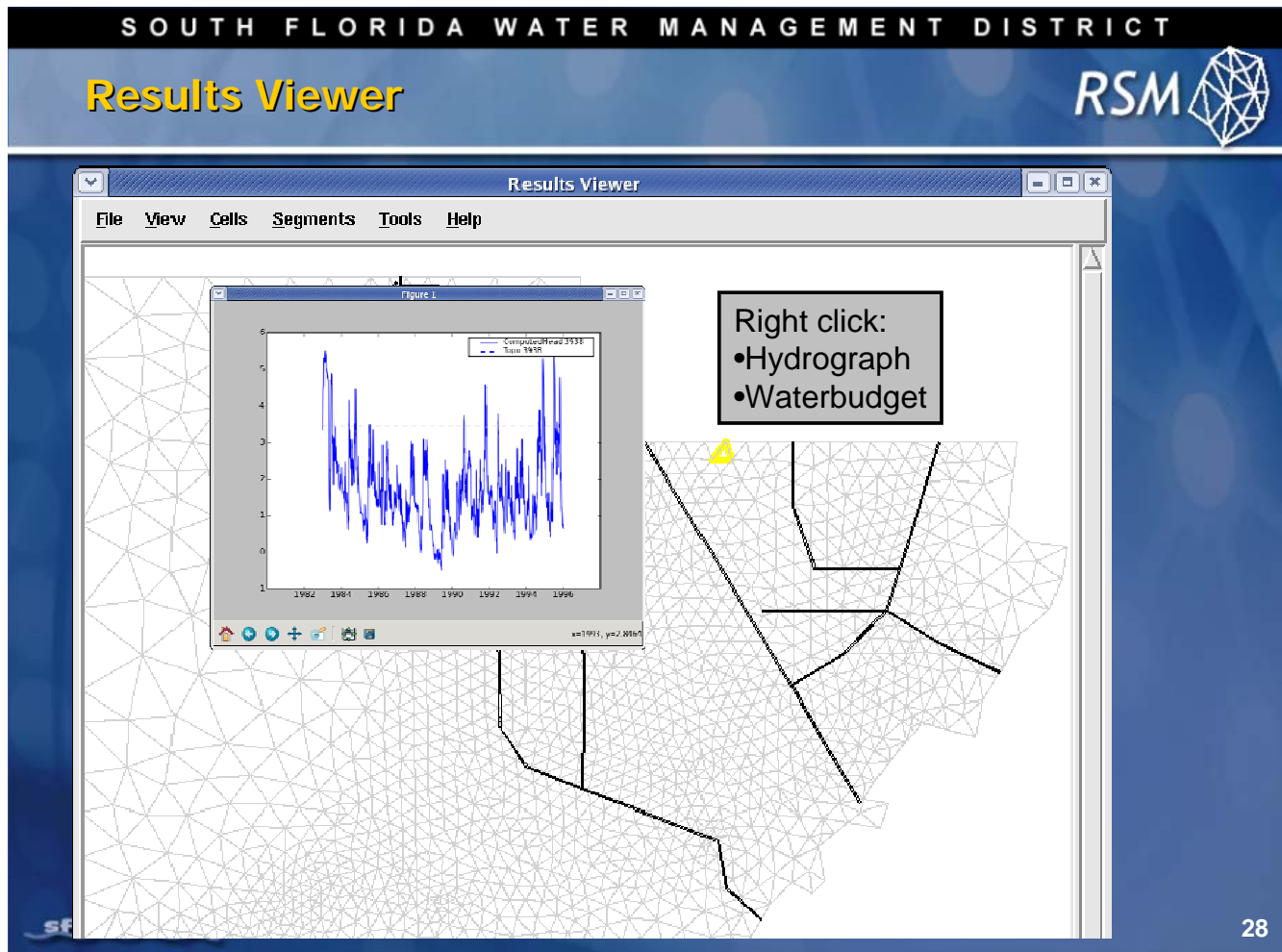
The **Segments** Menu offers a similar means to color-shade the canal segments. The attribute used to color-flood the segments can be **SegmentHead**. Optional means offer the ability to select other attributes output by each model.

After the cells are colorized the **Timeselect** Tool can be used to step through each timestep of the model and the color-floods will update to represent each timestep.



The **Tools** Menu contains a variety of tools to control how the model output is viewed and a variety of visualization tools to view hydrographs and **PEST** results.

- The **Digitize ROI** tool allows you to highlight a collection of cells by clicking and then closing the selection with a double-click. Only the subset of selected cells are colorized when the color-flood tool is activated.
- **Cell Colorflood** tool (no demo available).
- The **Time tools** display the **TimeNavigation** tool if it is ever deactivated.
- The **Hydrograph** tool generates a hydrograph for a select cell or multiple cells.
- **Segment Colorflood** tool (no demo available).
- **Change Flow Vector Grid Size** controls density of the grid used to display the flow vectors. A square grid is placed over the mesh and cells found at the center of each grid cell are then selected to display a flow vector arrow. The default grid size is 25x25 cells, covering the extent of the model region.
- **Movie** automatically steps through the timesteps offering an animation of the color-floods.
- **Summary Statistics** (not being demonstrated).
- **PEST Visualization** is used by model calibrators (not being demonstrated).
- **Show HTML Help** displays an HTML version of the Help documentation for the Results Viewer.



28

Right-clicking on any waterbody calls up a menu offering a display of a hydrograph or water budget for the selected cell. This feature is new and will be enhanced as requests are made for more features.

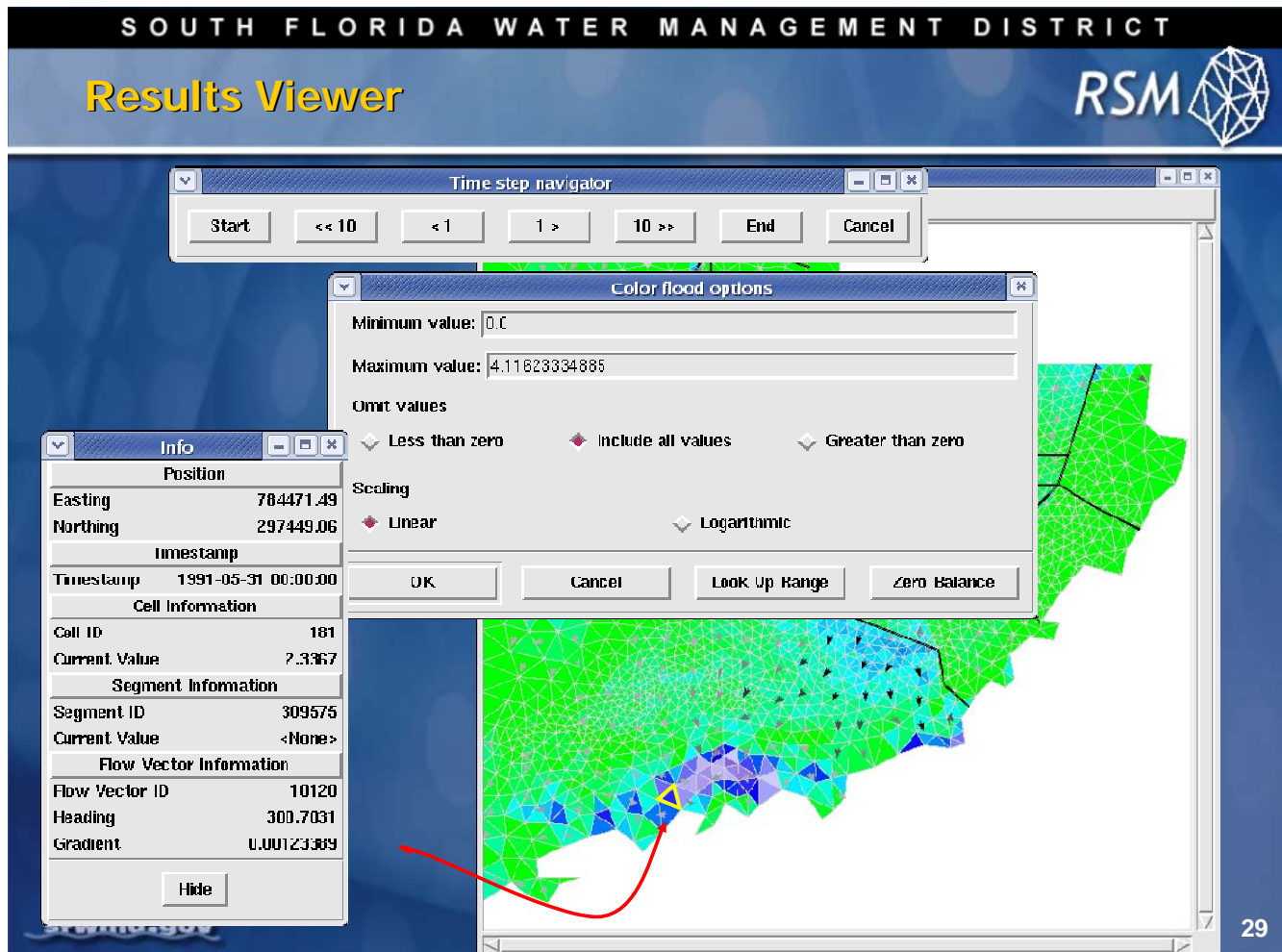
The **Hydrograph** tool displays multiple cell hydrographs in one graph. If an attribute is first selected for each additional cell the user can then digitize (left click) on a cell to acquire the cell ID.

The **Waterbudget** tool will automatically generate a cell water budget\*.



**NOTE:** \* Water budgets are currently being configured and new netCDF options are being added to aid with HPM Hubs.





29

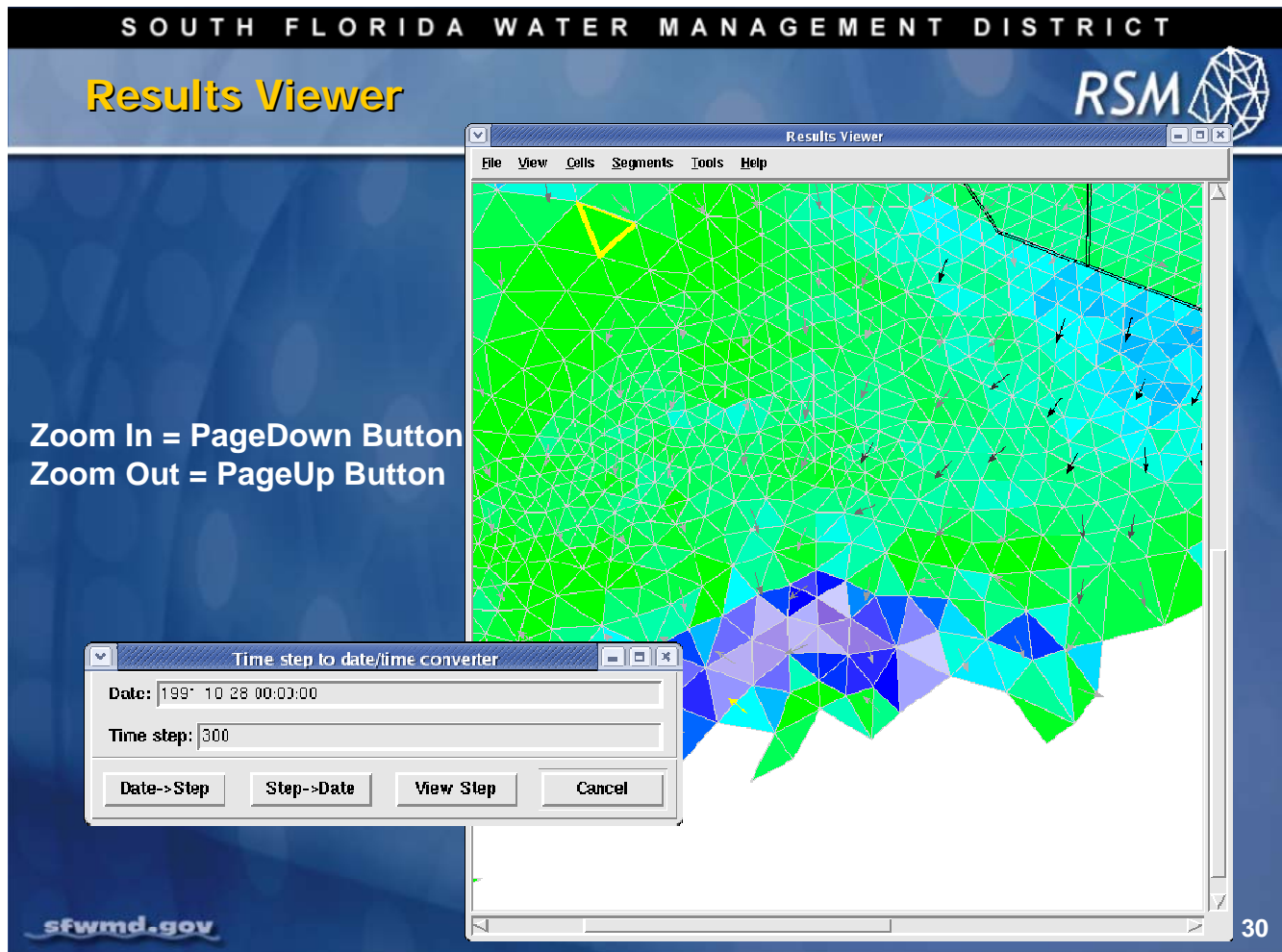
Cell colorfloods can be generated using the **Cell Colorfloods** tool found under the **Cells** menu.

After selecting **PondingDepth** or **ComputedHead**, a secondary menu prompts you for the range of the selected attribute or the range can be acquired by clicking the **Look Up Range** button.

All values can be displayed, only less than zero values, or greater than zero values can be specified.

The currently displayed timestep is then color-flooded with flow vectors. The flow vectors can be deactivated by selecting the option under the **View** menu.

You can mouse over any waterbody (cell or segment) to highlight and see information about it, in the Info window.



The **PAGE DOWN** key provides zoom-in capabilities and the **PAGE UP** key provides zoom-out capabilities.

The **arrow** keys pan left or right in the display window.

The **Time Converter** is a useful tool for helping:

- Select a timestep
- Convert the timestep to a date or vice versa
- View that timestep by jumping to it in the viewer

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

## View Model Results Menu

**RSM** 



The screenshot shows the RSM Python TOOLBAR ver 3.0.17 running on server: d6b9dmd1. The menu bar includes: File, PreProcessing, Run Model, View Model Results, Process Model Output, Output Graphics, Cluster Tools, and Help. The main window displays a 3D map of a watershed with a blue grid, overlaid with a red and blue hydrograph. The text "RSM Model Builder" is prominently displayed in red, with the tagline "Simulating South Florida's Water Needs for Today and Tomorrow" and "32bit" below it.

- Results Viewer
- rcBrowse
- HecDssVue
- DssMapVue
- Open IX
- Cell Comparison Hydrographs
- Waterbody\_CAT
- Waterbody\_PLOT
- Watermover\_CAT
- Watermover\_PLOT
- Google KMZ Animation
- Transect Tool


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31

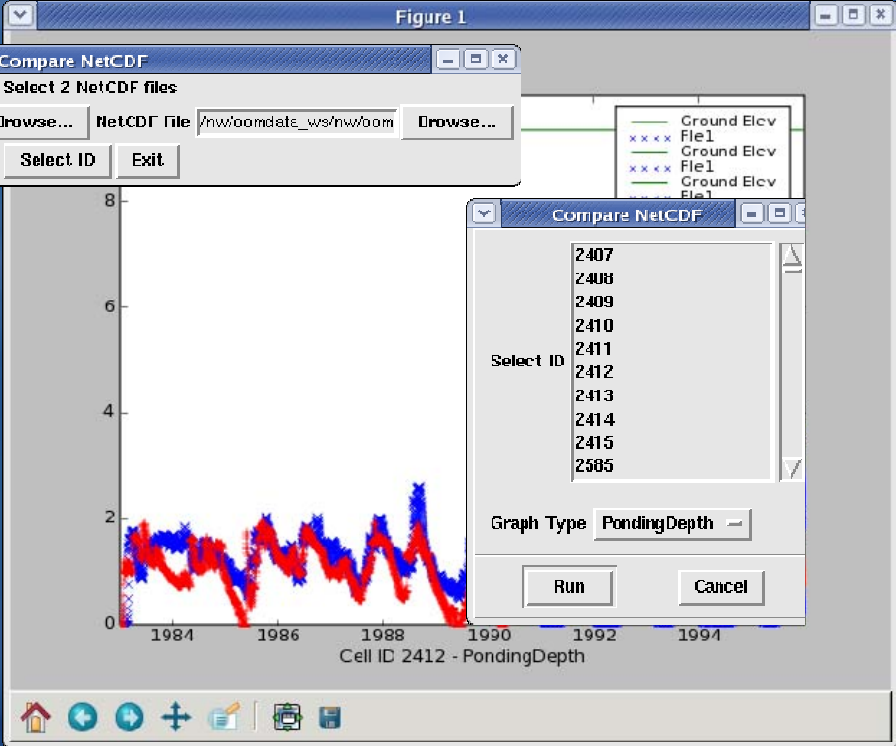
The **View Model Results** Menu offers a collection of tools to view and browse model output files.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

## Cell Comparison Hydrographs

RSM 

**Provide 2 similar netCDF files (same mesh, time period)  
Select cell ID for comparison**



32

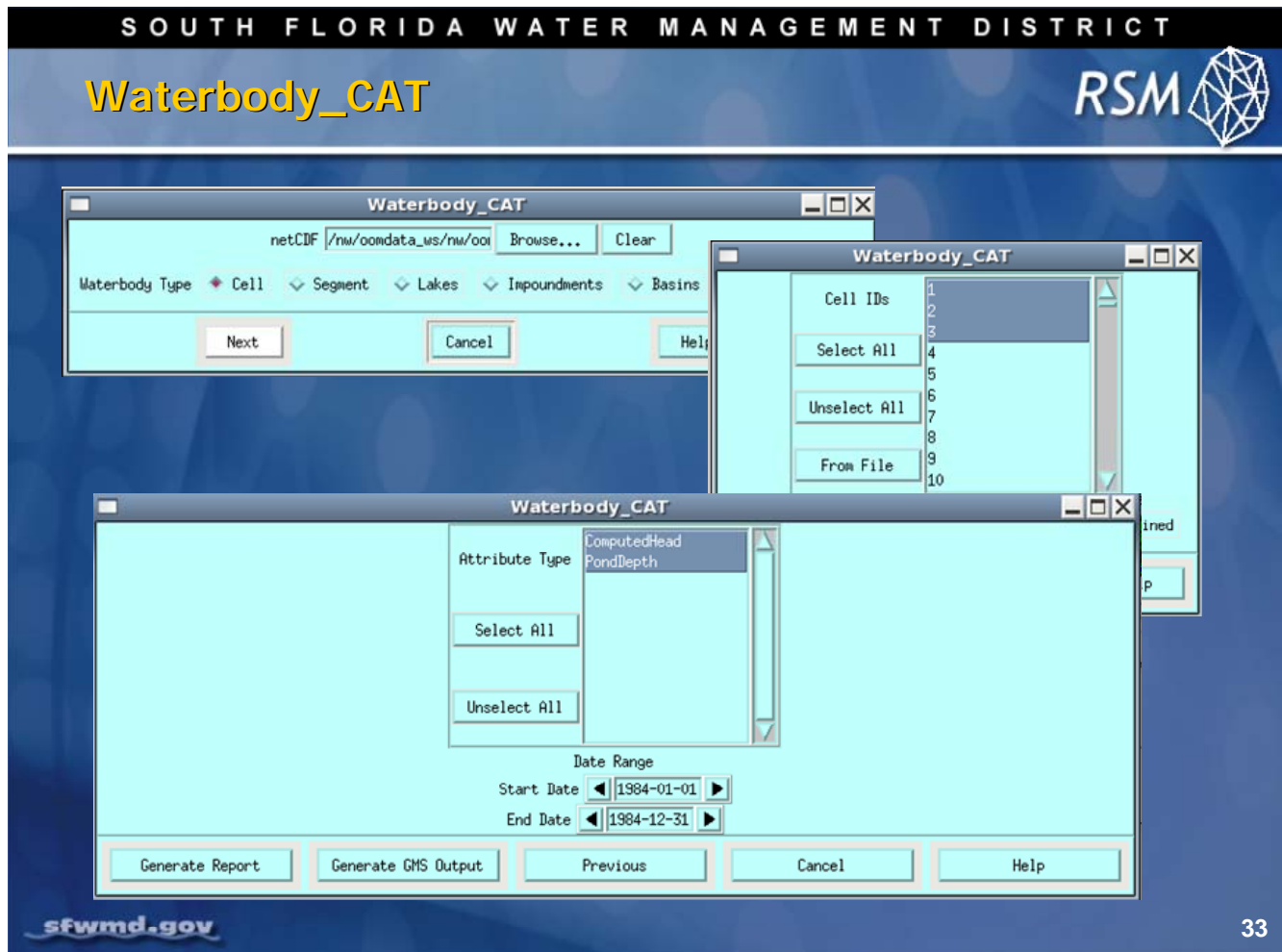
The **Cell Comparison Hydrographs** offer the ability to choose two netCDF model output files and generate a hydrograph comparing two cells. A list of cell IDs is generated from the first file and then corresponding cell information is read from the second file for comparison.

Use these sample files to run this tool:

- \$RSM/labs/lab8\_RSMtoolbar/2005Base\_AJ\_94-95\_global.nc
- \$RSM/labs/lab8\_RSMtoolbar/C111\_CERP\_ALT6\_94-95.nc



**NOTE:** The netCDF files being compared must be from runs built on the same mesh.



The **Waterbody\_CAT** tool provides a means to select portions of the data from a netCDF output file and generate an ASCII comma-delimited file. This example shows how easily the time series data for cells 1, 2, 3 can be extracted and displayed for analysis.

The file for testing this tool is: \$RSM/Labs/lab8\_RSMtoolbar/C111\_PIR1\_Alt2Db.nc

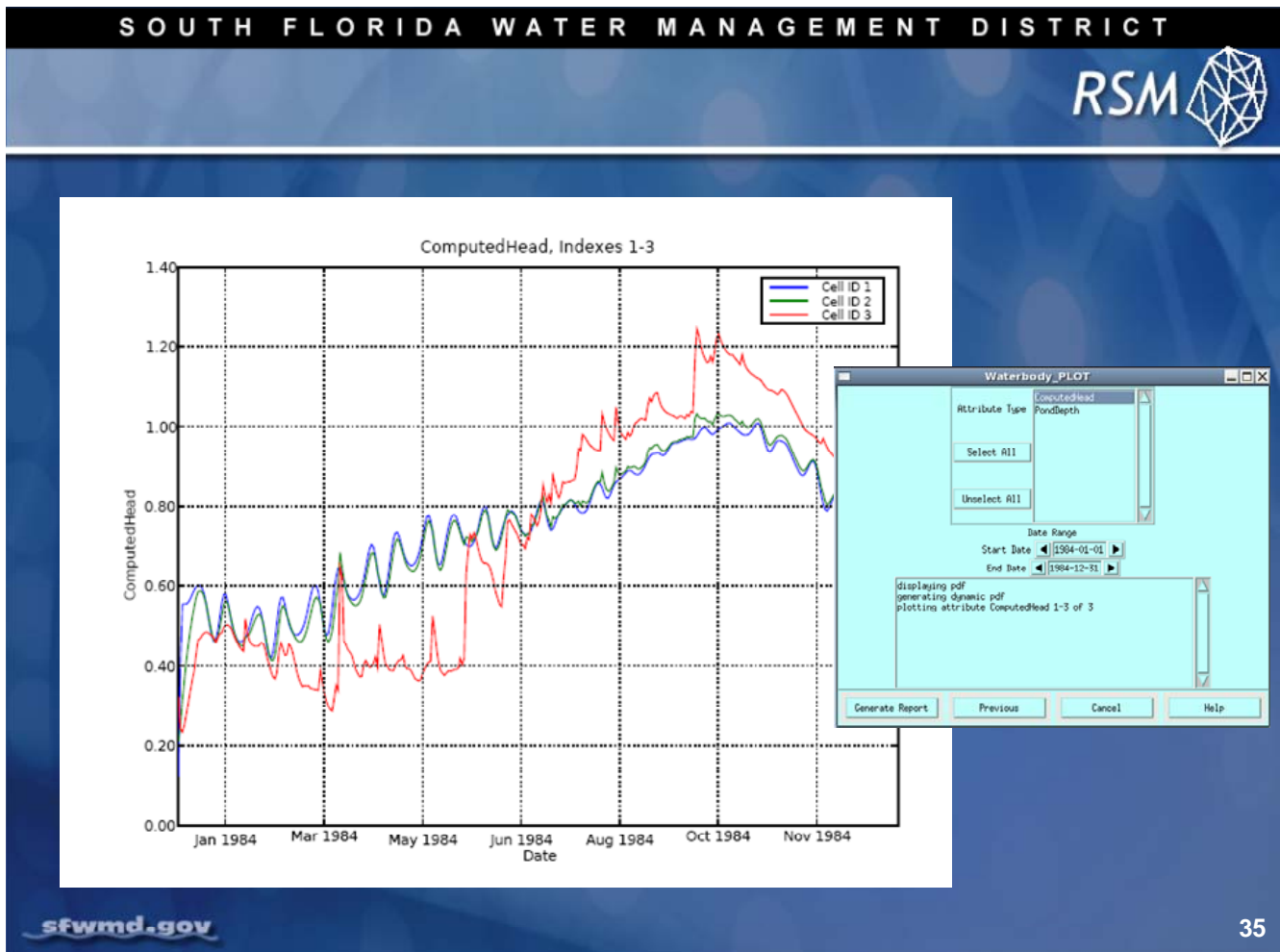


The screenshot displays the Waterbody\_CAT software interface. At the top, the header reads "SOUTH FLORIDA WATER MANAGEMENT DISTRICT" and "Waterbody\_CAT" in large yellow text. The RSM logo is visible in the top right corner. The main window shows a data table with the following columns: Cell ID, 1, 2, 3, .MIN, MAX, MEAN, SUM. The data rows represent time intervals from 1984-01-01 to 1984-01-27. Below the table, there is an "End Date" dropdown menu set to "1984-12-31". At the bottom of the window, there are five buttons: "Generate Report", "Generate GMS Output", "Previous", "Cancel", and "Help".

Cell ID	1	2	3	.MIN	MAX	MEAN	SUM
0 1984-01-01 00:00:00	0.122471399605	0.209652349353	0.322221726179	0.122471399605	0.322221726179	0.218115170797	0.65434551239
1 1984-01-02 00:00:00	0.398974597454	0.249644213875	0.242639369788	0.242639369788	0.398974597454	0.29710606734	0.891318202019
2 1984-01-03 00:00:00	0.554151952267	0.313151568174	0.23944029292	0.23944029292	0.554151952267	0.395782506307	1.10034751892
3 1984-01-04 00:00:00	0.554964125156	0.38388412118	0.250271379948	0.250271379948	0.554964125156	0.38970653216	1.16911959648
4 1984-01-05 00:00:00	0.554932377758	0.410835206509	0.277086317539	0.277086317539	0.554932377758	0.414304653804	1.24291396141
5 1984-01-06 00:00:00	0.558914661407	0.452397704124	0.306691527367	0.306691527367	0.558914661407	0.439334630966	1.3180038929
6 1984-01-07 00:00:00	0.567864120007	0.489435225725	0.336753875017	0.336753875017	0.567864120007	0.464684406916	1.39405322075
7 1984-01-08 00:00:00	0.578849136829	0.521064460278	0.362892836332	0.362892836332	0.578849136829	0.487602154414	1.46280646324
8 1984-01-09 00:00:00	0.589860022068	0.547467589378	0.387668073177	0.387668073177	0.589860022068	0.508331934611	1.52499580383
9 1984-01-10 00:00:00	0.597921788632	0.571014940739	0.429480195045	0.429480195045	0.597921788632	0.532805641492	1.59841692448
10 1984-01-11 00:00:00	0.601965068771	0.586011707783	0.465232461691	0.465232461691	0.601965068771	0.551069776217	1.65320932865
11 1984-01-12 00:00:00	0.600981414318	0.588273584843	0.468734741211	0.468734741211	0.600981414318	0.552653246791	1.65798974037
12 1984-01-13 00:00:00	0.594971358776	0.585412204266	0.477014630638	0.477014630638	0.594971358776	0.552465074626	1.65739822388
13 1984-01-14 00:00:00	0.590391128158	0.575116336346	0.482605040073	0.482605040073	0.590391128158	0.546237548192	1.63371264458
14 1984-01-15 00:00:00	0.589045629687	0.556495785713	0.485375314951	0.485375314951	0.589045629687	0.533305655516	1.59391689655
15 1984-01-16 00:00:00	0.529106557269	0.531563282012	0.484219014645	0.484219014645	0.531563282012	0.514962991079	1.54488997324
16 1984-01-17 00:00:00	0.500128805637	0.505004763603	0.47964578867	0.47964578867	0.500128805637	0.494926452637	1.48477935791
17 1984-01-18 00:00:00	0.47512280941	0.481395989656	0.476426392794	0.47512280941	0.481395989656	0.477648377419	1.43294513226
18 1984-01-19 00:00:00	0.46202981472	0.464857071638	0.470904313707	0.46202981472	0.470904313707	0.465797066689	1.39739120007
19 1984-01-20 00:00:00	0.4669457376	0.460419267416	0.459976404905	0.459976404905	0.4669457376	0.462447126706	1.38734138012
20 1984-01-21 00:00:00	0.488789349794	0.47332662344	0.471638172865	0.471638172865	0.488789349794	0.477918068858	1.4337542057
21 1984-01-22 00:00:00	0.522625625134	0.497206628323	0.481143683195	0.481143683195	0.522625625134	0.500325322151	1.50097596645
22 1984-01-23 00:00:00	0.557989458061	0.525040203293	0.482325325632	0.482325325632	0.557989458061	0.52185134093	1.56555402279
23 1984-01-24 00:00:00	0.578787446022	0.551244319489	0.498376792812	0.498376792812	0.578787446022	0.54233623551	1.62700687653
24 1984-01-25 00:00:00	0.579373459244	0.562913537025	0.502741515636	0.502741515636	0.579373459244	0.548542817434	1.6465284523
25 1984-01-26 00:00:00	0.561995267868	0.55594603548	0.503135144711	0.503135144711	0.561995267868	0.540325482686	1.62097644806
26 1984-01-27 00:00:00	0.53507232666	0.53597342968	0.499834477901	0.499834477901	0.53597342968	0.523626724879	1.57088017464

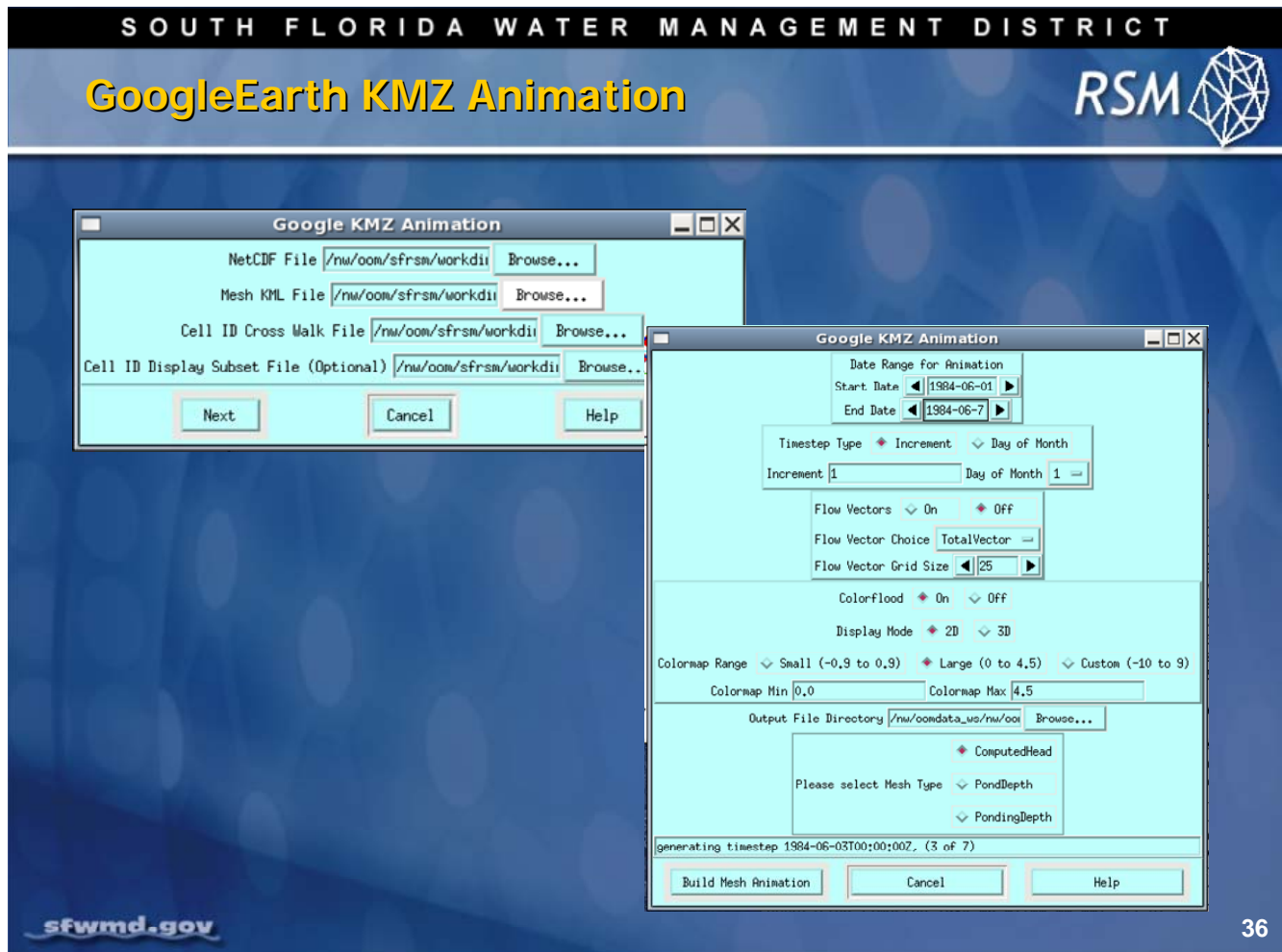
Output from the Waterbody\_CAT tool.





The **Waterbody\_PLOT** tool function is almost identical to the **Waterbody\_CAT**. The **Waterbody\_PLOT** tool produces a plot from the data selected from the netCDF file.

The file for testing this tool is: `$RSM/labs/lab8_RSMtoolbar/C111_PIR1_Alt2Db.nc`



36

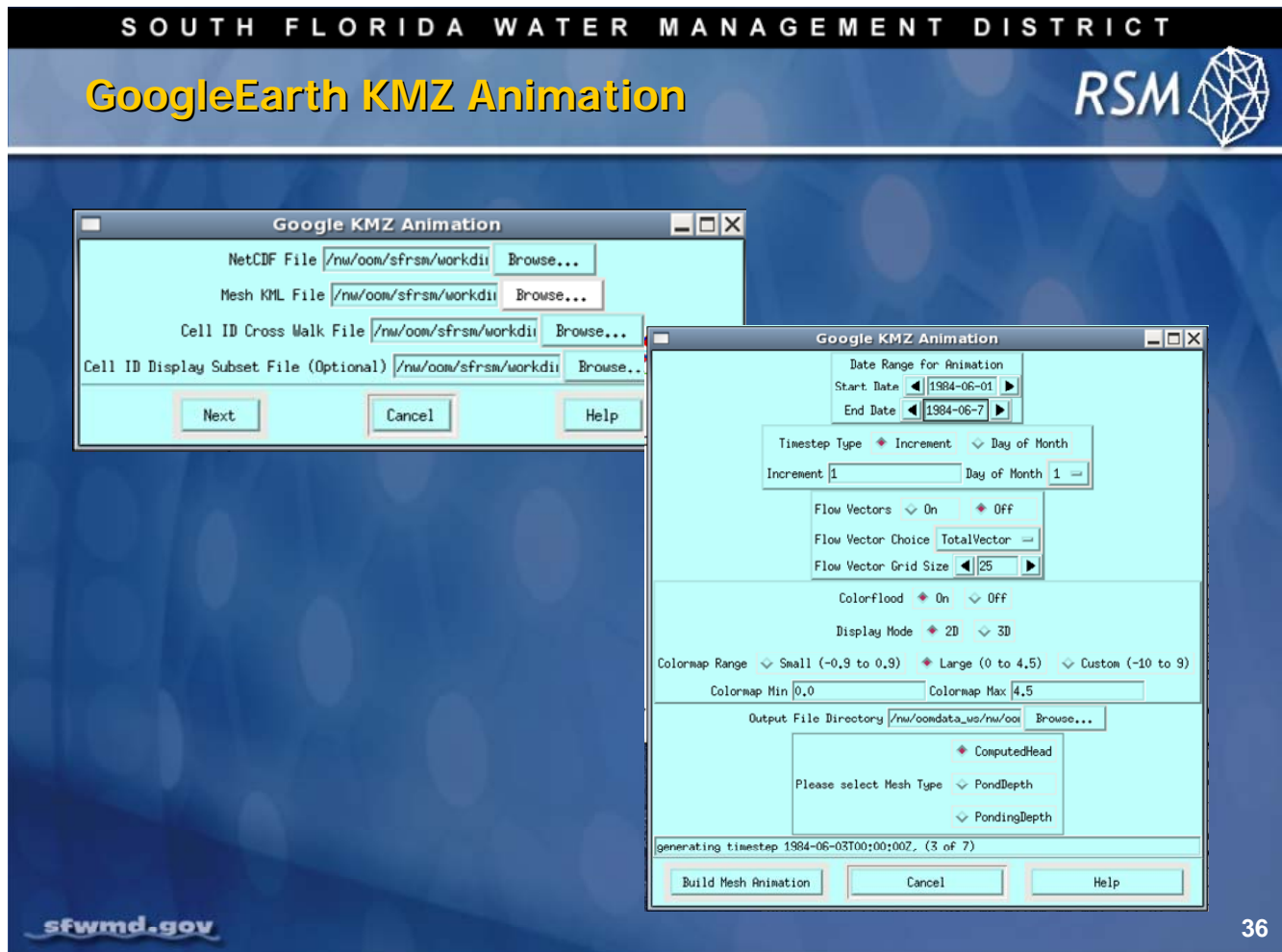
The **Google KMZ Animation** tool utilizes output from the GIS and the RSM netCDF file to produce a time series animation that can be viewed in GoogleEarth. (KMZ files are a variation of XML.)

The files needed to run this tool include:

- GlobalMonitor netCDF file containing Pondering or ComputedHead
- A mesh KML containing the mesh generated from Arc2Earth
- A cell ID crosswalk file. This is a two-column ASCII text file containing the ObjectID in column 1, and the cellID in column 2. The Index Tool from the GIS toolbar can be used to generate this file and then combined with the output in a spreadsheet to make the two-column file.
- Optional subset of cell IDs to be animated. This limits the cells that will be initially made visible in the animation. All cells will be present in the file and can be activated by selecting them in the GoogleEarth layer Table of Contents.



**NOTE:** To simplify usage of this tool, it is being redesigned to require only the netCDF file.



36


### Google KMZ Animation (continued from previous slide):

The second menu offers options for creating the Google KMZ file, including:

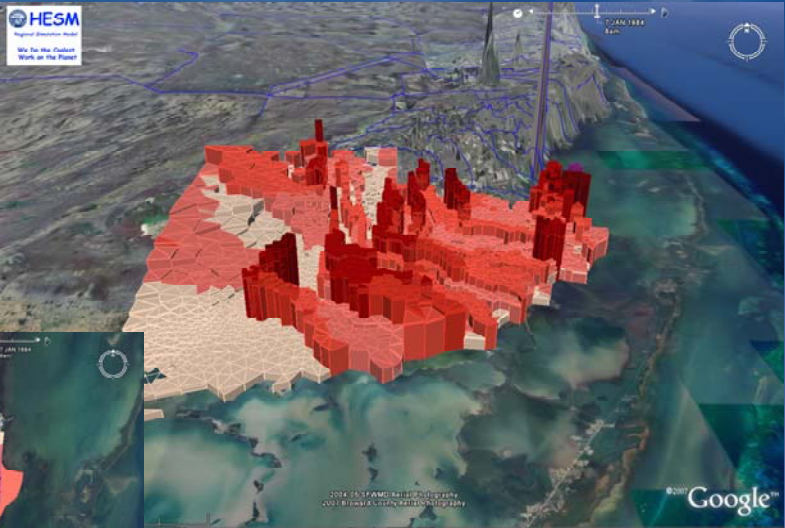
- Start/end date
- Timestep incremented by number of days, or day of the month
- Option to include animation of flow vectors, type of vector and control of the density for the square grid which is overlaid on the triangular mesh to generate corresponding flow vectors
- The mesh color-flood can be displayed in 2D or 3D
- Three color-range choices offer different colors and customizable ranges for assigning the colors
- User specified output location
- Choice of the variable to be animated. PondDepth is acquired if Pondering is output from the model otherwise PonderingDepth can be calculated if ComputedHead and Topo are output from the model.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

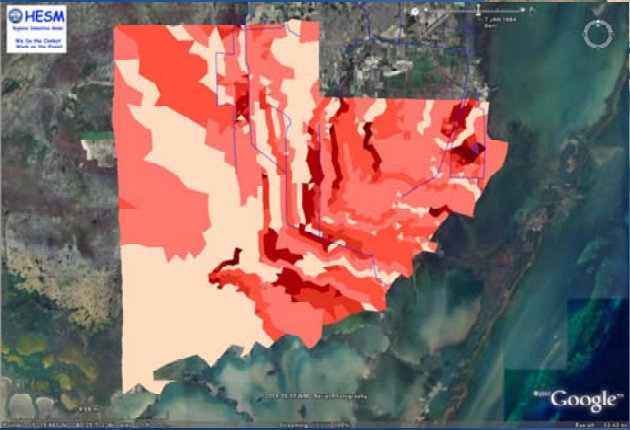
## GoogleEarth KMZ Animation

**RSM** 

**3-D ComputedHead**



**2-D ComputedHead**




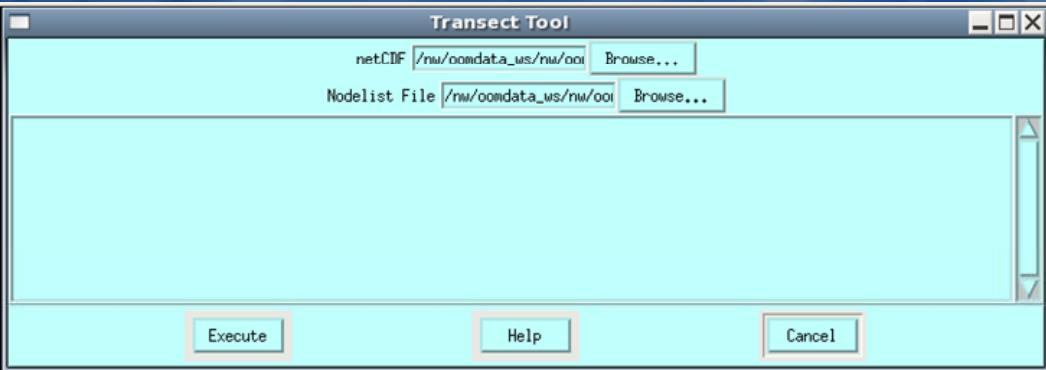
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37

The KMZ output file is viewed using GoogleEarth. This slide shows examples of 2D and 3D output from the **Google KMZ Animation** tool showing ComputedHead.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT


Transect Tool
RSM




```

<flowgage section="ol_gw" label="Transect_olgw">
  <nodelist> 888 947 1006 1062 1117 1171 1227 1279
             1326 1371 1415 1456 1500</nodelist>
  <asciiform file="./transect_7olgw.txt" format="%10.6f"></asciiform>
</flowgage>

```


38

The **Transect** tool calculates flow across any transect in the model.

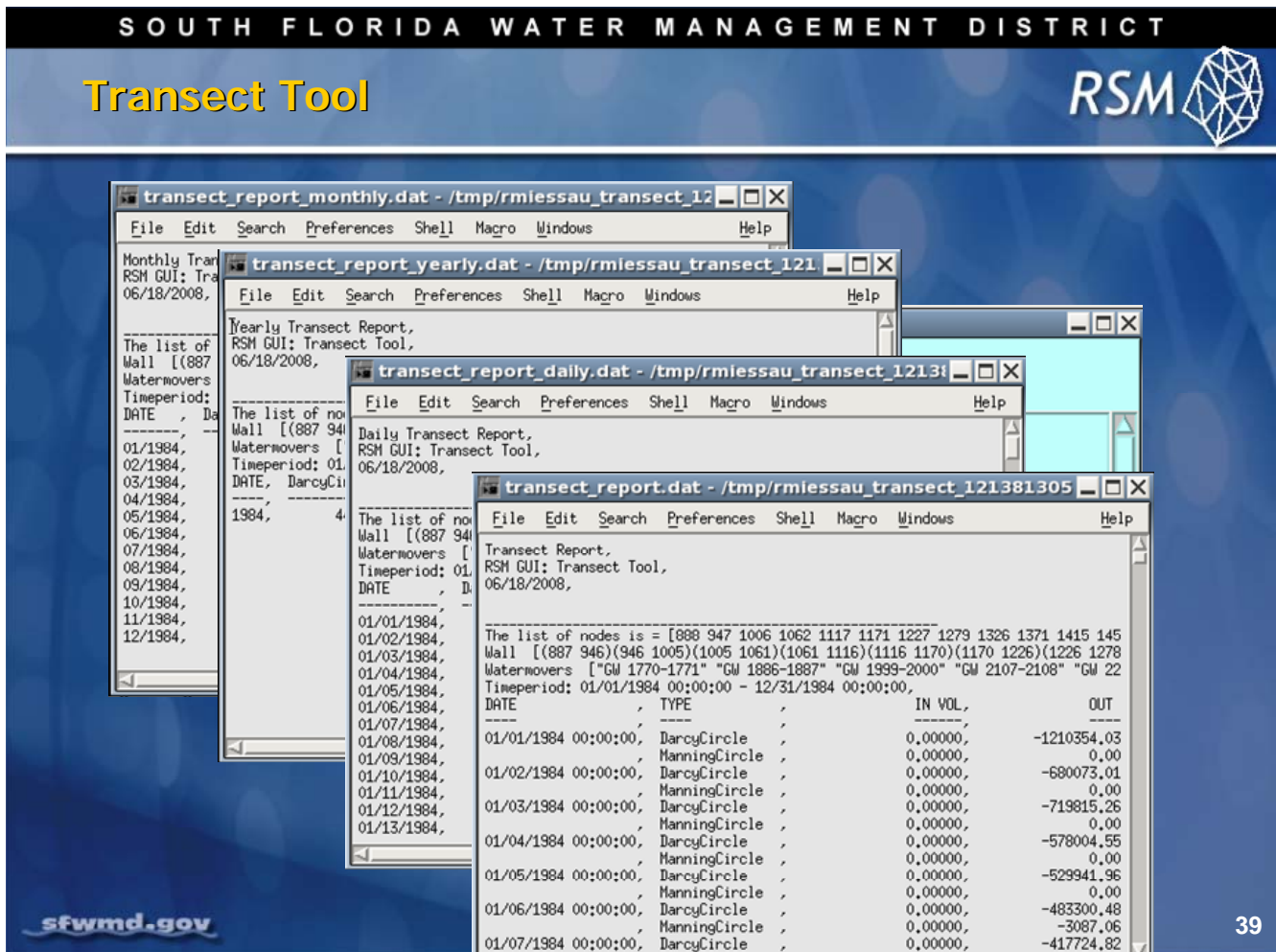
As input, the tool requires a netCDF file (wbbudgetpackage or budgetpackage composite) and a list of nodes. The list of nodes is a list of mesh nodes used to describe a transect. This same output can be generated from the RSM if this code is specified in the <output> block.

**Transect** tool sample files are:

- \$RSM/labs/lab8\_RSMtoolbar/wbbudgetpackage\_C111\_SR5\_sss.nc
- \$RSM/labs/lab8\_RSMtoolbar/transect/transect7.txt

Transect 7 consists of the nodes: 888 947 1006 1062 1117 1171 1227 1279 1326 1371 1415 1456 1500






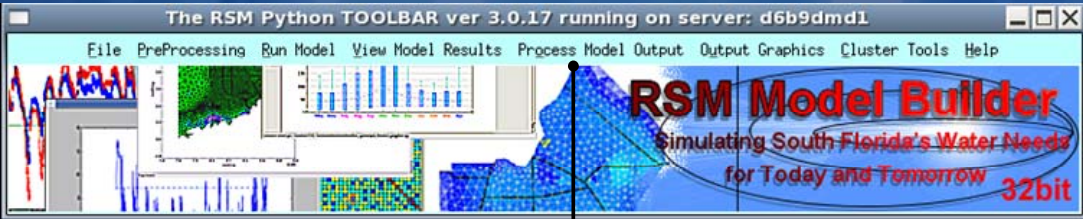
Output from the Transect tool.



SOUTH FLORIDA WATER MANAGEMENT DISTRICT

## The Process Model Output Menu

RSM 



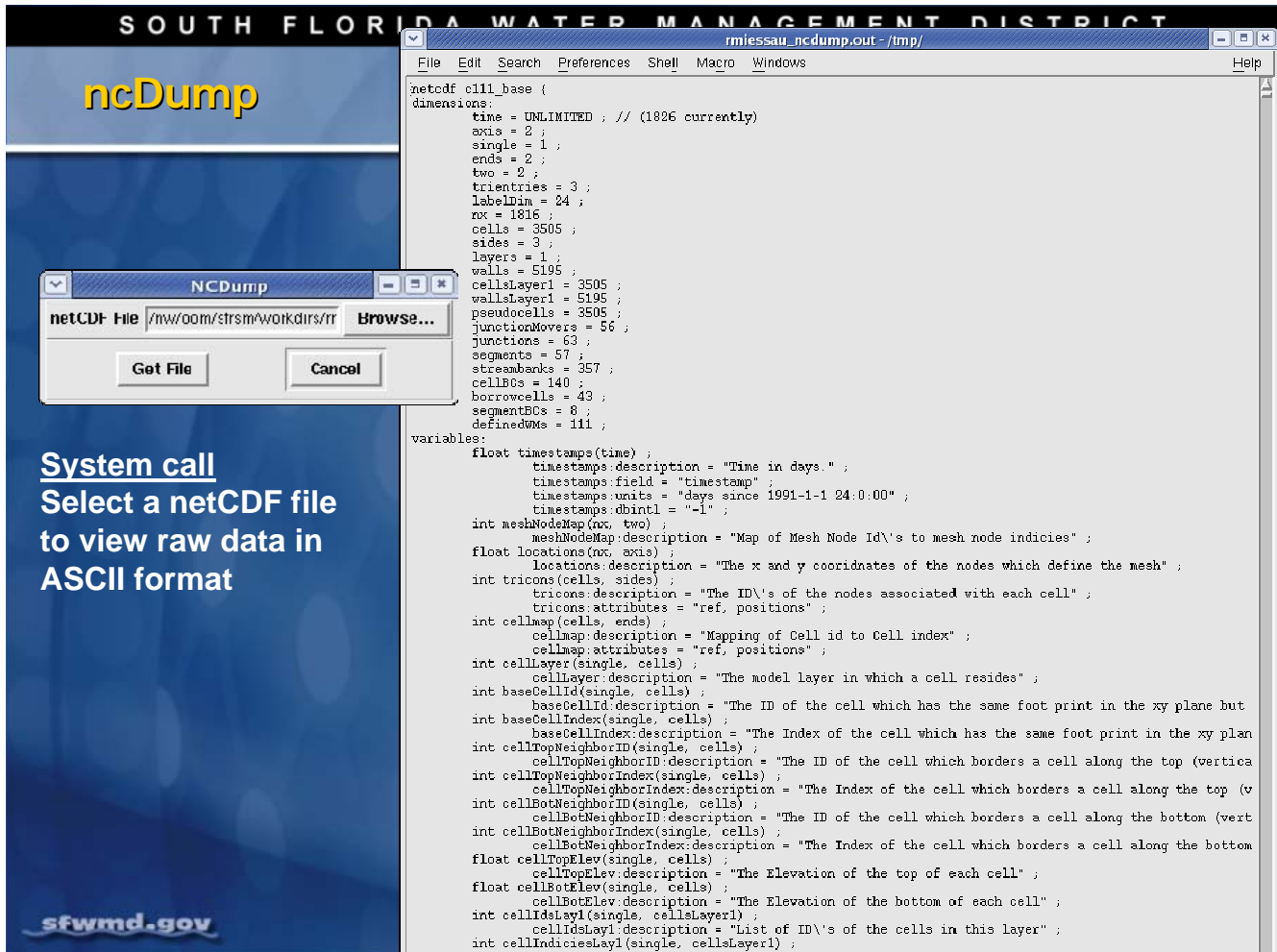
The screenshot shows the RSM Python TOOLBAR ver 3.0.17 running on server: d6b9dmd1. The menu bar includes: File, PreProcessing, Run Model, View Model Results, Process Model Output, Output Graphics, Cluster Tools, and Help. The main window displays a 3D map of South Florida with a blue mesh overlay. A callout box points to the 'Process Model Output' menu, which contains the following items:

- Waterbudget Residuals Animation
- NCDump
- List of Mesh Cells
- WBud
- NC Difference Tool
- Dynamic Charting Tool

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40

The **Process Model Output** Menu contains tools to process the model and view the data in the model output.



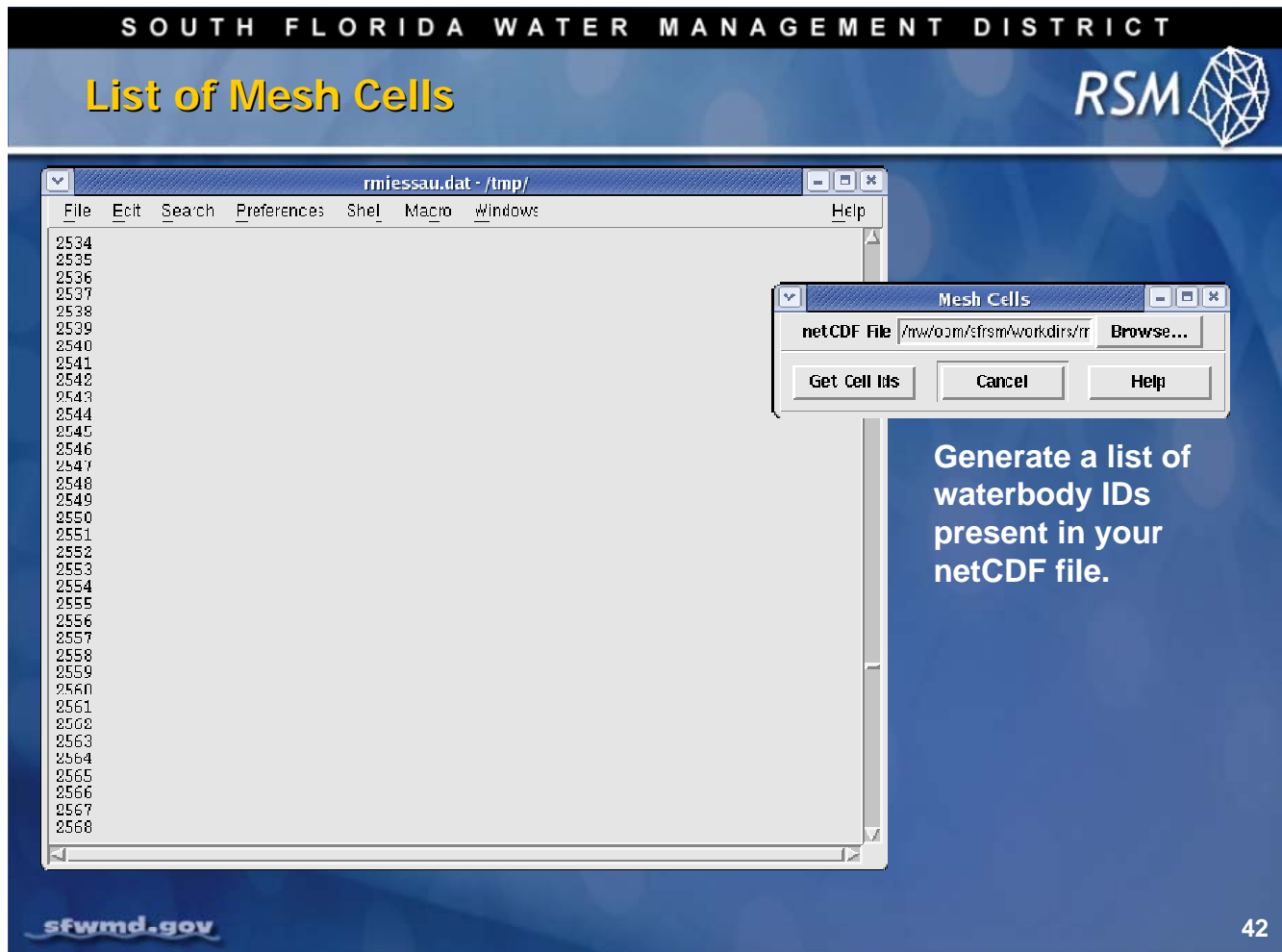
**ncDump** is a system call that generates an ASCII file from a netCDF. This functionality was added to the RSM GUI to help users running the toolbar via Windows emulating Linux.

ncDump is a quick and easy way to review the content of the model output. The ASCII file opens in a text editor which offers the ability to view, search and save the ASCII file. All output begins with a display of the netCDF file header.

This slide shows example output from ncDump with the header for a typical netCDF file

To view the header and ComputedHead data array, from the \$RSM/labs/lab8\_RSMTtoolbar directory type:

- `Ncdump wbbudgetpackage_C111_SR5_sss.nc -v ComputedHead | more`



The **Cell List** tool is a quick and simple way to generate a list of waterbodies (cells) in the model output. It reads a netCDF and generates a single column ASCII list which can be viewed or saved. This tool was created to help verify the model output matches with other files being used to generate graphics via the GUI.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

WBBUD Water Budget

Water Budget WBBUD

WBBudgetPackage NetCDF File  Browse...

MB CAT: (\*use with -a option\*)  -

IDs File: use -s option  Browse...

OR

IDs Subset: (\*space delimited\*)

MULTIPLIER

UNITS

OUTPUT:  Browse...

Condensed  Verbose

-c or -v

Volume  Rate  Depth

-t Transform

All  Day  Month  Annual

-f Format

Enable  Disable

-j Julian Date

Year	Rainfall, ft^3	ET, ft^3	HpwDelta, ft^3	sFlow, ft^3	gwFlow, ft^3	Sbseepage, ft^3	Sboverbank, ft^3	Residual, ft^3	WBDelta, ft^3	WBError, ft^3
1984.1,	14793.8,	-219087,	0,	0,	138907,	-93709.3,	0,	-0.046926,	159095,	0.00123077
1984.2,	59299.6,	-245895,	0,	0,	-602556,	776042,	0,	-0.00567561,	13108.9,	0.00231237
1984.3,	196954,	-313086,	0,	0,	-845311,	966735,	0,	0.00965681,	-5292.14,	-0.00378046
1984.4,	90078.3,	-332290,	0,	0,	-927583,	1.15107e+06,	0,	-0.0402329,	18726,	0.00468896
1984.5,	543352,	-364521,	0,	0,	-1.0299e+06,	1.00368e+06,	0,	-0.050016,	-152617,	0.00204125
1984.6,	335333,	-364110,	0,	0,	374369,	-428619,	0,	0.179118,	83027,	-0.00253071
1984.7,	272076,	-356196,	0,	0,	205517,	-139852,	0,	-0.040366,	18455.3,	0.00944635
1984.8,	235245,	-332009,	0,	0,	-31904.3,	130648,	0,	-0.0626294,	-2079.56,	-0.00467648
1984.9,	544151,	-289919,	0,	0,	279337,	-427857,	0,	0.333306,	-105713,	-0.00835006
1984.10,	27207.6,	-271125,	0,	424384,	496335,	-780006,	0,	1.08433,	102604,	0.0281802
1984.11,	53054.7,	-203008,	0,	0,	-71047.9,	290221,	0,	0.0175367,	13590,	-0.00149662
1984.12,	1360.38,	-191868,	0,	0,	-474016,	647764,	0,	0.00427859,	16758.8,	-0.00852354

43

**WBBUD** is a GUI interface to the WBBUD utility included with the RSM model code. It offers a variety of choices for configuring a wbbud water budget report. The tool requires a wbbudgetpackage netCDF file. Users can specify:

- All waterbodies of a particular type
- A subset of waterbodies from a list of waterbody IDs or a file containing a list of IDs
- A multiplier (e.g., 12 to convert from feet to inches)
- A user-specified label for units when using the multiplier option
- Condensed or verbose output for level of detail
- Volume, rate, depth
- Raw, daily, monthly or annual time step for summarizing the report
- Julian date conversion

The fields included in the output depend on the waterbodies used to generate the report. Residual is calculated by the model. WBDelta is the change in volume for the waterbodies represented in the report. WBError is calculated by adding all volumes and subtracting the sum from the Residual value.

To run this tool, use this file: \$RSM/labs/lab8\_RSMtoolbar/wbbudgetpackage\_C111\_SR5\_sss.nc

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

## The Output Graphics Menu

**RSM** 



The screenshot displays the RSM Python TOOLBAR ver 3.0.17 running on server: d6b9dmd1. The menu bar includes: File, PreProcessing, Run Model, View Model Results, Process Model Output, Output Graphics, Cluster Tools, and Help. The main window shows a 3D map of a water management system with the text "RSM Model Builder" and "Simulating South Florida's Water Needs for Today and Tomorrow 32bit". The Output Graphics menu is open, listing the following options:

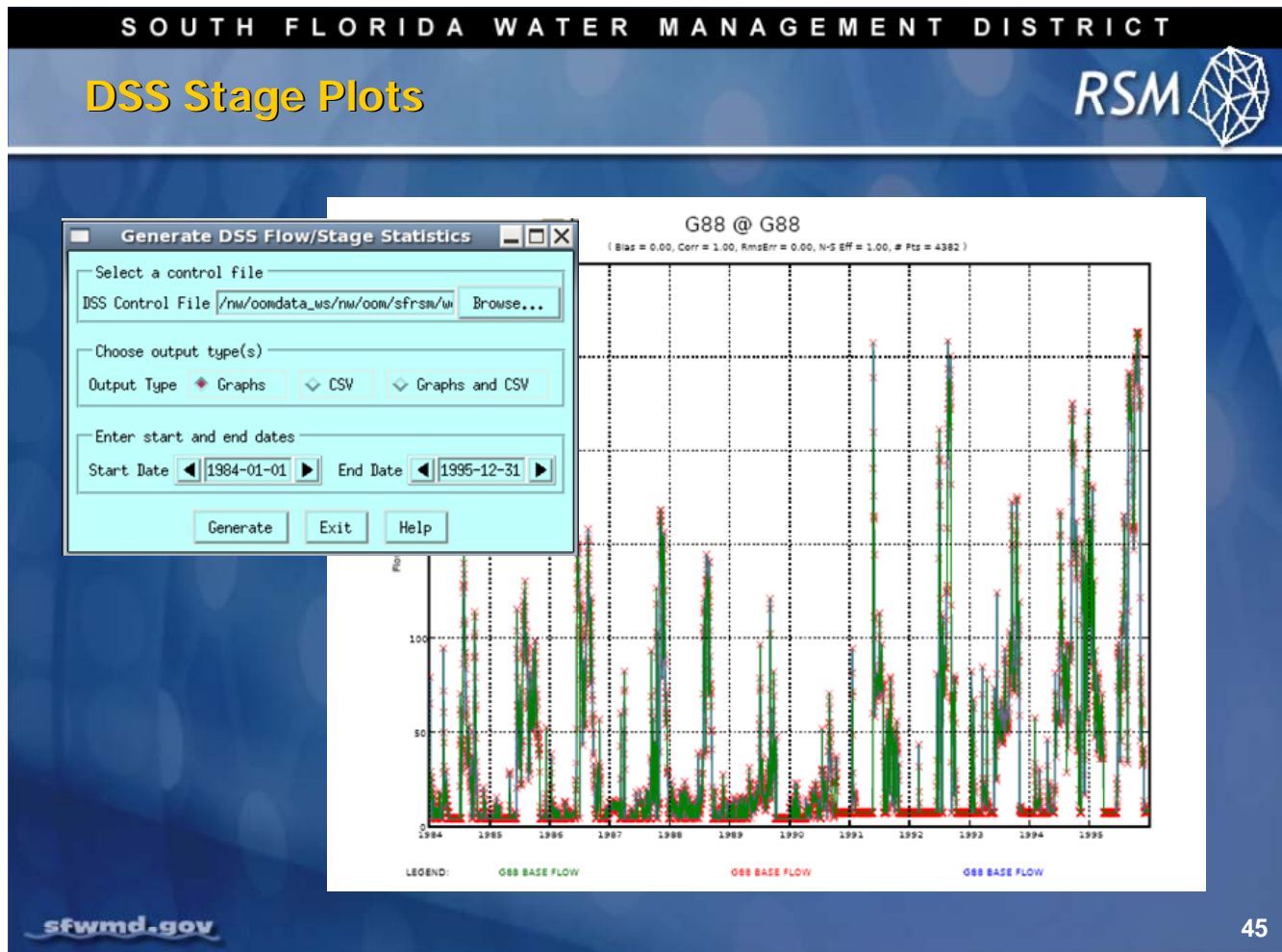
- ISS stage/flow Plots
- netCDF stage/flow Plots
- Canal Animation Graphics
- Presentation Graphics
- Verification Plots
- Inundation Report
- Levee Seepage Report
- Canal Stage and Flow Report
- LQK PMGs
- Estuary PMGs
- KISS PMGs
- PMIs
- Ponding Difference Tool

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44

The **Output Graphics** Menu offers tools to present your data in graphical format.





The **DSS Stage/Flow Plot** tool provides an easy means to generate DSS comparison plots and calculate bias statistics.

This tool requires a Control file as input. The control file contains references to DSS file locations and DSS data paths to assemble the graph. The control file is expected to provide the RSM simulated output, historical and 2x2 datasets, in that order.

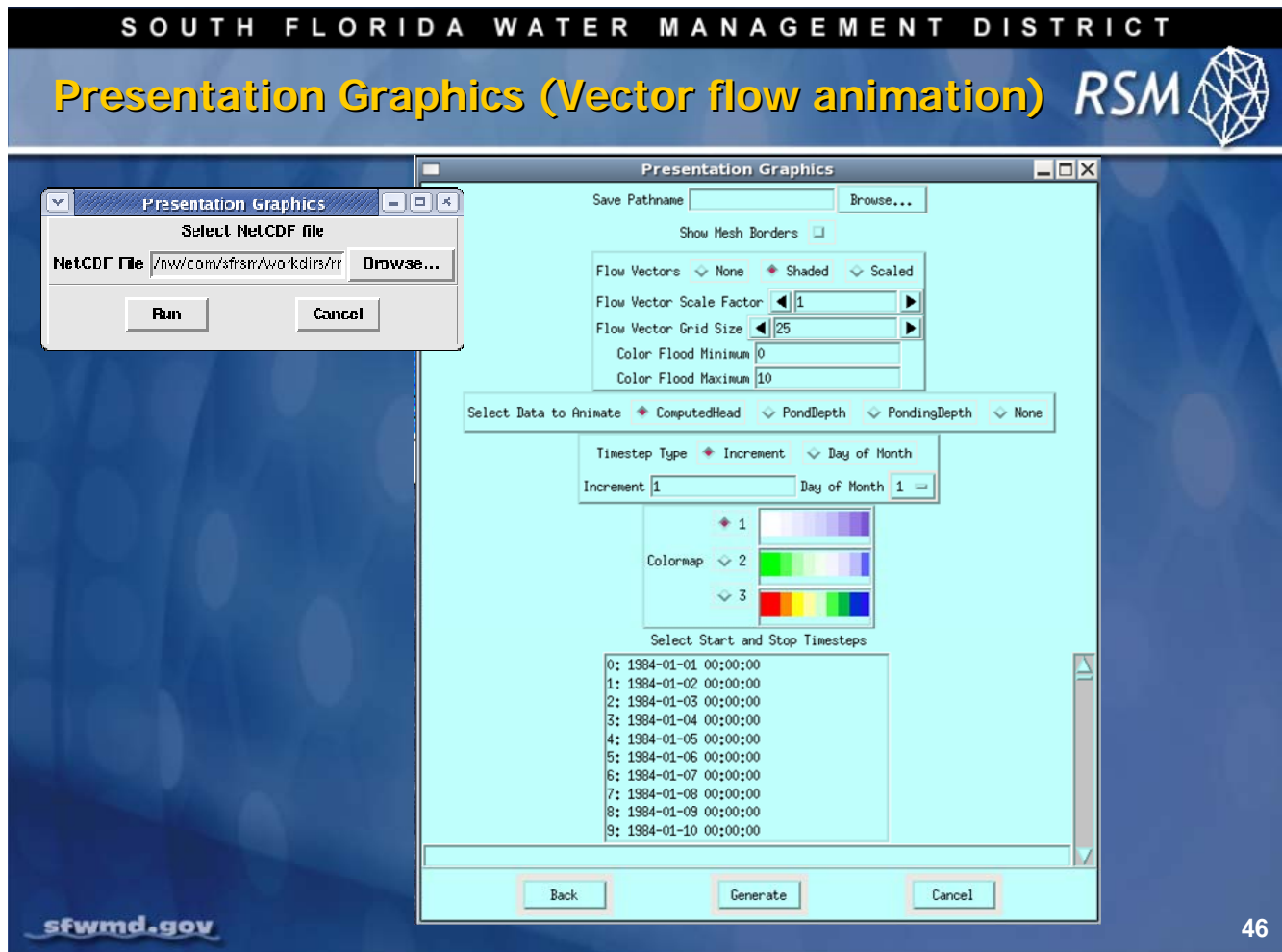
The tool also offers options to produce graphs, CSV data files or both. Users can limit the data range based on the range of data in the DSS files.

The graph label shows the gages to appear on each plot and offers a summary statistics page. The DSS files are expected to contain RSM Calculated, Historical Observations and South Florida Water Management Model (SFWMM) data. One DSS can contain all three datasets or individual files can be specified for each dataset. The resulting output from this tool is an indexed PDF file containing each plot, bias statistics and a summary statistics page at the end of the report.

The sample file for running the **DSS Stage/Flow Plot** tool is:

- \$RSM/labs/lab8\_RSMtoolbar/dss\_plots/sample.ctl





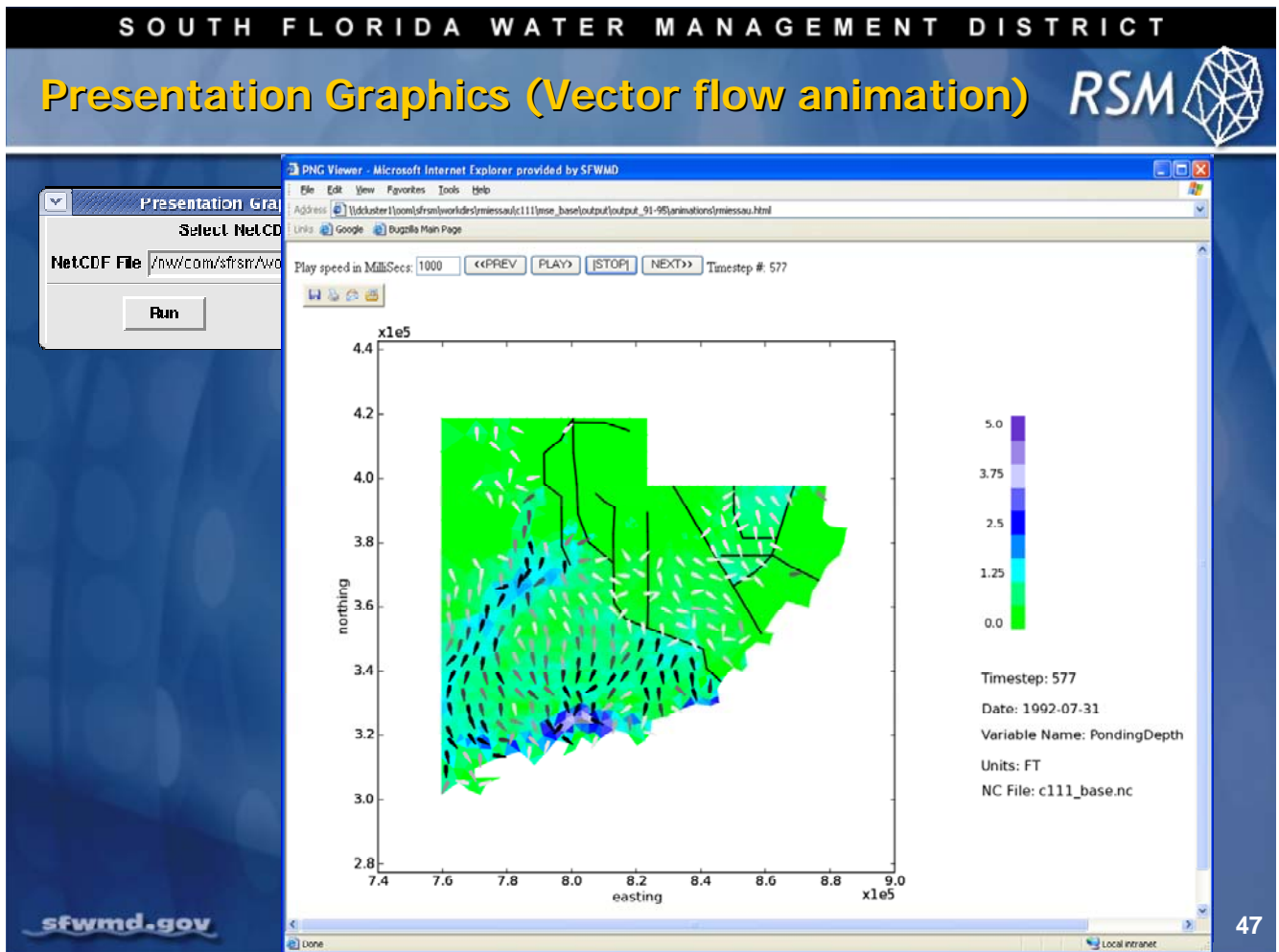
46

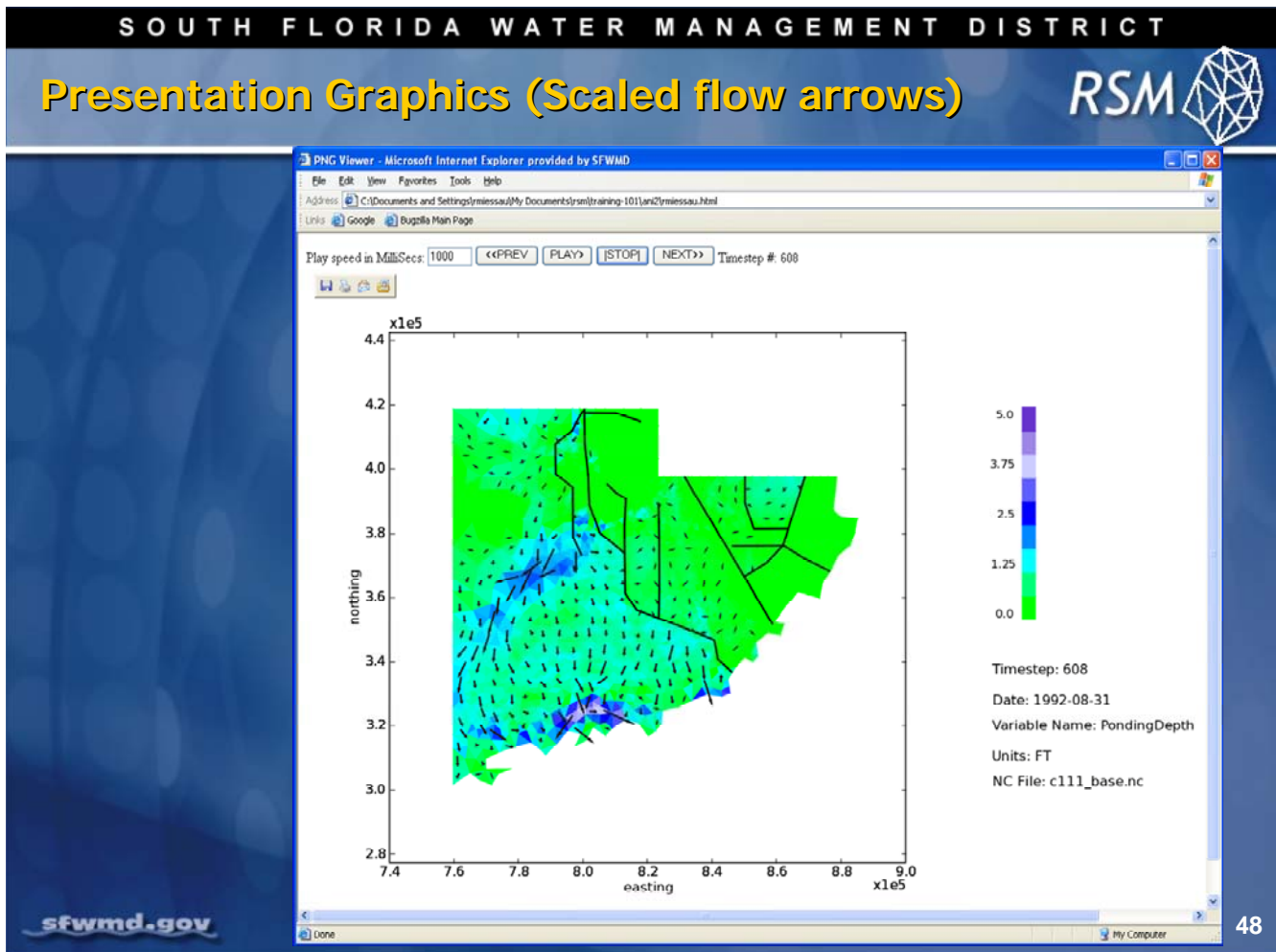
The **Presentation Graphics** tool offers a capability to generate animated time series graphics showing ponding depth or stage along with flow vector arrows. A variety of options offers ways to customize the animations based on the mode being presented.

- The flow vectors are generated based on a square grid overlay of a user-specified size
- The scale of the flow vector arrows can be specified
- Colorized arrows or scaled arrows can be selected to represent the magnitude of the flow.
- The range of the data being animated can be specified to help control the range of color used for the animations.
- The timestep can be specified to select a subset of the data in the netCDF mode (e.g., 10thday, month end, etc.)
- Output can be saved to a directory or generated in the /tamp directory and discarded after viewing
- The animation files include an HTML to play each image generated in the output from the tool

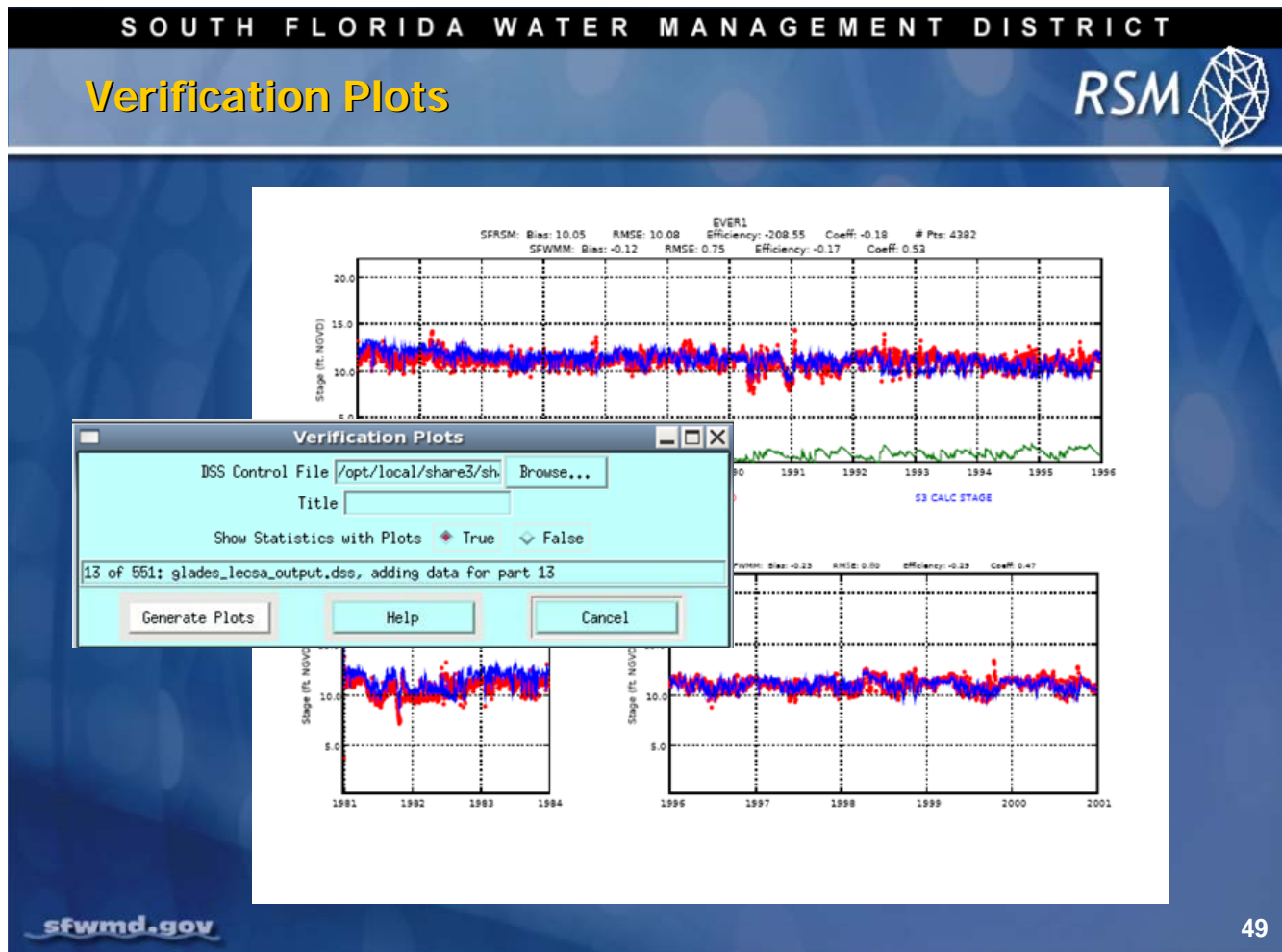
The sample file for running the **Presentation Graphics** tool is:

- \$RSM/labs/lab8/c111\_base.nc





Sample **Presentation Graphics** tool output with scaled arrows.

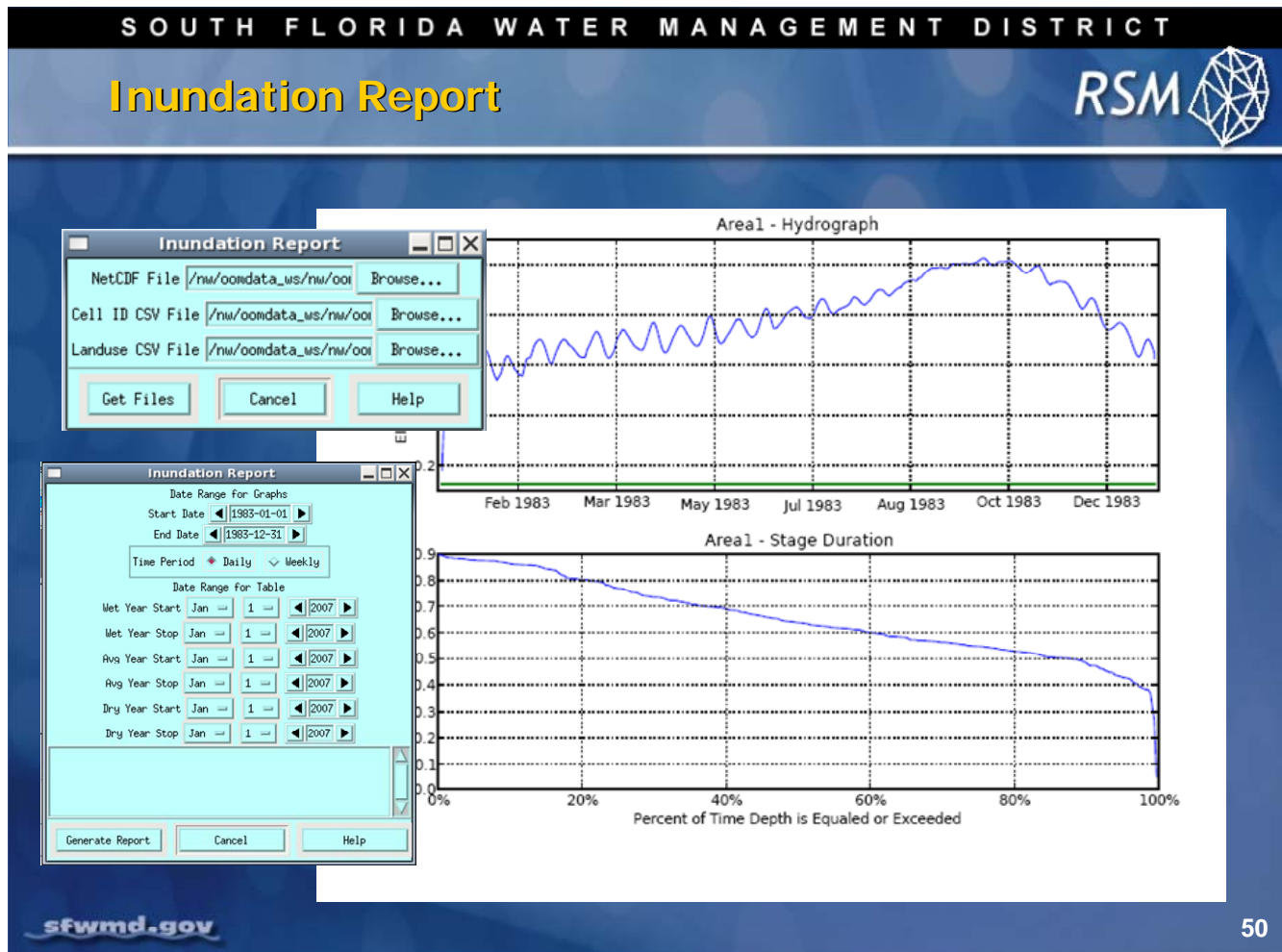


The **Verification Plots** tool generates stage hydrographs showing a calibration and split-validation time period. Statistics accompany each plot comparing the RSM simulations, South Florida Water Management Model (SFWMM) computed, and historical stages.

For input, this tool uses a Control file. The control file contains references to the location of DSS files and DSS data paths for generating each plot.

A sample file to run the **Verification Plots** tool is:

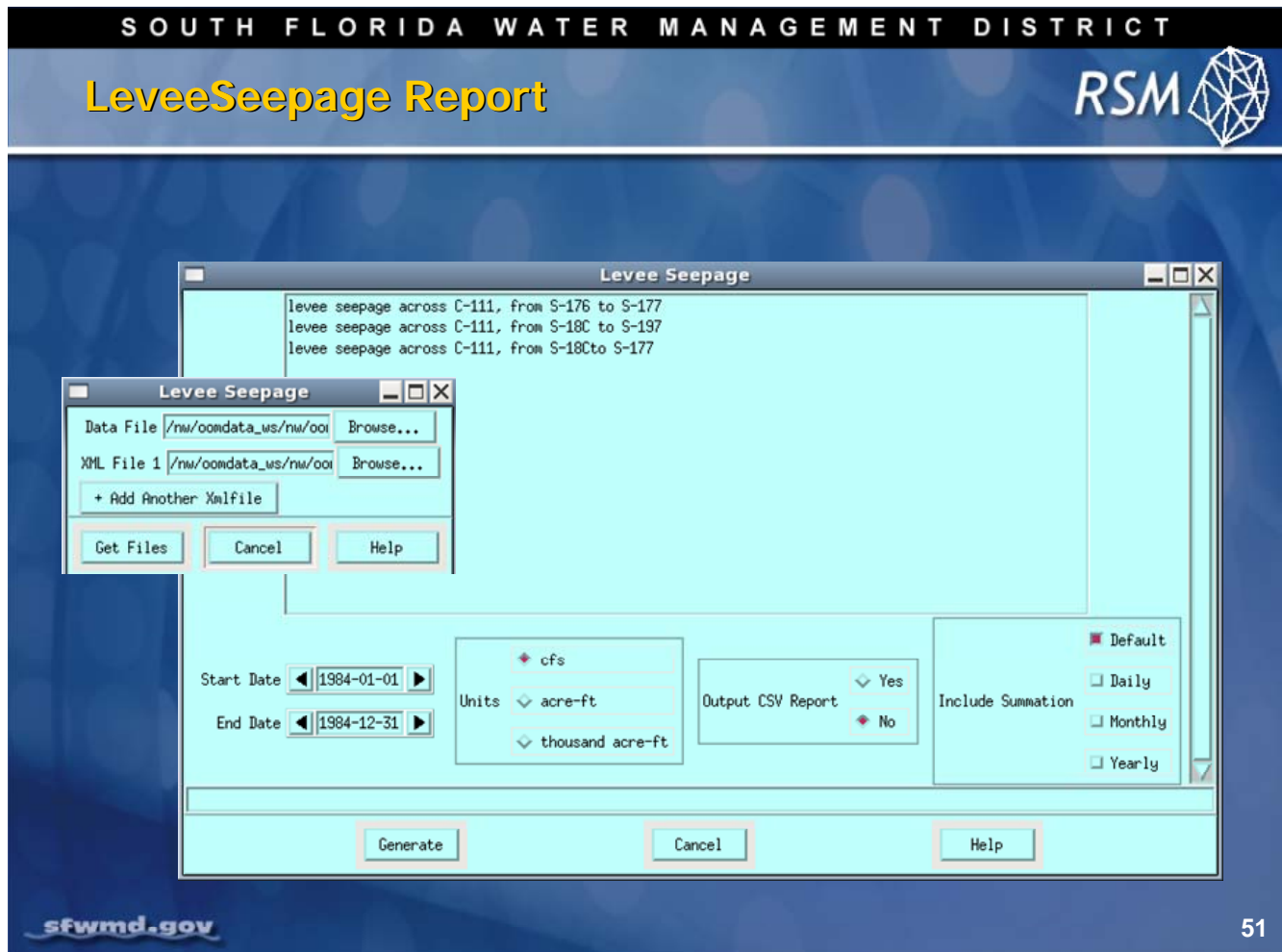
- \$RSM/labs/lab8\_RSMtoolbar/verification/sample.ctl



The **Inundation Report** tool generates a cell stage hydrograph and stage duration curve showing the percentage of time the depth exceeds the ground elevation in the cell. An added feature has been implemented giving RSM modelers the ability to customize for the RSM average wet/dry season reporting.

The sample files to run the **Inundation Report** tool are:

- \$RSM/labs/lab8\_RSMtoolbar/c111\_base.nc
- \$RSM/labs/lab8\_RSMtoolbar/inundation/obs\_cells.csv
- \$RSM/labs/lab8\_RSMtoolbar/inundation/landuse.csv



The **Levee Seepage Report** tool produces a CSV report and a hydrograph showing the seepage across levees in the model. This tool requires a wbbudgetpackage netCDF file and the levee seepage XML file used to run the model.

The main menu offers choices for the levees which are present in the XML. After selecting one or more levees to report on, options allow the user to configure the report/graphic.

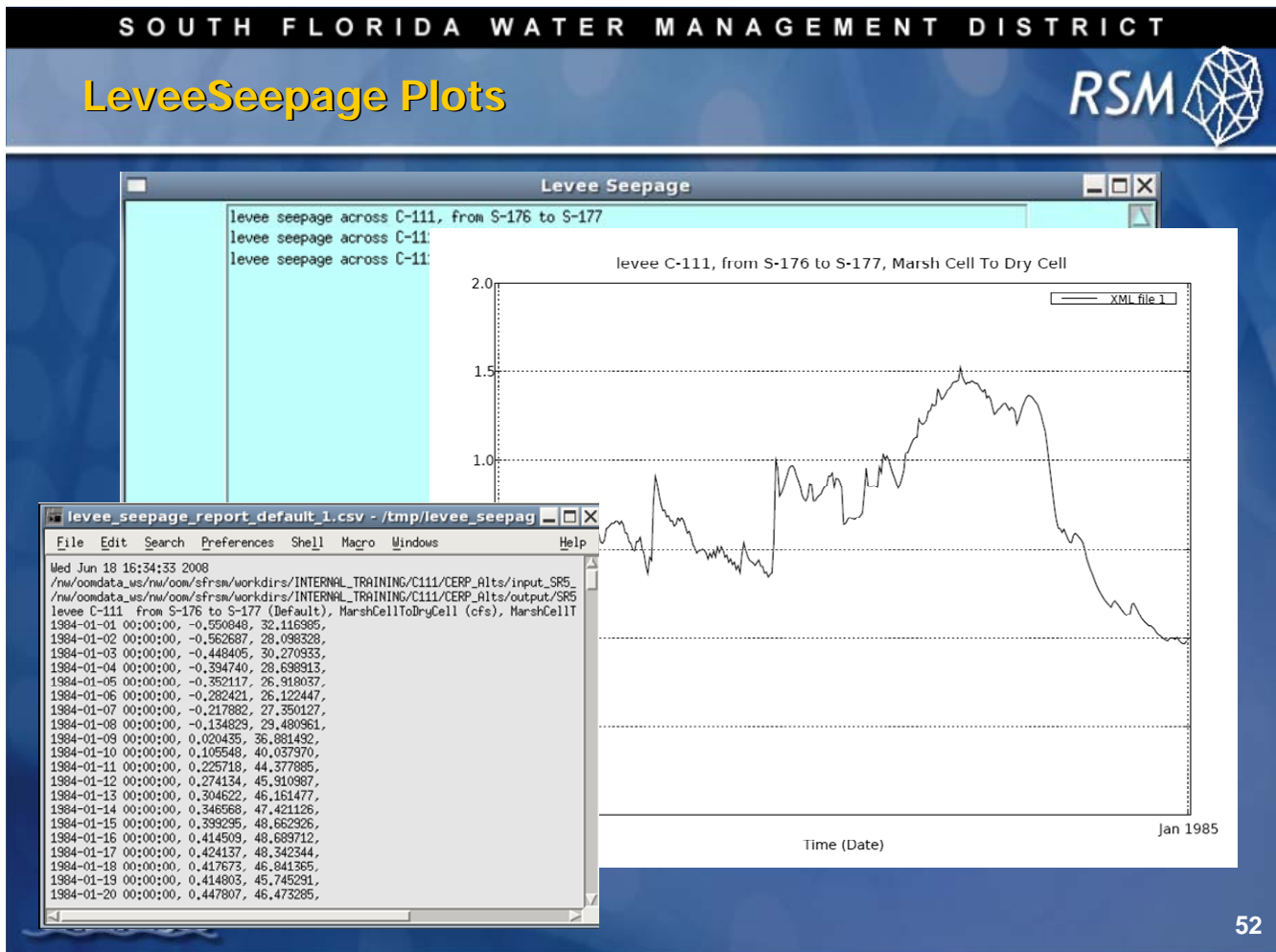
Options include:

- Specifying start/end dates
- Specifying units (cuffs, acre-feet or acre-feet\*1000)
- Inclusion of a CSV output file containing the values in addition to the default hydrograph
- Output by default timestamp of a daily, monthly or annual summation

Files to run the **Levee Seepage Report** tool are found at:

- \$RSM/labs/lab8\_RSMtoolbar/wbbudgetpackage\_C111\_SR5\_sss.nc
- \$RSM/data/C111/input\_SR5\_ss/PIR1\_Alt2Db\_levee-seepage.xml





Output from the Levee Seepage Report tool.

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## Performance Measure Graphics




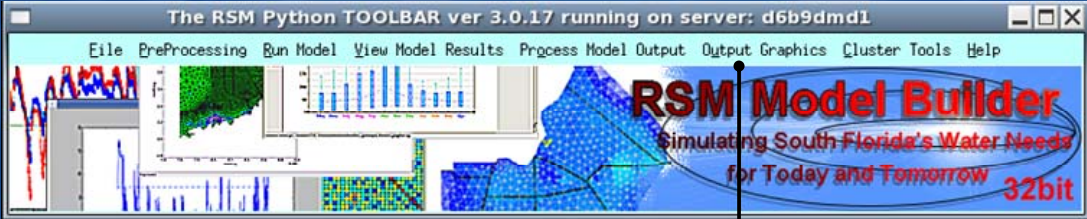
- **Currently the Performance Measure Graphics (PMGs) are very specific to each RSM implementation**
- **To date, PMGs have been created in support of the Northern Everglades Project**
- **The GUI Development Team implements new PMGs as needed by RSM implementation projects**

Subtypes are used for canals and structures. They are useful for Zymology, creating maps showing the unique components of the model. Subtypes maintain certain rules for network connectivity and they provide a basic framework for editing and data validation.

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## Performance Measure Graphics





The screenshot shows the RSM Python TOOLBAR ver 3.0.17 running on server: d6b9dmd1. The interface includes a menu bar with options: File, PreProcessing, Run Model, View Model Results, Process Model Output, Output Graphics, Cluster Tools, and Help. The main window displays several plots and a map, with the text "RSM Model Builder" and "Simulating South Florida's Water Needs for Today and Tomorrow 32bit".

- ISS stage/flow Plots
- netCDF stage/flow Plots
- Canal Animation Graphics
- Presentation Graphics
- Verification Plots
- Inundation Report
- Levee Seepage Report
- Canal Stage and Flow Report
- LQK PMGs
- Estuary PMGs
- KISS PMGs
- PMIs
- Ponding Difference Tool

- 1-4 LOK Envelope
- 5 - LOK Minimum Water Level
- 1-4 Caloo and STL
- 1-4 Caloo and STL (NERSM rivers)
- 43 Target Flow Index
- 1 - LKB Mean Monthly Flows
- 2 - LKB Seasonal Min/Max Flows
- 3 - LKB 14 day Low Flows
- 4 - KUB Probable High Lake Stages
- 1 - LOK Stage Duration Curve
- 5a - Watersupply Indicator 7 Worst Years
- 5b - 4-in-1 LOK water Supply Indicator
- 8 - Intra-Annual Lake Variability
- 9 - KUB Stage Duration for Navigation

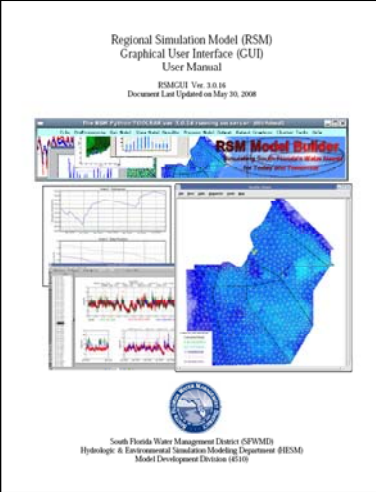

[sfwmd.gov](http://sfwmd.gov)



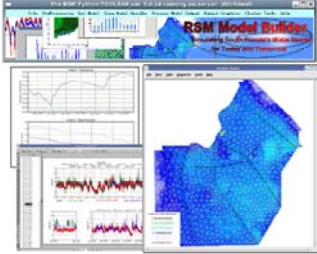
**Cluster** tools offer ways to monitor activity on the D Cluster and the computer you are using to run the RSM GUI.

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# RSM Documentation




Regional Simulation Model (RSM)  
Graphical User Interface (GUI)  
User Manual  
RSMGUI Ver. 3.0.16  
Document Last Updated on May 20, 2008

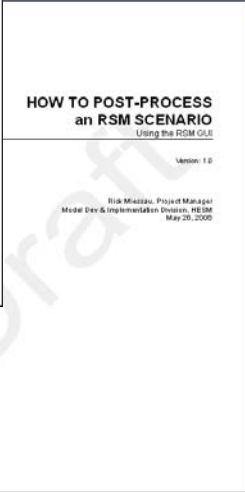


South Florida Water Management District (SFWMD)  
Hydrologic & Environmental Simulation Modeling Department (HESM)  
Model Development Division (MDD)

RSM GUI User Manual  
Available in the HELP Menu



USING THE RSM GUI  
AND RUN AN RSM SCENARIO  
RSM GUI Training 101  
Version: 1.0  
Risk Mitigation, Project Manager  
Model Dev. & Implementation Division, HESM  
Sept. 15, 2008



HOW TO POST-PROCESS  
an RSM SCENARIO  
Using the RSM GUI  
Version: 1.0  
Risk Mitigation, Project Manager  
Model Dev. & Implementation Division, HESM  
May 20, 2008

sfwmd.gov

56

Documentation is available via the **Help** button on the RSM GIS Toolbar and the RSM GUI. The **Help** Menu offers a variety of help options, manuals and a link to request additional help.





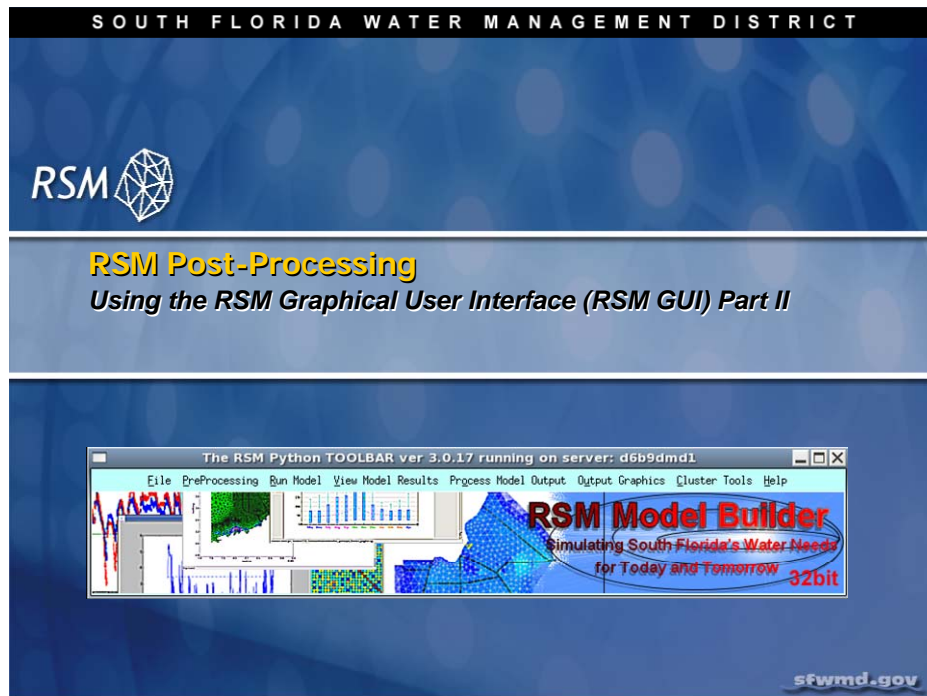
**KNOWLEDGE ASSESSMENT**

(pre- and post-lecture quiz to assess efficacy of training materials)

1. What is the purpose of the RSMGUI?
2. How is the RSMGUI implemented?
3. What is the scenario builder?
4. What is the advantage of using the Run Model Tool?
5. What data are used by the Results Viewer utilities?
6. What data are displayed by the Results Viewer?
7. How does the RSMGUI produce animations?
8. What is in the netCDF file and how can it be viewed?
9. Where do you find the tool to create a water budget?
10. How are flow vector animations created?
11. What are Inundation plots?
12. What Performance Measure graphics are available?

## Answers

1. The RSMGUI toolbar provides a means to access the various tools for processing water budgets, creating presentation graphics and Performance Measure graphics.
2. The RSMGUI is implemented at the Linux operating system prompt.
3. The scenario builder is a group of utilities that can be used to build the necessary XML files for creating an RSM implementation.
4. The Run Model Tool documents the model run and captures the statistics of the model run in a model log file.
5. The Results Viewer use a NetCDF file to plot cell and segment heads based on the model geometry.
6. The Results Viewer can be used to visualize hydrographs, hydrograph comparisons, spatial maps, segment profiles, animations, and PEST calibration results.
7. Animations are produced using the Google Earth KMZ animation tool.
8. The netCDF file is a binary file that contains a series of tables that contain the attributes and selected data for each waterbody. A netCDF file can be viewed using the *ncdump* utility. Viewing the netCDF file is often useful for trouble-shooting problems with model output.
9. The water budget tool *Process Model Output* → *wbbud*.
10. Vector flow animation plots are created using the *Output Graphics* → *Presentation Graphics* tool.
11. The inundations plots are the cell hydrograph with the stage duration plot.
12. There are several Performance Measure graphs available for selected RSM implementations as defined by the specific project plan.



## *Lab 8: Analyze RSM Output*

**Time Estimate: 2.5 hours**

**Training Objective:** Demonstrate post-processing features in the RSM Graphical User Interface (RSM GUI) and familiarize users with the different types of output from the Regional Simulation Model.

Lab 8 reviews Output Monitors and Waterbudget Packages, Global Monitors and Animation Graphics, Flowgages, RSM Plots and Statistics, as well as some additional output. This lab provides the opportunity to create a water budget, global monitors and flow vector animation, and use flowgages to view groundwater flows. Plot calibration statistics, spatial data maps and the Inundation Tool are also examined.

**NOTE:**

For ease of navigation, you may wish to set an environment variable to the directory where you install the RSM code using the syntax

```
setenv RSM <path>
```

For SFWMD modelers, the path you should use for the NAS is:

```
/nw/oomdata_ws/nw/oom/sfrsm/workdirs/<username>/trunk
```

```
setenv RSM /nw/oomdata_ws/nw/oom/sfrsm/workdirs/<username>/trunk
```

Once you have set the RSM environment variable to your trunk path, you can use \$RSM in any path statement, such as:

```
cd $RSM/benchmarks
```

```
INTERNAL_TRAINING
|
|__data
|   |__geographic
|   |__C111
|   |__rain+et
|   |__glades_lecsa
|   |__losa_eaa
|   |__BBCW
|
|__trunk
|   |__benchmarks
|   |__hpmbud
|
|__labs
```

Files for this lab are located in the `$RSM/labs/lab8_RSMToolbar` directory.

## Activity 8.1: Output Monitors and Waterbudget Packages

### Overview

**Activity 8.1** This activity includes two exercises:

- **Exercise 8.1.1** Becoming familiar with monitors
- **Exercise 8.1.2** Creating a water budget

The typical output from the RSM is in the form of monitors that report the time series state values of the waterbodies and the flows in the watermovers and water budgets that report the water balance for groups of waterbodies.

### Exercise 8.1.1 Becoming familiar with monitors

The outputs from the model are generated from the <output> block of the main XML file. The typical output elements and attributes are provided in **Table 8.1**. The details are found in the **HSE User Manual, Chapter 7**.

The time series data can be output in one of four formats: ASCII\_formatted, DSS, netCDF or CSV. The most common form is DSS because of the availability of DSSVue which includes a graphical user interface (GUI) and data processing utilities. The netCDF format is used for several applications in the RSM GUI.

**Table 8.1** Commonly used output elements and attributes for the Regional Simulation Model-Hydrologic Simulation Engine (RSM-HSE)

Elements	Attributes
<b>globalmonitor</b>	totalvector, topo, head, segmenthead, olvector,
<b>cellmonitor</b>	head
<b>hpmmonitor</b>	hpm_rain, refET, ps_et, etvol
<b>segmentmonitor</b>	head, levdrytosegflow,levmarshtosegflow
<b>lakemonitor</b>	Head
<b>impoundmentmonitor</b>	head, rain, refET,seepageflow
<b>wcdmonitor</b>	Head
<b>wcumonitor</b>	levdrytosegflow, seepageflow, levmarshtodegflow, overbankflow, sbflow
<b>basinmonitor</b>	head
<b>junctionmonitor</b>	flow
<b>wmmonitor</b>	flow
<b>bcmonitor</b>	flow
<b>flowgage</b>	flow across a transect formed by an ordered set of nodes
<b>Water budget outputs</b>	
<b>budget</b>	ASCII providing all inflow/outflows for all waterbodies
<b>wbbudgetpackage</b>	netCDF for post-processing water budgets

3. Run **benchmark \$RSM/labs/lab8\_RSMToolbar/BM33** using the RSM GUI. Look at the results for the hpmmonitor:
  - What are the three attributes output from each Hydrologic Process Module (HPM)?
  - What are the differences in irrigation volume for the different HPMs?
  - What are the differences in runoff volume for the different HPMs?
  - Create head monitors for a cell with unsat HPM and citrus-microjet HPM:

```
<cellmonitor id="1" attr="head">
  <dss file="recharge.dss"
    pn="/c1/citrus_micro/head//1day/micro irr1/"></dss>
</cellmonitor>
```

- Compare the resulting cell heads using **HEC-DSSVue** from the RSM GUI.

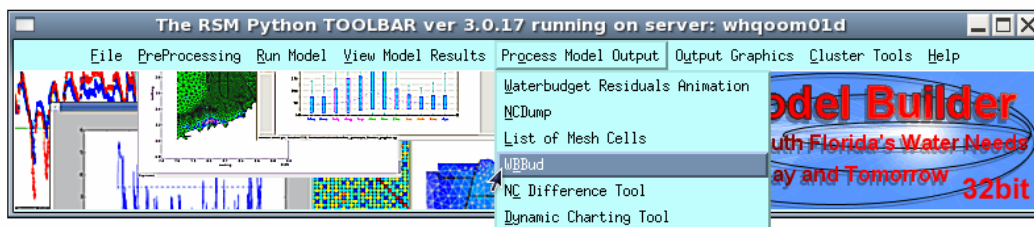
### Exercise 8.1.2 Creating a water budget

There is a command line post-processing utility for calculating water budgets called WBBud. The WBBud utility is used to calculate water budgets for the waterbodies (cells, segments, lakes, basins, wcds, impoundments or any group of waterbodies).

4. Open the **\$RSM/labs/lab8\_RSMToolbar/BM33/run3x3.xml** file. Add the following statements to the <output> block:

```
<output>
  <wbbudgetpackage file="wbbudget.nc" />
</output>
```

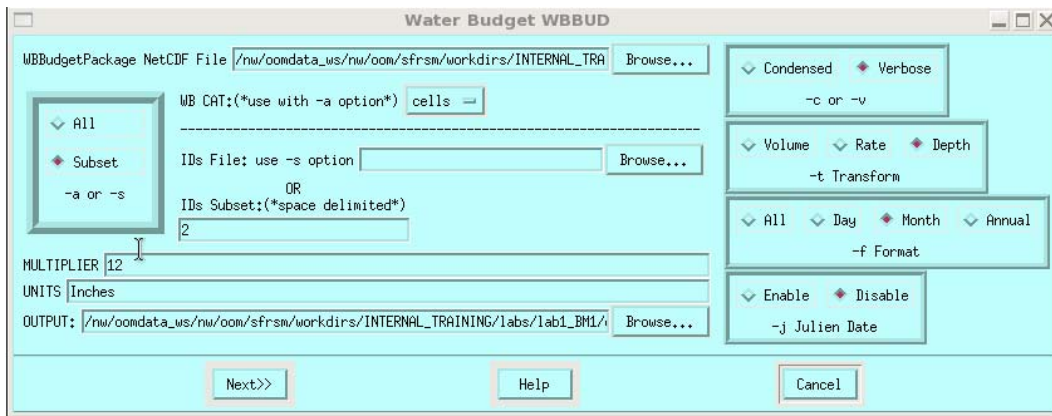
5. Create a waterbudget using the WBBud utility (see **Fig. 8.1**).



**Figure 8.1** Selecting the **WBBud** utility from the **Process Model Output** drop-down menu.



6. Run the **WBBUD** utility of the RSM GUI from the **Process Model Output** drop-down menu (see **Fig. 8.2**).



**Figure 8.2.** Options available in the **WBBud** utility.

Features in **WBBud** include:

- a** A summed report for all waterbodies of the specified type
- s** A summed report for a subset (list) of waterbodies either provided in a file or entered manually
- m** Multiply the output (e.g., `-m 12` to convert feet to inches)
- u** Units to be displayed in the header (required field if using the multiplier option)
- v** Verbose expanded output
- c** Condensed report
- t** Transform output to volume, rate or depth
- f** Format the report to summarize all (raw) data, daily, monthly or annual
- j** Julian date conversion

7. Enter these options to run **WBBUD**:

- Select to the file: [`$RSM/./benchmarks/BM1/wbbudget.nc`]
- Select the **Subset** option
- Enter **2** in the IDs Subset input box
- Enter a multiplier of **12** to convert feet to inches
- Enter **Inches** as the label for your output units
- Enter a path in the output box [`$RSM/labs/lab1_BM1`]
- Select the **Verbose** option
- Select the **Depth transform** option
- Select the **Month** format option
- Disable the **Julian** option
- Click **Next>>**

The output will be written to the output file and a window will prompt the user to view the file that has been written.

8. When **WBBud** is complete an alert message will remind you where the output has been written.
9. Click the **View** button to view the output.

The results should look like the output in **Table 8.2**.

### Hydrologic Process Modules (HPM) Water Budgets:

The **hpmbud** utility was developed to calculate water budgets for a HPM or group of HPMs. The **hpmbud** is implemented at the command line as follows:

```
$RSM/trunk/hpmbud/hpmbud -n hpmbudget_mo.nc -s 12 -d -m 12
```

The switches are defined in the **hpmbud** directory.

- n** List the name of the netCDF file
- s** Followed by a list of cell IDs (comma delimited list) or the name of a file that contains the list of cells for the HPMs
- d** Provide the results in depth (feet or meter, as defined in the Control block in the run file run3x3.xml) rather than volume
- m** Provide a multiplier to the output. (a multiplier of 12 provides results in inches if the default units for the model output are US Standard feet)

**Table 8.2** shows two examples of water budget output from Cells 1 and 8 in Benchmark 33.

**Table 8.2** Typical WBBud waterbudget output for BM33

Water budget for Cell 1 containing an Agricultural Field Scale Irrigation Requirement Simulation Model (AFSIRS) citrus-microjet HPM:

```
wbbud -n wbbudget.nc -s 1 -f month -t depth -m 12 -u inches -v
```

Year	Rainfall, inches	ET, inches	HpmDelta, inches	sfFlow, inches	gwFlow, inches	Residual, inches	WBDelta, inches	WBError inches
1965,1	0.158496	-0.977845	0.601053	0	-0.193361	4.16175e-10	0.411657	-4.98968e-08
1965,2	0.92964	-0.583662	-0.566936	0	-0.0586383	-7.59195e-10	0.279596	1.03391e-07
1965,3	0.371856	-0.991733	0.399903	0	-0.0998059	-1.65752e-07	0.31978	7.7998e-08
1965,4	0.417576	-0.881325	0.0173389	0	0.0764687	3.03042e-09	0.369942	3.03937e-08
1965,5	0.301752	-1.02997	0.00852279	0	-0.248759	-3.28761e-10	0.96845	1.01185e-07
1965,6	2.58166	-1.64151	-0.516328	0	-0.101929	-8.54053e-07	-0.321888	2.44431e-08
1965,7	3.84962	-2.07101	-0.161248	0	-0.304999	-2.04625e-05	-1.31234	-2.12382e-07
1965,8	2.01473	-1.92111	0.4328	0	0.0851718	-3.01372e-05	-0.611563	1.07531e-07
1965,9	1.93548	-1.6219	-0.270582	0.000395873	0.0386891	4.8311e-06	-0.082083	1.59067e-07
1965,10	2.44754	-1.6765	-0.0553688	0.0116014	0.130426	6.57778e-06	-0.857707	-1.07489e-07
1965,11	0.432816	-1.35377	0.695032	0.000209728	-0.0534724	7.05885e-07	0.27918	-9.56778e-08
1965,12	0.19812	-0.7412	-0.109807	-0.000136581	-0.0343446	1.8446e-06	0.687366	-7.15286e-08

Water budget for Cell 8:

```
wbbud -n wbbudget.nc -s 8 -f month -t depth -m 12 -u inches -v
```

Year	Rainfall, inches	ET, inches	HpmDelta, inches	sfFlow, inches	gwFlow, inches	Residual, inches	WBDelta, inches	WBError inches
1965,1	0.158496	-0.918522	0	9.14897e-07	0.21474	2.80418e-07	0.545285	8.54303e-09
1965,2	0.92964	-0.687172	0	0	0.142944	-1.9053e-08	-0.385413	-1.38968e-08
1965,3	0.371856	-0.817745	0	3.19148e-05	0.180347	1.31617e-06	0.265509	1.79828e-09
1965,4	0.417576	-0.972007	0	0	0.272552	3.78592e-08	0.28188	2.2342e-09
1965,5	0.301752	-1.27315	0	0	0.452485	-2.67304e-09	0.518911	-3.63198e-11
1965,6	2.58166	-1.3681	0	0.00820946	0.26383	-1.70912e-06	-1.4856	6.15863e-08
1965,7	3.84962	-1.57707	0	0.156405	0.0990012	-3.13073e-05	-2.52793	-2.60924e-08
1965,8	2.01473	-1.48613	0	0.17875	0.0279432	-4.37428e-05	-0.735252	-4.71725e-09
1965,9	1.93548	-1.25855	0	-0.113746	-0.00538524	9.31083e-06	-0.557804	2.63004e-09
1965,10	2.44754	-1.31072	0	-0.00691794	0.00622521	5.75381e-06	-1.13614	5.19337e-08
1965,11	0.432816	-1.21537	0	-0.0216731	0.00425739	5.92386e-06	0.799962	1.56177e-08
1965,12	0.19812	-1.10157	0	-0.0251453	0.0040317	4.80151e-06	0.924558	1.08828e-08

## Activity 8.2: Global Monitors and Animation Graphics

### Overview

**Activity 8.2** This activity includes two exercises:

- **Exercise 8.2.1** Creating global monitors
- **Exercise 8.2.2** Creating a flow vector animation

The global monitors produce the output for the display of spatial data and animations. The exercises in this activity will use the C111 Model found in the /data/C111 directory and the /labs/lab8\_RSMtoolbar directory.

### Exercise 8.2.1 Creating global monitors

10. In the top of the `$RSM/data/C111/run_c111_mse_SR5_sss.xml` file check to see that there is an **Entity** for the `c111_output.xml` file
11. Check for a reference for the file in the `<output>` block
12. Look in the `<entity>` block at the top of the XML to find the reference **&c111\_output**

The `<output>` block, an included entity, has been used to reference an external XML containing the output portion of the XML.

```
<output>
  &c111_output;
</output>
```


13. If not present, add the following global monitors to the `<output>` block:

```
<!-- output to netcdf file -->
  <globalmonitor attr="topo">
    <netcdf file="./output/SR5_sss/C111_PIR1_Alt2Db.nc">
</netcdf>
  </globalmonitor>
  <globalmonitor attr="head">
    <netcdf file="./output/SR5_sss/C111_PIR1_Alt2Db.nc">
</netcdf>
  </globalmonitor>
  <globalmonitor attr="segmenthead">
    <netcdf file="./output/SR5_sss/C111_PIR1_Alt2Db .nc">
</netcdf>
  </globalmonitor>
  <globalmonitor attr="olvector" >
    <netcdf file="./output/SR5_sss/C111_PIR1_Alt2Db.nc">
</netcdf>
  </globalmonitor>
```

14. Run the **C111 Model** using the RSM GUI to create the global variables

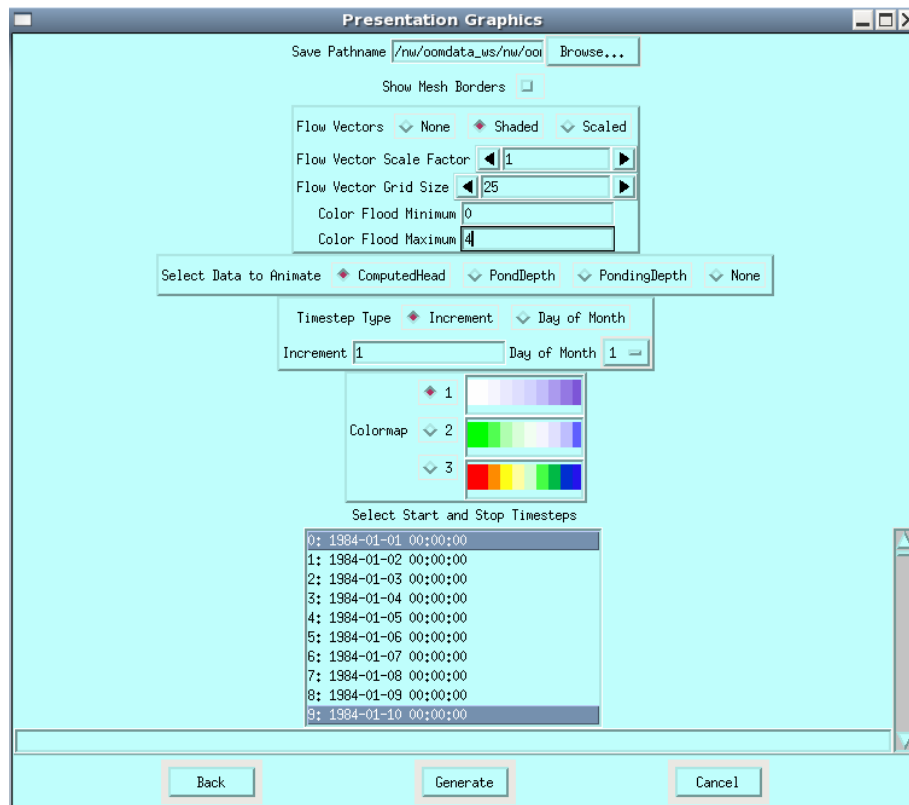
**Exercise 8.2.2 Creating a flow vector animation**

15. From the **Output Graphics** menu, select the **Presentation Graphics** Tool (see **Fig. 8.3**)
16. Input the **netCDF** filename:  
`$RSM/labs/lab8_RSMtoolbar/C111_PIR1_Alt2Db.nc`
17. Select **pathname** for output plots `$RSM/labs/lab8_RSMtoolbar`
18. Unselect **Show Mesh Borders**
19. Select **vector** and **flooding** options:
  - (shaded, scale=1, grid size=25, min=0, max=4)
20. Select **data to animate** = **ComputedHead**
21. Select **Timestep type=Increment**
  - Enter **Increment=1**
  - Select **Colormap=3** (1 is selected by default)
  - Select start and end **timesteps** (**start=0** timestep, **end=12th** timestep)

 **NOTE:** Click start and end dates with the left mouse button. There is a scroll bar on the right side of the window to scroll through more timesteps.

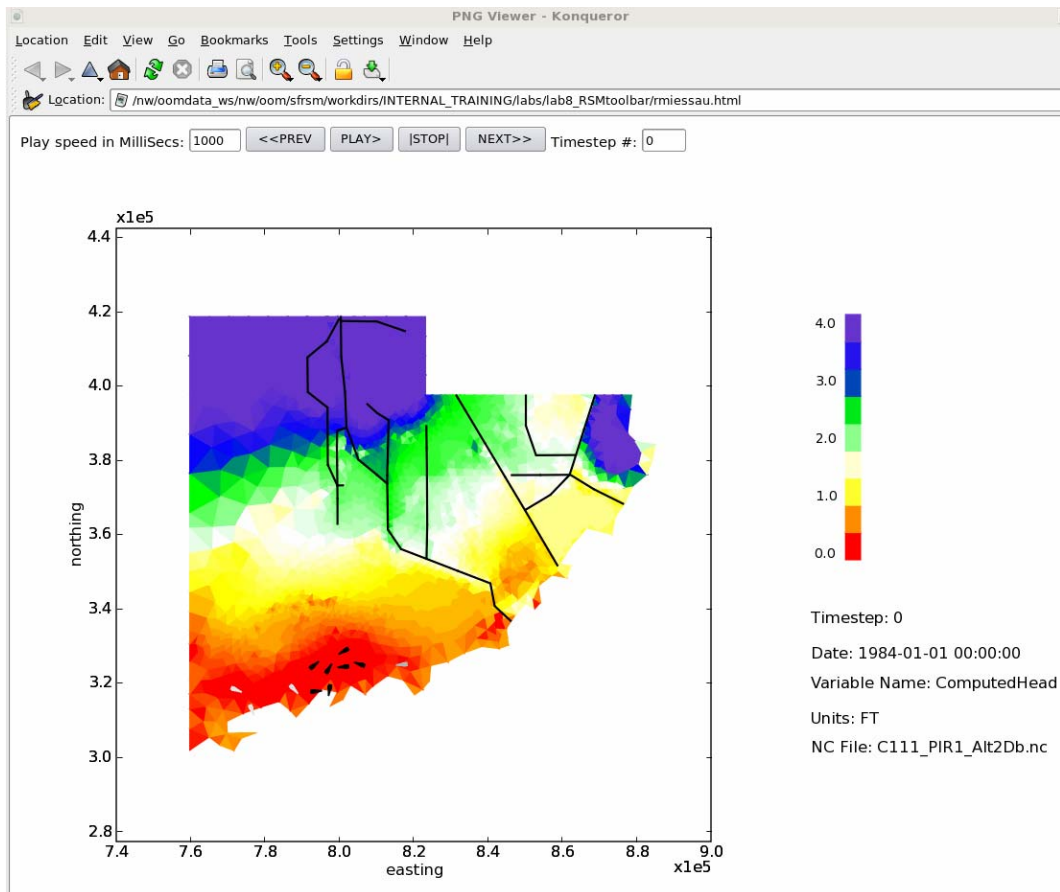
- Click the **Generate** button

Output results will take a minute or two and will open in a browser



**Figure 8.3** Presentation Graphics Tool Main Input Menu

Output from the **Presentation Graphics** Tool is presented in a browser window (**Fig. 8.4**). The animation can be started by clicking the **Play** button. Speed of the animation can be increased by entering a smaller number in the **Play Speed** box, shortening the time each frame is displayed on the screen. **Flow vectors** will be displayed as shaded arrowheads – darker arrowheads indicate greater flow rates.



**Figure 8.4** Browser window displaying computed heads and flow vectors



## Activity 8.3: Flowgages

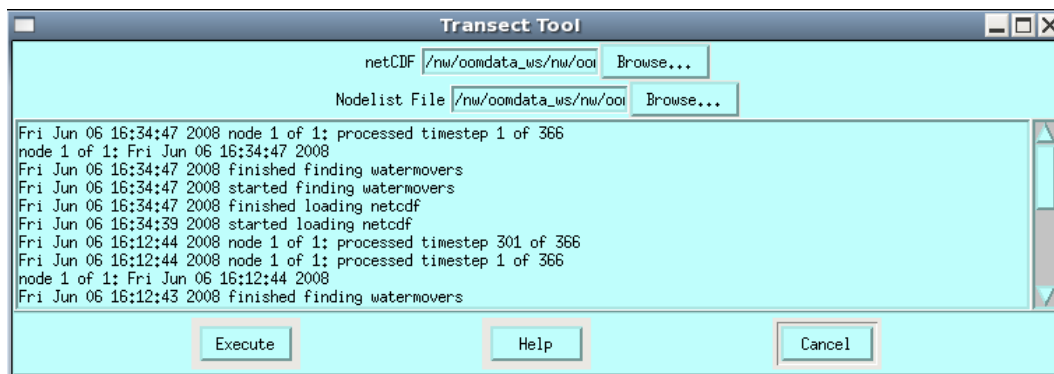
### Overview

**Activity 8.3** This activity includes one exercise:

- **Exercise 8.3.1** Use flowgages to view groundwater flows

This activity will investigate the use of flowgages, which are used to calculate the flow across a transect (**Fig 8.5**). This is useful for determining the volume of sheet flow across a marsh. Transects are represented by an ordered list of nodes defining the transect line. Output is directed to a DSS time series file.

Flowgages can be used to determine the groundwater flow as recharge or loss from a marsh.



**Figure 8.5** Main Interface for the Transect Tool

### Exercise 8.3.1 Use flowgages to view groundwater flows

22. In ArcMap9.2, open `$RSM/labs/lab8_RSMToolbar/lab8.mxd`
23. Locate **transect 23b** as defined by the list of nodes:  
(91 90 111 134 164 196 229 263 264 304 305 355 411 471 472 473 474 526 578 577)
24. **Select by Attribute** from the mesh layer: **[mesh\_Node1]=91**
25. Determine the order of the list of the nodes. The canal is assumed to be on the left side of the transect traveling in the direction the nodes are given.
26. Create a text file containing the list of nodes called **transect23b.txt** (see **Fig. 8.6**)
27. Open the RSM GUI
28. From the **View Model Results** menu, select the **Transect Tool**
29. From the `$RSM/labs/lab8` folder run the **Transect tool** using the following files and leaving other options with default values: **wbbudgetpackage\_C111\_SR5\_sss.nc** and **transect23b.txt**

```

<!-- Flow gauge 2x2 transect 23b -->
<flowgage section="ol" label="2x2 Transect 23b ">
  <nodelist> 91 90 111 134 164 196 229 263 264 304 305 355
             411 471 472 473 474 526 578 577 </nodelist>
  <dss file="./output/SR5_sss/transect_flows_2005Baseline.dss"
        pn="/C111/TRANSECT_TR-23B_OL/FLOW//1DAY/SR5_sss/"> </dss>
</flowgage>

```

```

<!-- Flow gauge transect for tidal model boundary -->
<flowgage section="ol" label="tidal boundary flow - 1991 to 1995 ">
  <nodelist> 1773 1754 1733 1732 1753 1730 1705 1681 1654 1623 1589
             1552 1514 1474 1430 1387 1341 1295 1245 1195 1244 1193 1139
             1085 1029 1028 972 914 854 793 791 730 674 618 560 506 443
             380 326 325 278 240 204 171 141 140 139 114 92 74 73 56 40
             29 20 12 7 14 21 13 11 6 3 2 </nodelist>
  <dss file="./output/SR5_sss/transect_flows_2005Baseline.dss"
        pn="/C111/TRANSECT_TR-TIDE_OL/FLOW//1DAY/SR5_sss/"> </dss>
</flowgage>

```

**Figure 8.6** Example text files with lists of nodes comprising transects.

The **Transect Tool** will produce four reports summarizing flow across a transect, formatted as: **raw data**, **daily** (Fig. 8.7), **monthly** and **annual**.

30. View the flowgage time series using **HEC-DSSVue** (Fig. 8.8)

- Open the file `transect_flows_2005Baseline.dss` and look for transect 23b.

transect\_report\_daily.dat - /tmp/rmiessau\_transect\_1212784487/

File Edit Search Preferences Shell Macro Windows Help

Daily Transect Report,  
RSM GUI: Transect Tool,  
06/06/2008,

The list of nodes is = [91 90 111 134 164 196 229 263 264 304 305 355 411 471 472 473 474 526 578 577]  
Wall [(90 89)(89 110)(110 133)(133 163)(163 195)(195 228)(228 262)(262 263)(263 303)(303 304)(304 354)(354 303)(303 111)(111 90)(90 89)]  
Watermovers ["GW 1050-1162" "GW 1054-1055" "GW 140-177" "GW 175-176" "GW 217-218" "GW 268-269" "GW 326-327"]  
Timeperiod: 01/01/1984 00:00:00 - 12/31/1984 00:00:00,

DATE	DarcyCircle	ManningCircle	TOTAL
01/01/1984,	10198008,44922,	0,00000,	10198008,44922
01/02/1984,	10774336,17188,	0,00000,	10774336,17188
01/03/1984,	9763878,31250,	9214,14258,	9773092,45508
01/04/1984,	9509259,57812,	15693,88281,	9524953,46094
01/05/1984,	9478030,96875,	28204,57275,	9506235,54150
01/06/1984,	9522567,67188,	39418,67908,	9561986,35095
01/07/1984,	9522823,15625,	50257,54346,	9573080,69971
01/08/1984,	9543567,90625,	60710,22095,	9604278,12720
01/09/1984,	9558666,53125,	71692,10498,	9630358,63623
01/10/1984,	9570253,62500,	83183,64258,	9653437,26758
01/11/1984,	9504725,43750,	109132,92285,	9613858,36035
01/12/1984,	9459424,50000,	136979,87305,	9596404,37305
01/13/1984,	9425431,65625,	149262,02148,	9574693,67773
01/14/1984,	9370289,92188,	182515,70435,	9552805,62622
01/15/1984,	9325886,92188,	196680,22607,	9522567,14795
01/16/1984,	9270151,82812,	209983,10107,	9480134,92920
01/17/1984,	9228692,76562,	219610,13281,	9448302,89844
01/18/1984,	9196182,09375,	226417,65381,	9422599,74756
01/19/1984,	9159184,89062,	232237,80762,	9391422,69824
01/20/1984,	9112584,95312,	232831,31128,	9345416,26440
01/21/1984,	9100700,17188,	232211,79907,	9332911,97095
01/22/1984,	9021924,56250,	239863,87329,	9261788,43579
01/23/1984,	8930044,92188,	252058,32446,	9182103,24634
01/24/1984,	8870782,26562,	245915,26721,	9116697,53284
01/25/1984,	8779509,78125,	248754,49817,	9028264,27942

Figure 8.7 Part of the Transect Tool's Daily Transect Report

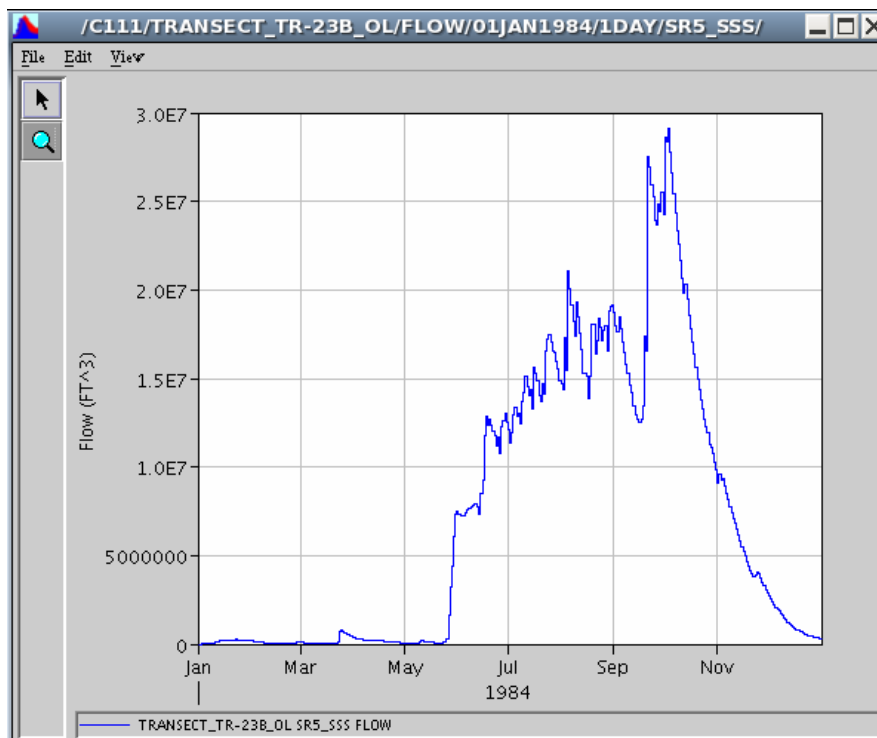


Figure 8.8 Typical output from a transect flowgage

## Activity 8.4: RSM Plots, Statistics and Other Output

### Overview

**Activity 8.4** This activity includes two exercises:

- **Exercise 8.4.1** Review and plot calibration statistics
- **Exercise 8.4.2** Review spatial data maps and Inundation Tool

The objective of this activity is to produce the plots and statistics used to interpret the efficacy of model calibration at selected locations (**Fig. 8.9**). The RSM is calibrated using PEST to minimize the root mean squared error (RMSE) and Bias. PEST will be covered in detail in training modules 13 and 14.

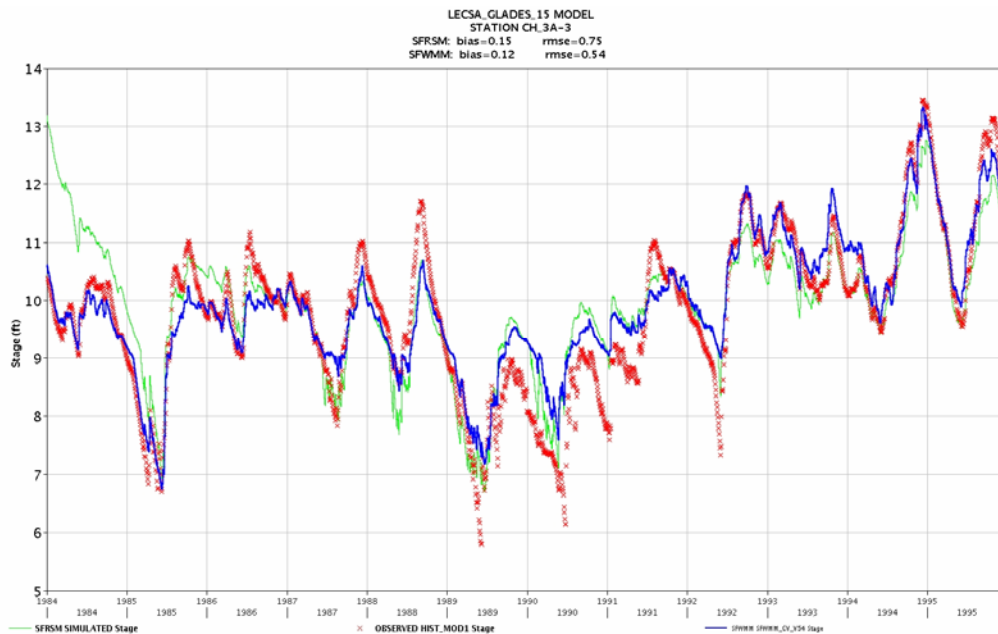
Other statistics, mean squared error and Nash-Sutcliffe efficiency coefficient are also calculated using RSM output. It is useful to review the plots of the simulated versus observed stage or flow time series as well as the calibration statistics. There are two Python scripts for processing the simulated and observed data in DSS file format:

```
./bin/makePlots.py ./bin/fetch-calib.ctl
./bin/calcStats.py ./bin/fetch-calib.ctl
```

The **fetch-calib.ctl** file contains the location of the files that contain the simulated, historical observed and South Florida Water Management Model (SFWMM) values along with a list of the individual stations and their DSS tags (**Fig. 8.9**). A typical output from the makePlots script is presented in **Fig. 8.10**.

```
file ./output/meas_submodel.dss
./input/all_canal_historical.dss
./input/2x2_simulated_all.dss
run CH_EVER1 /SFRSM/EVER1/STAGE//1DAY/COMPUTED/
/SFWMM/EVER1/STAGE//1DAY/HIST_MOD1/
/SFWMM/EVER1/STAGE//1DAY/SIMULATED/
run CH_EVER2B /SFRSM/EVER2B/STAGE//1DAY/COMPUTED/
/SFWMM/EVER2B/STAGE//1DAY/HIST_MOD1/
/SFWMM/EVER2B/STAGE//1DAY/SIMULATED/
...
```

**Figure 8.9** The **fetch-calib.ctl** file containing locations of files with simulated, historical observed, and SFWMM values.



**Figure 8.10** Typical output from makePlots.py showing simulated and observed time series and associated bias and mean squared error.

### Exercise 8.4.1 Review and plot calibration statistics

31. Calculate statistics using a command line Python script.

- Go to the `$RSM/data/BBCW/bbcw` directory
- Run script:

```
/opt/local/share2/bin/dssvue ./bin/calcStats.py
./bin/fetch_calib.ctl
```

- Open output file and view results, bias and RMSE for each time series.

32. Create plots using a command line Python script

- Go to the `$RSM/data/BBCW/pest`
- Run script:

```
/opt/local/share2/bin/dssvue ./bin/makePlots.py
./bin/fetch_calib.ctl
```

- Open **Plots** directory and view graphs

33. Create plots and statistics using the RSM GUI:

- Go to the `$RSM\data\BBCW` directory
- Start the RSM GUI: from the command line type, **RSMGUI**
- From the **Output Graphics** menu, select **DSS stage/flow Plots** (see Fig. 8.11)
- Provide a **Control** file to run the **DSS stage/flow tool** (see Fig. 8.12)

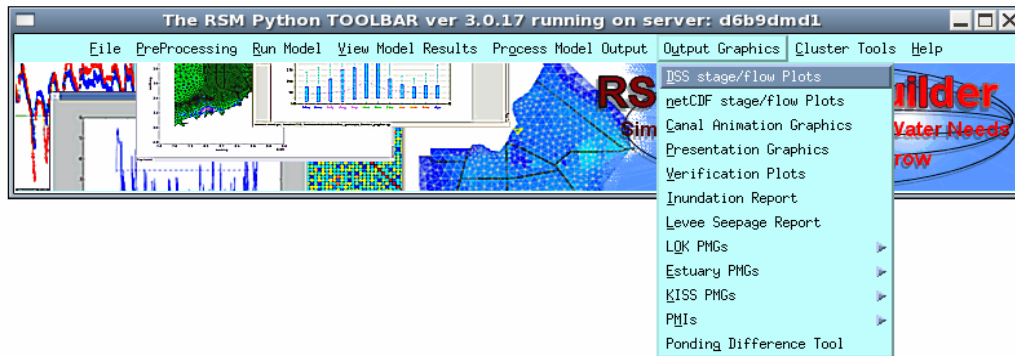


Figure 8.11 Selecting the DSS stage/flow plots.

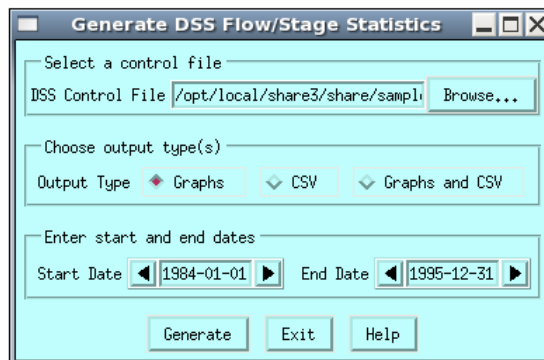


Figure 8.12 Input options menu for the DSS stage/flow tool.

You can use any text editor to create the control file. The first line of the control file contains the path/filename of two or three DSS files. Typically, this is used to show the simulation, corresponding historical data, and results from a different model simulation. The second line contains the DSS path corresponding to the gage being reported for each of the files listed in line 1.

For this example, compare three files. On the first line of the control file, enter the following three DSS path/filenames on one line, in this same order:

- Pick **output DSS** file:  
`./Final_Results_BBW16_sens1/output/bbw_output.dss`
- Pick **historical data**:  
`./input/dss_files/all_bbw_historical.dss`
- Pick **another model's output**:  
`./input/dss_files/sfwmm_cv_v54_gages_lecsaglades.dss`



On the second line of the control file, enter the DSS paths to the CH\_EVER4 data sets being compared:

- **Output** gage:            /BBW/EVER4/STAGE//1DAY/COMPUTED
- **Historical** gage:       /SFWMM/EVER4/STAGE//1DAY/HIST\_MOD1
- **SFWMM** gage:           /C111TIDAL/EVER4\_R8C25/STAGE//1DAY/SFWMM\_CV\_V54

Create this control file (name it ch\_ever4.ctl) and save it to the directory:

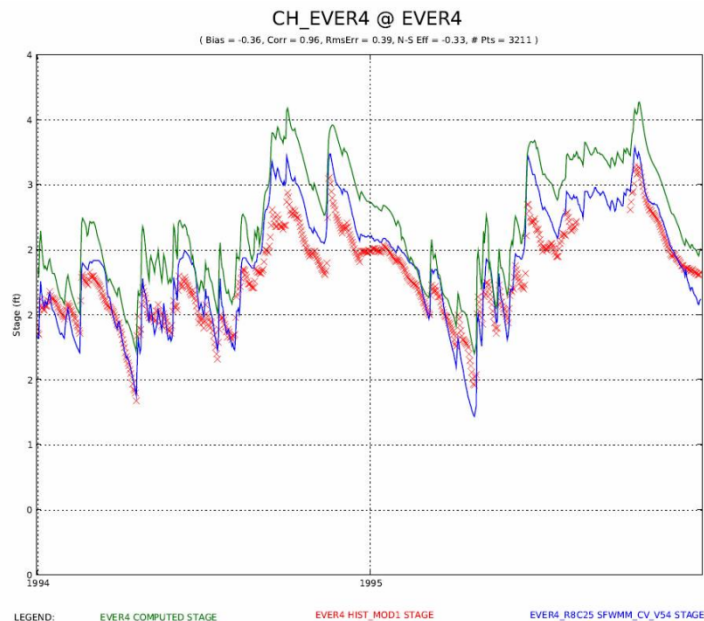
```
$RSM/data/BBCW/Final_Results_BBW16_sens1
```

Use this control file (see Fig.8.13) to test the DSS stage/flow tool.

```
file ./output/bbw_output.dss
./input/dss_files/all_bbw_historical.dss
./input/dss_files/sfwmm_cv_v54_gages_lecsaglades.dss
run CH_EVER4 /BBW/EVER4/STAGE//1DAY/COMPUTED/
/SFWMM/EVER4/STAGE//1DAY/HIST_MOD1/
/C111TIDAL/EVER4_R8C25/STAGE//1DAY/SFWMM_CV_V54
```

**Figure 8.13** The ch\_ever4.ctl file containing locations of files with simulated and historical values, plus results from another model.

The resulting graph is shown in Fig.8.14.



**Figure 8.14** Output from the DSS Stage/Flow Plots tool, showing stages at gage CH\_EVER4.



**HINT**

The **HELP** button on the RSM Python Toolbar offers an example and help for running the tool.

**Exercise 8.4.2 Other RSM output: spatial data maps and Inundation tool**

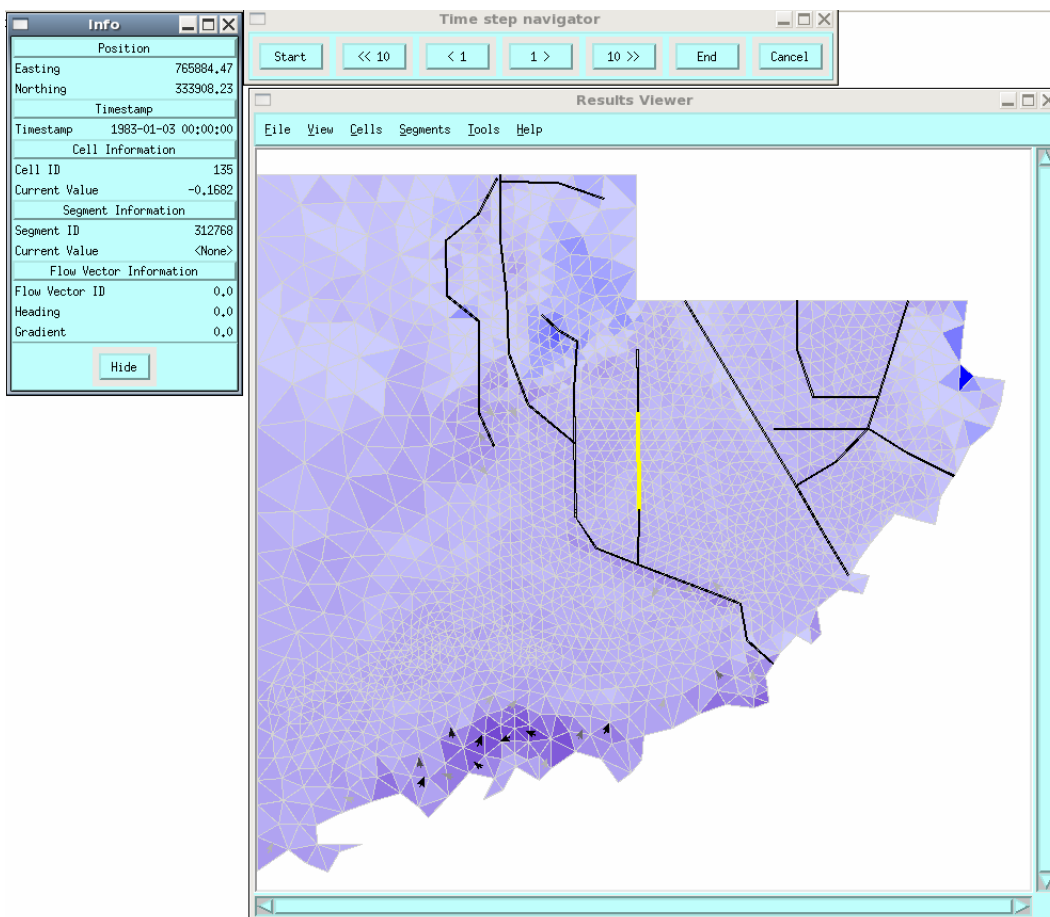
For this exercise, work in the **Lab8\_RSMTtoolbar** folder.

34. Start the RSM GUI

35. View results from `/lab8_RSMTtoolbar/C111_PIR1_Alt2Db.nc` in the

**ResultsViewer**

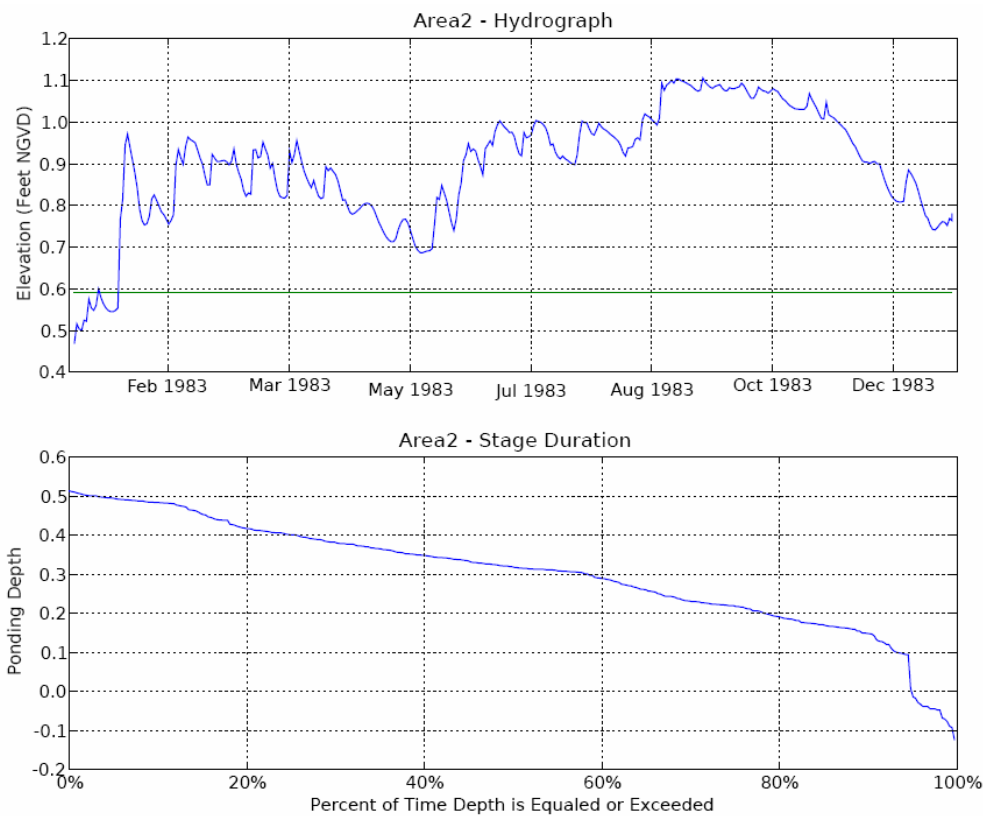
- From the **Cells** drop-down menu in the **ResultsViewer**, select “**Cell Colorflood**” and then choose **PondingDepth** to **colorflood** the display
- Use the “**Look Up Range**” feature to auto select the range for the **ponding depth**
- Leave other defaults as they are. Click the **OK** button
- Using the **TimestepNavigator**, advance to the **3rd timestep: (1983-01-03)**
- Under the **File** drop-down menu, **Export a PNG** of the view and save it in your own directory



**Figure 8.15** RSM animation Cell Colorflood map using Results Viewer

36. Run the **Inundation Report Tool**. The Inundation ReportTool calculates a stage-duration graph.

- Under the **Output Graphics** Menu on the RSM GUI, select the **Inundation Report Tool**
- From inside the **lab8\_RSMtoolbar** folder, select **c111\_calib.nc**
- From the inundation subfolder, select **obs\_cells.csv** and **landuse.csv** files as input for running the Inundation tool
- Make sure Jan 1, 1983 is set as start dates and Dec 31, 1983 is set for all end dates. Click the **Generate Report** button to run the tool
- View the ascii report file, quit, do not save it, and then the PDF graphic will be displayed.
- Save the **Adobe PDF** output file to your **lab8\_RSMtoolbar** folder and call it **inundation.pdf** (see Fig. 8.16)

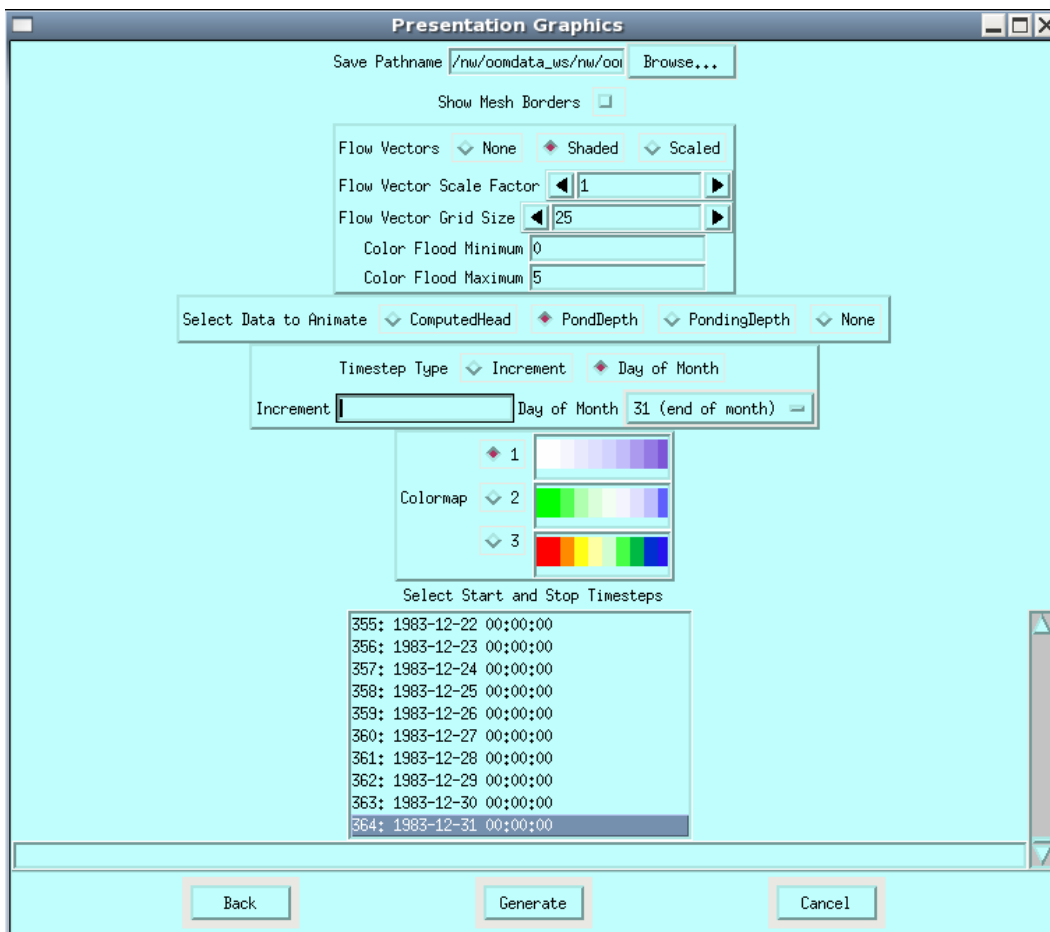


**Figure 8.16** Output from the Inundation Report Tool

37. Run **Vector Flow Animation**

- Under the **Output Graphics** Menu, start the **Presentation Graphics** Tool. The first menu will prompt you to browse to a NetCDF file and there is an option to include a flow vector type. The flow vector output must exist in the NetCDF file. Browse to the **lab8\_RSMtoolbar** folder and select the **C111\_PIR1\_Alt2Db.nc** file
- In the Settings menu, select **None** as the **Vector Choice** and click **Next**

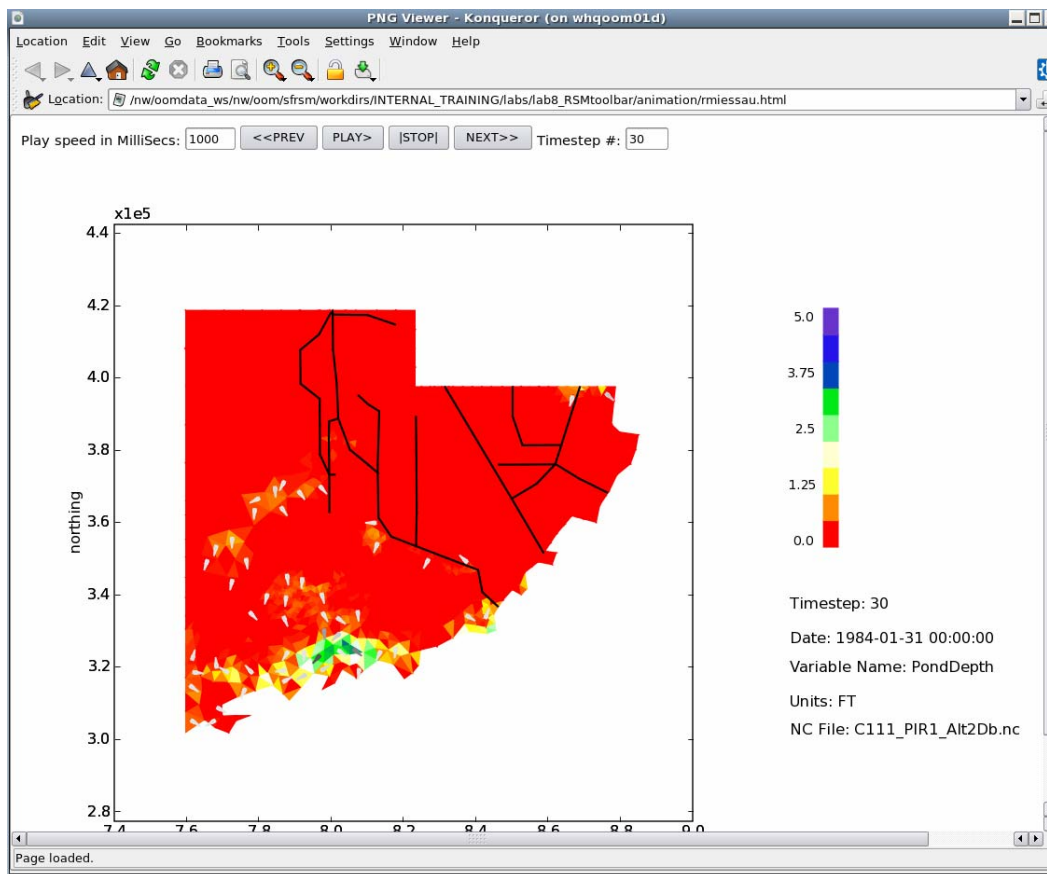
- The next menu will appear (see **Fig. 8.17**), offering several settings to create the animation. The first item is to browse to a folder where your output will be saved.
- Make the following additional menu choices:
  - Show Mesh Border: Uncheck box
  - Flow Vectors: Check box for **None**
  - Flow Vector Scale Factor: Enter **1**
  - Flow Vector Grid Size: Enter **25**
  - Color Flood Minimum: Enter **0**
  - Color Flood Maximum: Enter **5**
  - Select Data to Animate: Check box for **PondDepth**
  - Timestep Type: Check box for **Day of Month**
  - Day of Month: Select **31** (end of month) from dropdown menu
  - Color Ramp: Check box for **Color Ramp 3**
- Using the left mouse button, select the first timestep on **1983-01-01** and then scroll down to the last timestep on **1983-12-31** and select using the left mouse button.
- Click the **Generate** button to generate the animation



**Figure 8.17** Menu for **Presentation Graphics** tool

Output from this tool will display the animation viewer in a browser (**Fig. 8.18**).

- Click the **Play** button to start the animation



**Figure 8.18** Output from RSM GUI Presentation Graphics Tool





## Answers for Lab 8

### *Exercise 8.1.1*

38. three attributes output from each HPM

- water content
- water supply
- runoff

differences in irrigation volume for different HPMs

- Spring Rice seepage irrigation volume is steady, but in relatively small amounts compared to the other crops. Fall rice is similar but with two large flooding cycles before the fall season.
- Citrus is irrigated periodically (nearly biweekly), with relatively large amounts of water.
- Spring tomatoes have smaller weekly irrigations. Fall tomatoes also seem to follow this pattern.
- Sugar uses a small amount of water

differences in runoff volume for different HPMs

- Generally, most runoff (excess water) occurs in late summer. Also, runoff is generally more sporadic (less steady) than irrigation, and comes in pulses. Rice and citrus have the highest runoff rates of the crops analyzed.

### *Exercise 8.1.2*

Compare results with those in the **lab8\_RSMtoolbar** directory

### *Exercise 8.2.1*

Compare results with those in the **lab8\_RSMtoolbar** directory

### *Exercise 8.2.2*

Compare results with those in the **lab8\_RSMtoolbar** directory

### *Exercise 8.3.1*

Compare results with those in the **lab8\_RSMtoolbar** directory

### *Exercise 8.4.1*

Compare results with those in the **lab8\_RSMtoolbar** directory

### *Exercise 8.4.2*

Compare results with those in the **lab8\_RSMtoolbar** directory



## Index

- AFSIRS, see also HPM ..... 67
- animation 27, 36, 37, 47, 59, 60, 61, 68, 69, 70, 80
- ArcGIS ..... 6
- ArcMap ..... 71
- attribute ..... 15, 26, 28, 29, 60, 63, 64, 83
- basin ..... 64
- BBCW, see also Biscayne Bay Coastal Wetlands ..... 62, 75, 76, 77
- benchmark ..... 62, 65, 66
- BM33 ..... 64, 66
- BM33 output ..... 67
- bias ..... 46, 75
- C111 model . 20, 32, 33, 35, 39, 42, 44, 52, 62, 68, 69, 71, 72, 78, 79
- calcStats.py ..... 74, 75
- calibration ..... 50, 60, 61, 74, 75
- statistics ..... 61, 74, 75
- canal ..... 6, 54
- network ..... 24
- segment ..... 26
- canal, see also WCD ..... 24, 26, 71, 74
- cell
- heads ..... 64
- cell, see also mesh .. 13, 14, 24, 26, 27, 28, 29, 32, 33, 36, 43, 51, 60, 64, 66, 67, 78, 79
- cellmonitor, see also monitor 13, 14, 63, 64
- citrus ..... 64, 67, 83
- coefficient ..... 74
- Color Flood Maximum ..... 80
- Color Flood Minimum ..... 80
- Color Ramp ..... 80
- Colormap= ..... 69
- condensed report ..... 65
- conductivity, see also hydraulic
- conductivity ..... 4, 11
- control ..... 27, 37, 46, 47, 50, 76, 77
- file ..... 46, 50, 76, 77
- conveyance ..... 11
- CSV ..... 46, 52, 63
- data processing utilities ..... 63
- data to animate = ComputedHead ..... 69
- datasets ..... 46, 77
- Day of Month ..... 80
- default values ..... 71
- Depth transform ..... 65
- DSS stage/flow tool ..... 76, 77
- DSS time series file ..... 71
- DSSVue ..... 63, 64, 72, 75
- duration ..... 21, 51, 60
- entity ..... 68
- environment variable ..... 62
- ET ..... 63
- file format
- ASCII ..... 33, 36, 42, 43, 63
- binary ..... 60
- DSS .4, 46, 50, 63, 64, 71, 72, 74, 76, 77
- NetCDF ..... 23, 24, 28, 32, 33, 35, 36, 39, 42, 43, 44, 47, 52, 59, 60, 63, 66, 68, 69, 79
- PDF ..... 79
- XML ..... 5, 20, 52, 68
- flood ..... 26, 27, 37, 69, 83
- flow ... 25, 27, 29, 37, 39, 46, 47, 59, 60, 61, 63, 68, 69, 70, 72, 77, 79, 80
- flow rate ..... 70
- flowgage ..... 61, 63, 71, 72
- time series ..... 72
- framework ..... 54
- gage ..... 76, 77
- Generate button ..... 69, 80
- generate the animation ..... 80
- geodatabase ..... 4, 8
- GMS ..... 4, 7
- groundwater ..... 61, 71
- flow ..... 61, 71
- head ..... 63, 64, 68
- HELP button ..... 77
- HINT ..... 77
- historical data ..... 4, 46, 50, 74, 76, 77
- how to
- calculate statistics using a command line
- Python script ..... 75
- calculate the flow across a transect .... 71
- calculate water budgets ..... 64, 66
- convert feet to inches ..... 65
- create a water budget ..... 64
- create global variables ..... 68
- create head monitors for a cell ..... 64
- create plots using a command line
- Python script ..... 75

determine the groundwater flow as recharge or loss from a marsh.....	71	mean squared error.....	74, 75
determine the volume of sheet flow across a marsh.....	71	mesh .....	6, 7, 24, 26, 27, 32, 36, 37, 39, 71
display an animation .....	81	node.....	39, 63, 71, 72
display the animation viewer in a browser.....	81	minimize the root mean squared error (RMSE) and Bias .....	74
Export a PNG.....	78	model input, see input data .....	4
format a report to summarize all (raw) data .....	65	model output, see output data .	3, 8, 23, 27, 31, 32, 41, 42, 43, 60, 66
process model output.....	41, 60, 64, 65	model parameters .....	5
produce calibration plots and statistics	74	monitor .....	8, 11, 56, 61, 63, 68
use command line post-processing utility for calculating water budgets.....	64	basinmonitor .....	63
HPM .....	28, 62, 63, 64, 66, 83	bcmonitor .....	63
afsirs citrus.....	64, 67	global .....	61, 63, 68
hub.....	28	HPM.....	63, 64
rain.....	63	impoundment.....	63
water budget .....	62, 66	watermover.....	63
HSE .....	21, 63	WCU .....	63
Hydrologic Process Module, see also HPM .....	64, 66	Month format option .....	65
Hydrologic Simulation Engine, see also HSE .....	20, 63	multiplier option .....	44, 65
impoundment.....	64	Multiply the output .....	65
Increment= .....	69	Nash-Sutcliffe efficiency .....	74
Index Tool.....	36	network.....	2, 54
inflow .....	63	note .....	2, 24, 28, 32, 36, 62, 69
inflow/outflows .....	63	observation file, see also rsmpest.obf .....	4
input for running the Inundation tool .....	79	OL .....	72
inundation.....	51, 79	olvector.....	63, 68
Inundation Tool.....	61, 74, 78	output	
irrigation volume .....	64, 83	from RSMGUI .....	70
irrigation, see also HPM .....	64, 67, 83	output data2, 3, 4, 5, 6, 7, 8, 12, 14, 15, 21, 26, 33, 36, 37, 38, 39, 42, 43, 44, 46, 47, 49, 52, 61, 63, 64, 65, 66, 67, 68, 69, 72, 74, 75, 76, 77, 78, 79, 80, 83	
Julian date conversion.....	44, 65	computed heads .....	70
junctionmonitor .....	63	DSS .....	76
lake.....	64	flow vectors.....	25, 27, 29, 37, 47, 70, 80
lakemonitor, see also monitor.....	63	spatial data and animations .....	68
landuse .....	51, 79	water budget...28, 39, 42, 44, 52, 59, 60, 61, 63, 64, 65, 66, 67, 71	
levdrytosegflow.....	63	output elements.....	63
levee.....	52	Output Graphics menu .....	69, 76
levee seepage, see also seepage .....	52	overbank flow .....	63
Linux.....	2, 10, 42, 60	parameter.....	4, 5
Look Up Range.....	29, 78	PEST .....	27, 60, 74
Main Interface for the Transect Tool.....	71	plot ...35, 46, 50, 59, 60, 61, 69, 74, 75, 76, 77	
main XML file.....	63	ponding .....	26, 29, 37, 47, 78
make, see makefile.....	1, 21, 36	post-processing features .....	61
makePlots.py, see also Python.....	74, 75	post-processing water budgets .....	63

Presentation Graphics Tool .	47, 49, 60, 69, 79, 80, 81	Select by Attribute from the mesh layer..	71
ps_et.....	63	Select Data to Animate.....	80
public water supply, see also pws .....	4, 15	setenv.....	62
pws .....	15, 16	SFRSM.....	74
Python .....	6, 7, 74, 77	SFWMM .....	46, 50, 74, 77
rainfall.....	62, 63	Show Mesh Border.....	69, 80
raw data.....	72	simulated versus observed stage or flow	74
recharge .....	64	South Florida Water Management Model,	
DSS file.....	64	see also SFWMM .....	46, 50, 74
reference		spatial data maps .....	61, 74, 78
HSE User Manual .....	63	Speed of the animation .....	70
reference ET, see also ET .....	63	stage .....	47, 50, 51, 60, 76, 79
Regional Simulation Model, see also RSM		stage/flow .....	76
.....	1, 2, 6, 61, 63	stage-duration graph .....	79
residual.....	44	start the animation.....	81
ResultsViewer.....	78	statistics .....	20, 46, 60, 74, 76
RMSE .....	75	structure .....	6, 54
RSM		switches .....	66
animation .....	78	template .....	7
geodatabase .....	7	text file.....	36, 71, 72
implementation.....	60	time series.....	33, 36, 47, 63, 74, 75
RSM GUI .	1, 2, 3, 5, 6, 7, 9, 20, 21, 42, 43, 44, 56, 57, 61, 63, 64, 65, 68, 71, 76, 78, 79, 81	state values .....	63
GIS ToolBar .....	6, 7, 8, 23, 36, 57	time step.....	24, 26, 27, 29, 30, 37, 44, 47, 69, 78, 80
toolbar .....	6, 59, 60, 76	TimestepNavigator .....	78
RSM, see also Regional Simulation Model		to colorflood the display.....	78
1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 20, 21, 23, 32,		Toolbar .....	6, 7, 8, 57, 77
33, 35, 36, 39, 42, 44, 46, 47, 50, 51, 52,		topo, see topography.....	63, 68
56, 57, 60, 61, 62, 63, 64, 65, 66, 68, 69,		totalvector.....	63
71, 74, 75, 76, 77, 78, 79, 81		transect .....	39, 40, 63, 71, 72, 73
Run benchmark .....	64	transect line.....	71
Run Model Tool .....	59, 60	transect tool.....	39, 40, 71, 72, 73
run WBBUD .....	65	Typical output from a transect flowgage.	73
run3x3.xml.....	64, 66	Typical output from makePlots.py showing	
runoff .....	64, 83	simulated and observed time series and	
sbflow .....	63	associated .....	75
scale .....	47, 69	typical output from the makePlots script.	74
script.....	75	unsat, see HPM	
seepage.....	52, 83	unsat.....	64
segment		utilities .....	1, 44, 59, 60, 64, 65, 66
head.....	60	vector .....	27, 37, 47, 59, 61, 68, 69, 79
monitor .....	63	Vector Choice.....	79
segmenthead .....	63, 68	view graphs .....	75
segment, see also waterbody		View Model Results.....	22, 31, 71
segment .....	26, 29, 60, 64	view results .....	75
Select by Attribute .....	71	volume.....	44, 64, 65, 66, 83
		water balance .....	63
		water content.....	83

water supply ..... 15, 83  
waterbody .... 24, 25, 28, 29, 33, 34, 35, 43,  
44, 60, 63, 64, 65  
watermover..... 63

WCD  
    monitor..... 63  
WCD, see also Water Control District .... 64  
well..... 61, 74