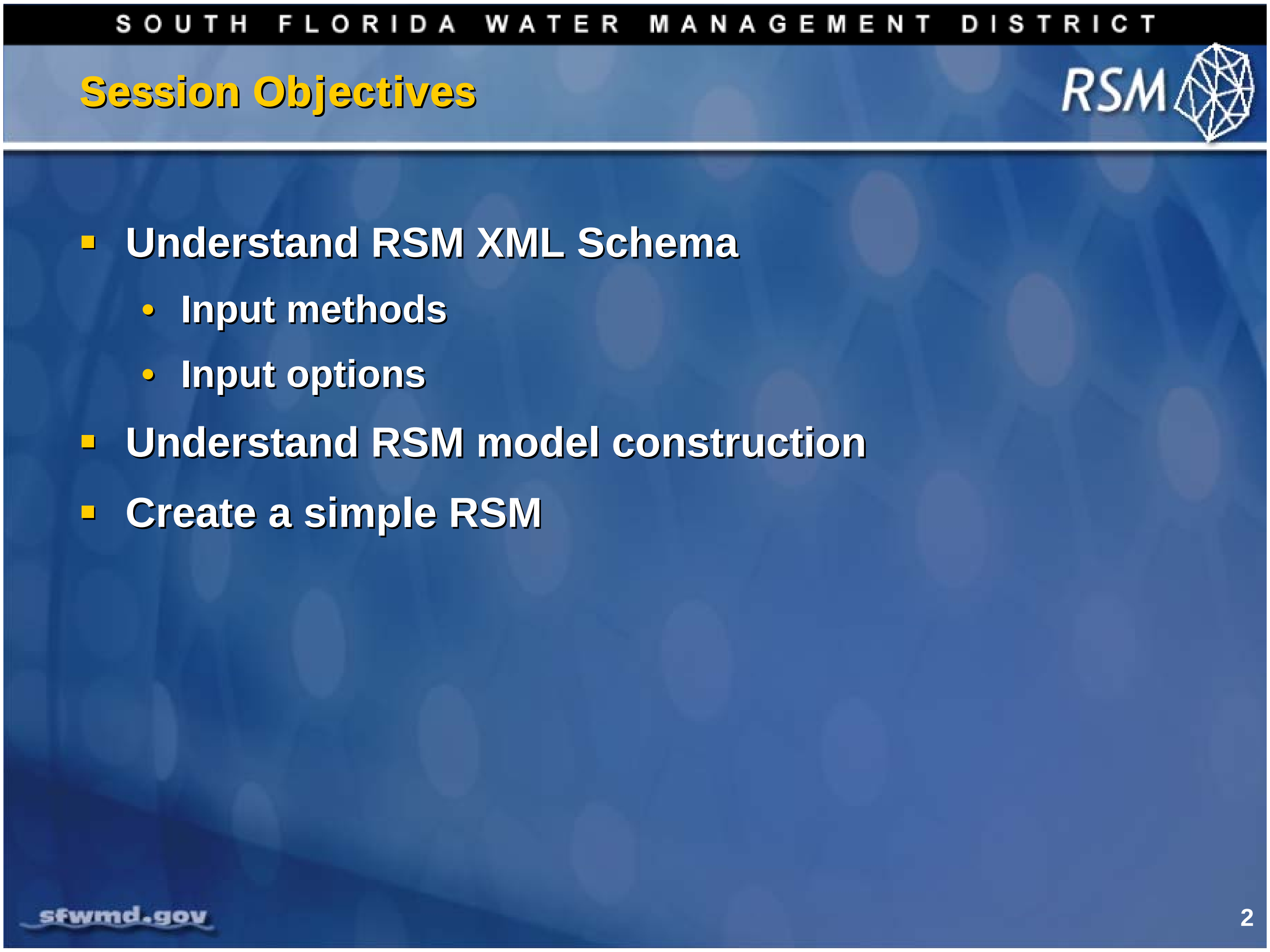
Lecture 3: RSM Meshes and Networks

As with many simulation models, the best method for learning how the model works is to build a model. This lecture describes how a simple Regional Simulation Model (RSM) implementation is built.

NOTE:

Additional Resources

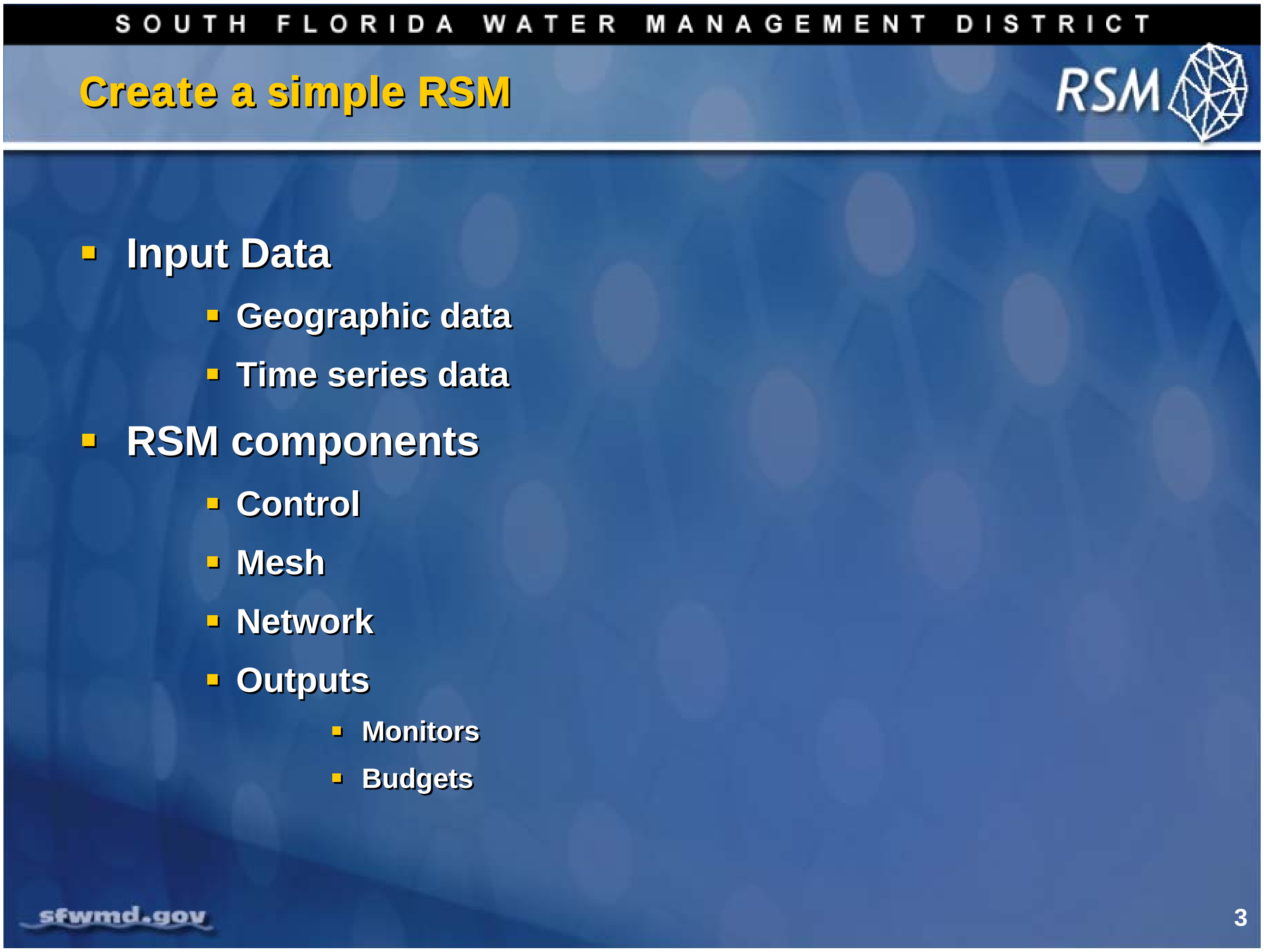
The HSE User Manual can be found in the labs/lab4_complete_RSM directory.

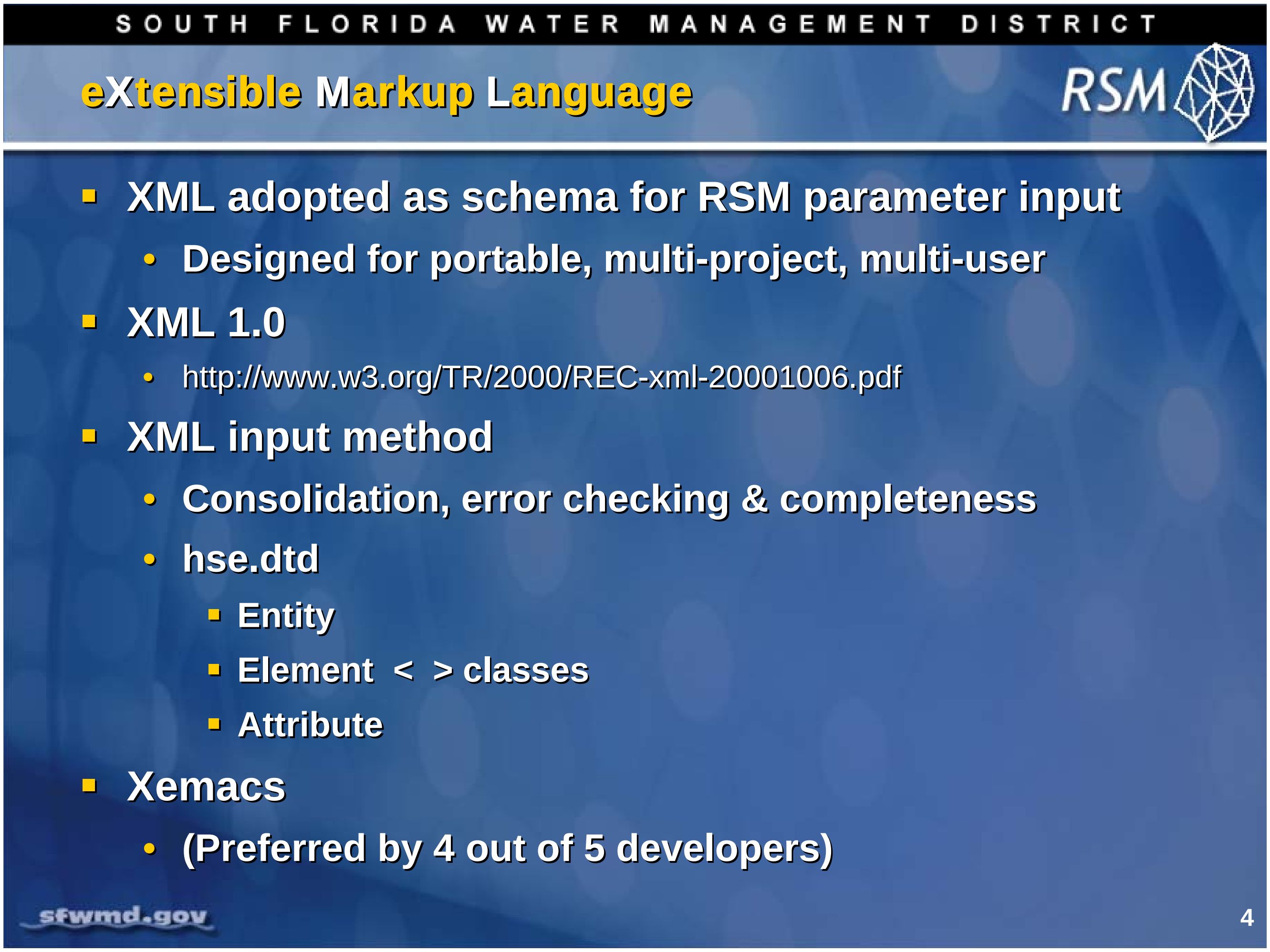


Session Objectives

1. To review how the Hydrologic Environmental Systems Modeling (HESM) team uses the XML schema for organizing the RSM input and the advantages that the XML schema provides
2. To discuss content of the XML schema
3. To review the full XML input of typical RSM implementations by reviewing the content of several subregional models

The subregional models show how we use the different functions available in the RSM to simulate the hydrology and water management; water supply (WS) and flood control (FC) of south Florida. Although the functions have been presented in the benchmarks and the HSE User Manual, actual implementations of the functions are the best place to see and understand how the functions work, what are typical ranges for the parameters, how the functions relate to other RSM components and how the model performs i.e., output. In this module we review five different subregional implementations. The key files of those subregional models are located in the $RSM/data directory in your installation.


SOUTH FLORIDA WATER MANAGEMENT DISTRICT
Create a simple RSM
RSM
Input Data
Geographic data
Time series data
RSM components
Control
Mesh
Network
Outputs
Monitors
Budgets
sfwmd.gov
3



The XML schema was adopted by the South Florida Water Management District's (SFWMD) HESM to organize the different kinds of data required by the different functions in the RSM. The schema provide the structure and syntax for inputting the data in a form that is readable.

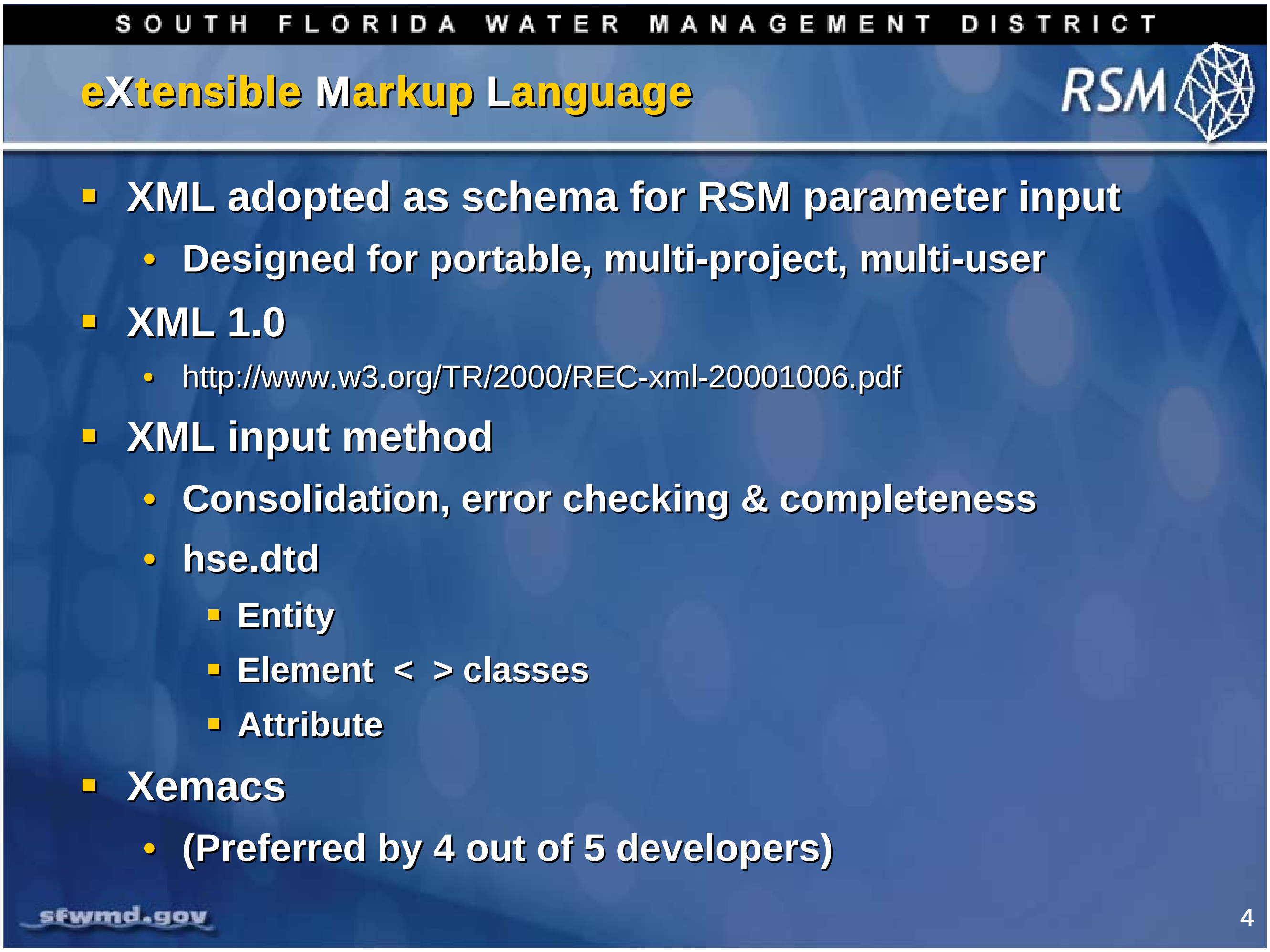
The XML schema provides the organization and the error checking. However, the error checking has not been thoroughly implemented. As long as the parameters are provided and they are the correct type, they will not cause an error. But they may not work.

For example, "ol_gw" is the correct parameter value. Entering the term "ol/gw" will not cause a crash but it will not implement the function. This is another reason why it is important to build the RSM implementations in steps, as reviewed in Module 2.

There are several editors available in Linux for editing the input XML files. The 'xemacs' editor has the advantage of interpreting the hse.dtd file and providing prompts for allowable elements.

The XML schema is portable, and can be edited and maintained by multiple users. It is in ASCII format, so it is easy to maintain.

The HESM has only implemented the basic components of the XML schema.



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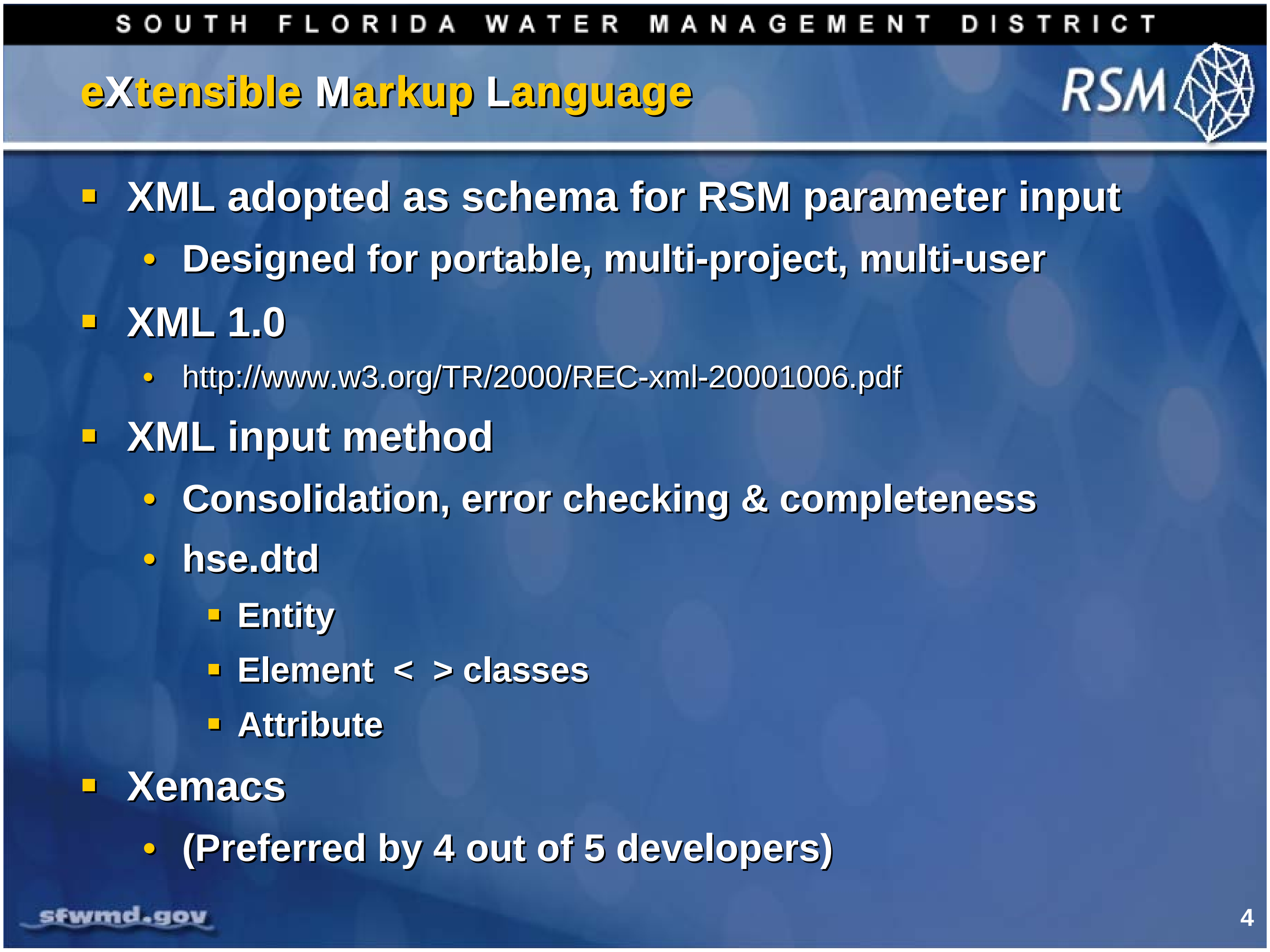
XML supports error checking and completeness. It provides the capability for input consolidation, which means the XML input file can be divided up into several different files that contain the necessary elements and attributes necessary for specific functions. This keeps individual files from becoming too large and allows the user to edit only those files the user needs to edit.

The three components of the XML schema that are used in the RSM include the Entity, Element and Attribute:

1. The Entity tag allows for the inclusion of external files into the main XML file.
2. The Element tag, which is closely associated with classes defined within the RSM source code, is the primary tag used in the RSM input.
3. The Attribute tag is used to provide the input parameters for the Elements. The actual syntax for the input files is found in the hse.dtd file.



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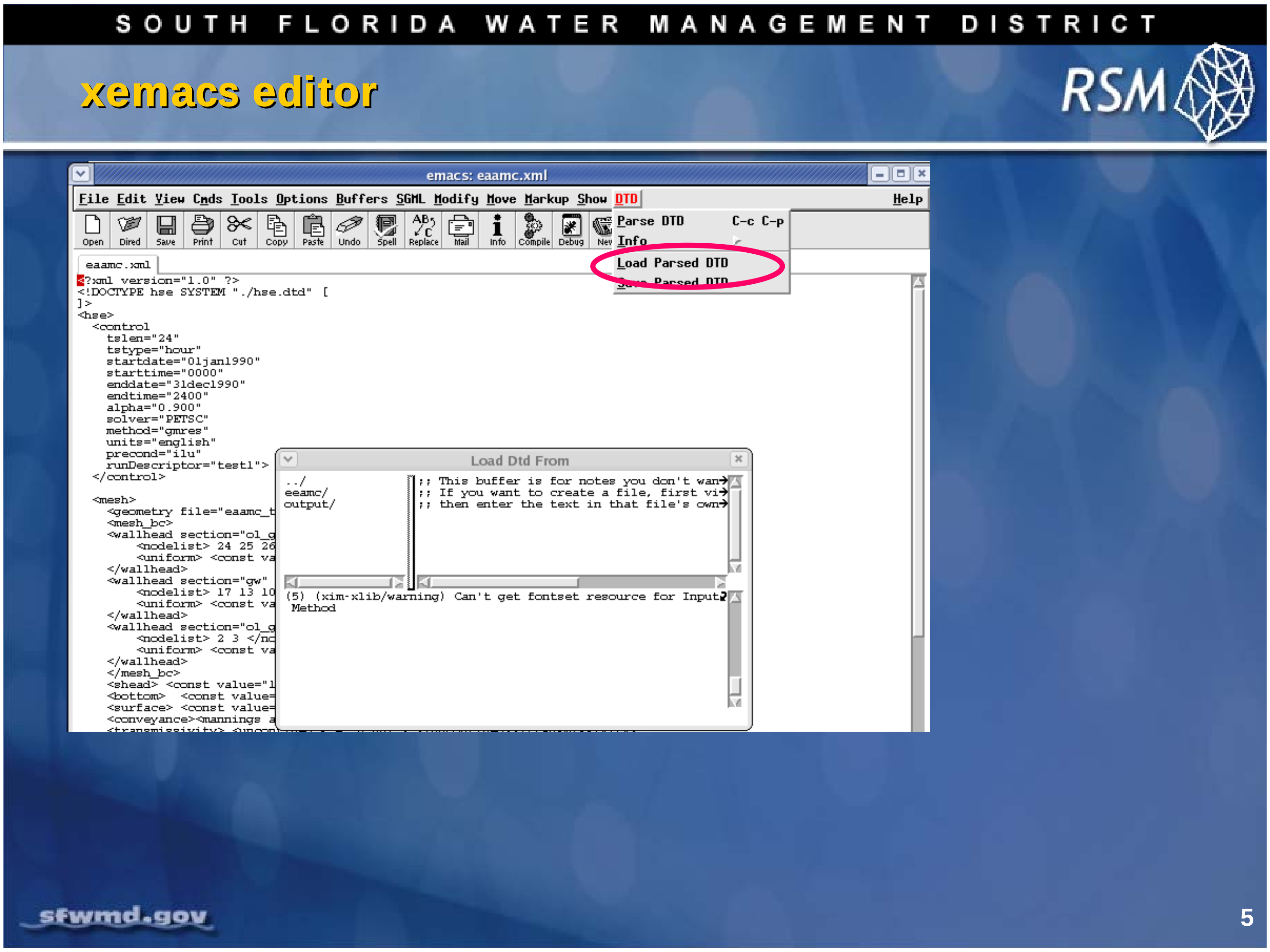
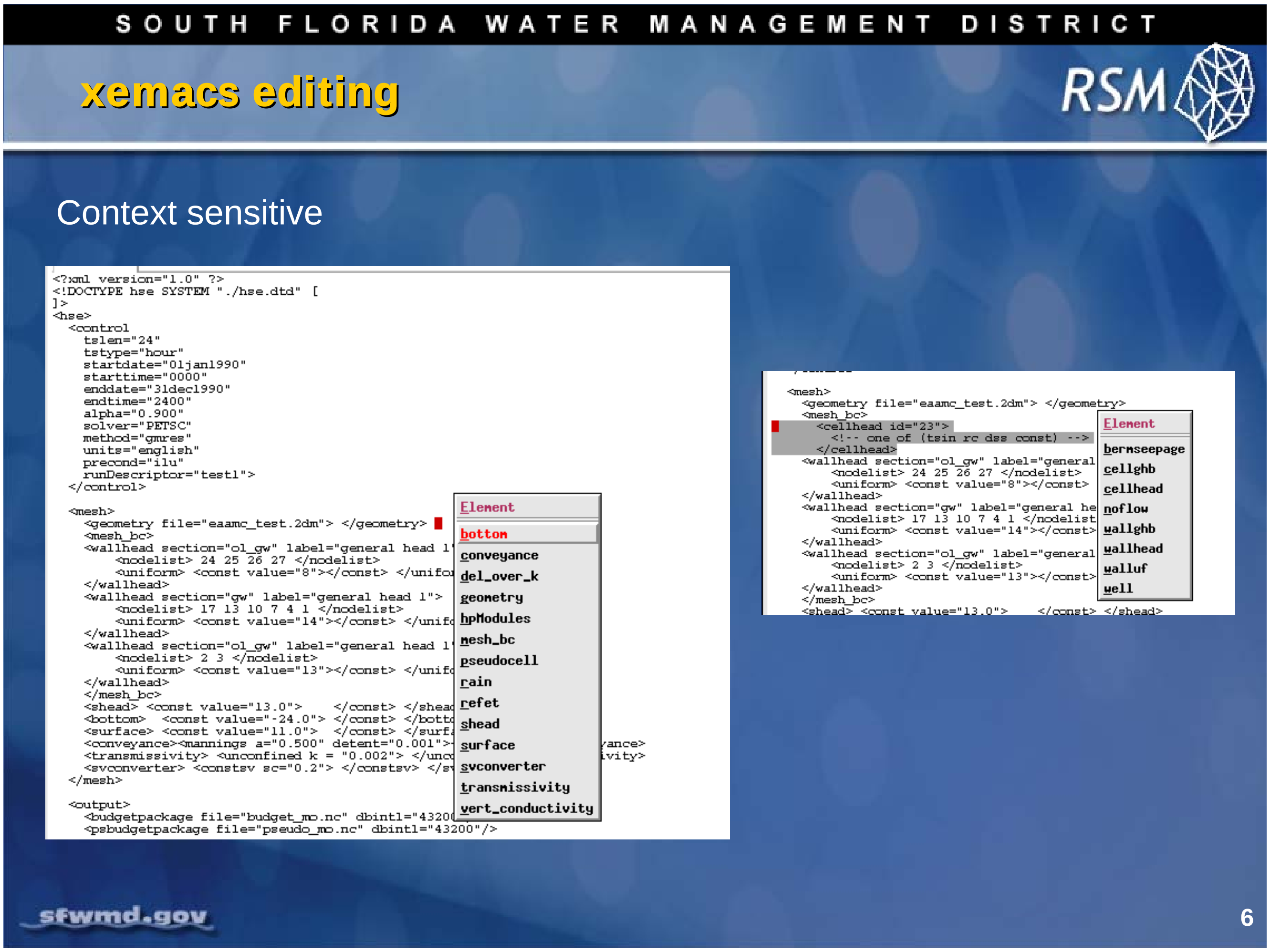
The hse.dtd file defines the allowable syntax for the input XML file. This file is created when the current version of the source code is checked out from the SVN repository, and only applies to that version of the source code. The hse.dtd file is found in the trunk/benchmarks directory while the executable HSE file is found in the /trunk/src directory. A frequent error occurs when the wrong hse.dtd file is used with the wrong executable version of HSE (when the HSE file is copied to the working directory but the hse.dtd file is not).

"Xemacs" is a useful Linux editor. In addition to being a highly functional editor, it has the capability of loading a parsed hse.dtd file when an XML file is opened. When this occurs a right-click of the mouse will highlight the allowable elements, or attributes, at each point in the XML file. If the cursor is placed within the mesh block only the legal mesh elements will be selectable. Once the appropriate element is selected, the appropriate attributes will be requested.

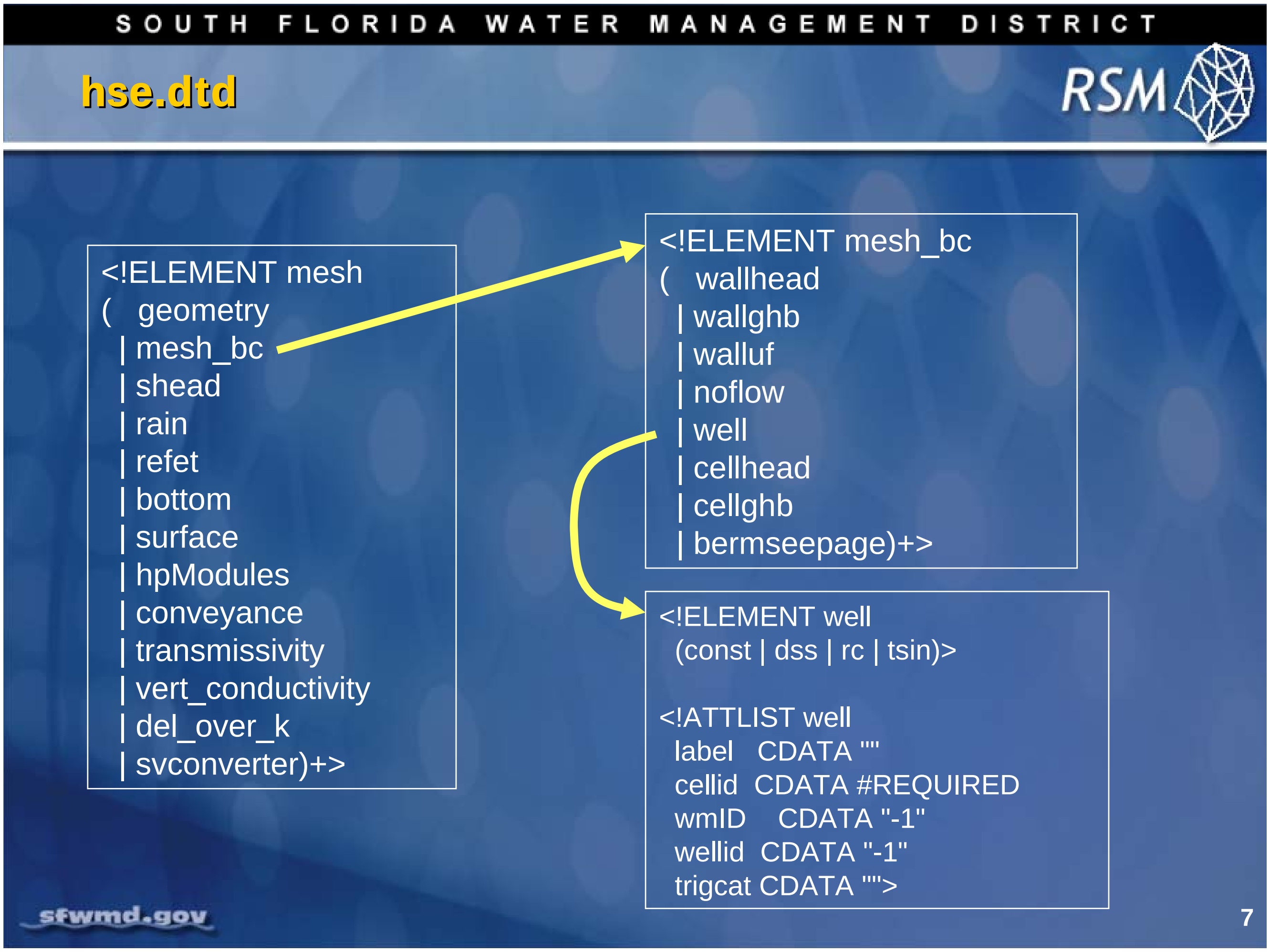
The attribute selection is complete for some, but not all, elements. This use of xemacs is good for checking the completeness of your RSM program.



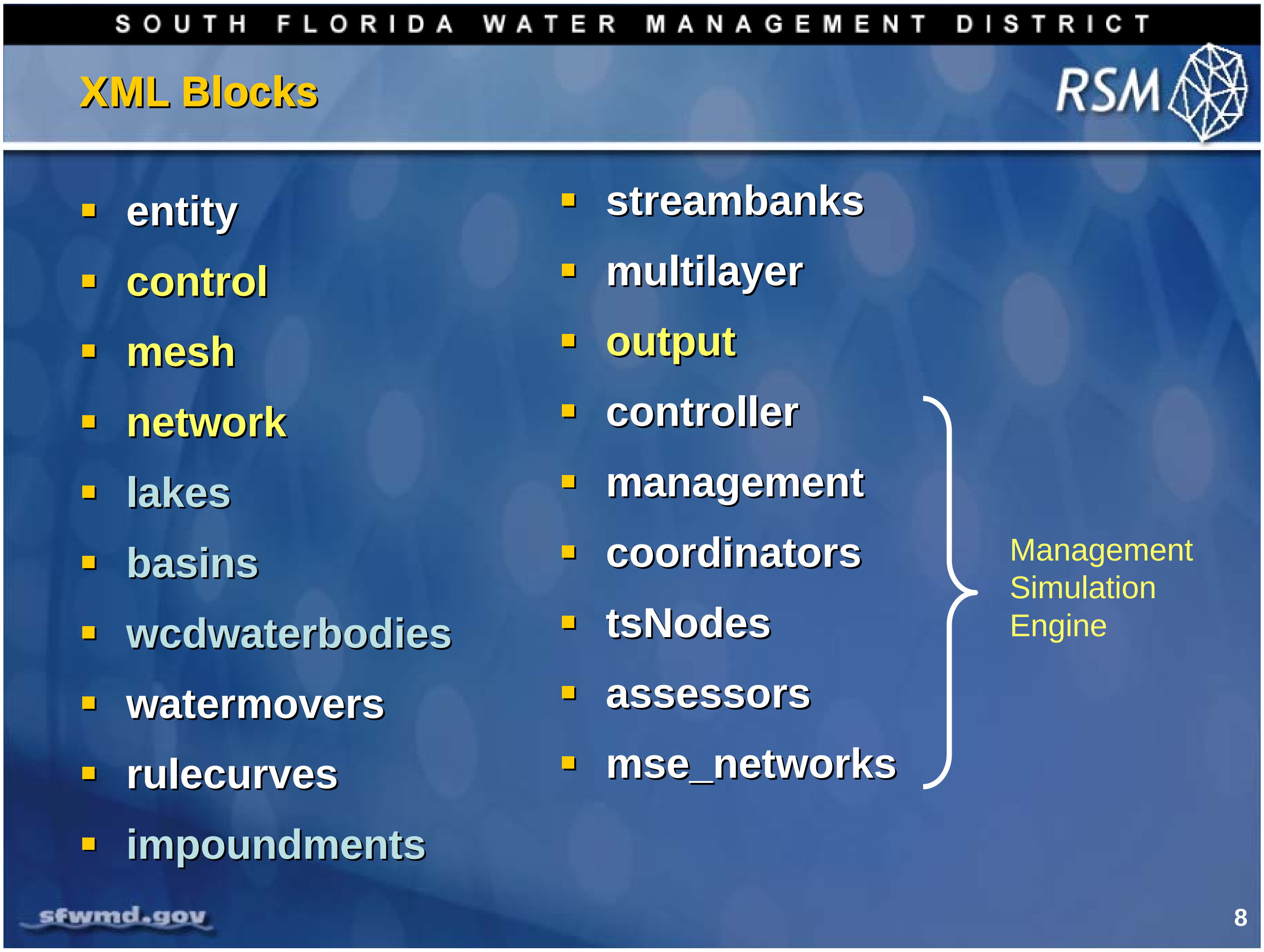
When xemacs is selected, the appropriate hse.dtd file can be parsed. This capability is available in other editors.



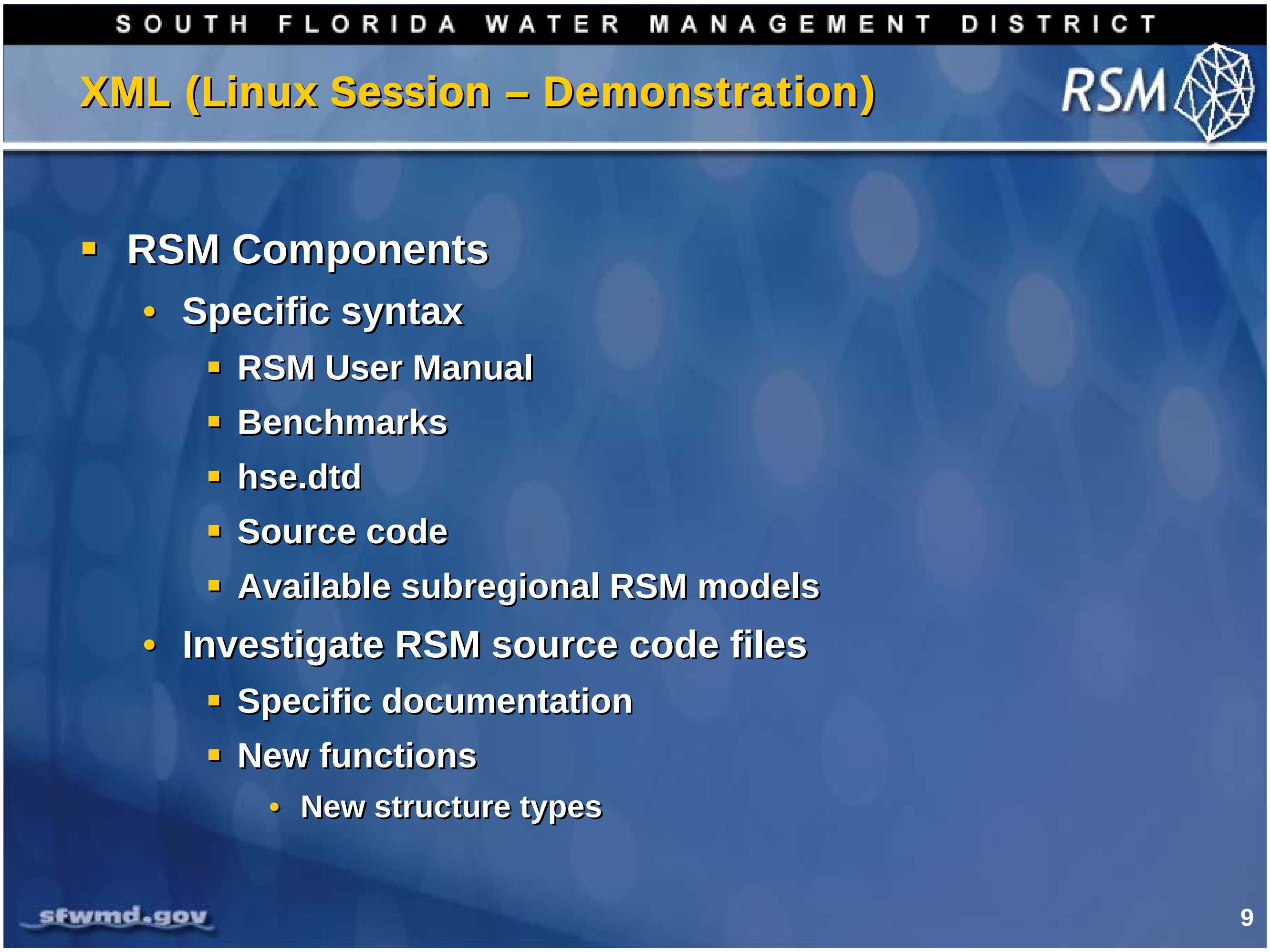
An advantage of the xemacs editor is that it is context sensitive. Once the hse.dtd file is parsed, a right-click on the mouse will produce the allowable options. After selecting an element, xemacs will prompt the user for the required data and display the available options.



The hse.dtd file contains the schema for the RSM. This is the structure of the input blocks, elements and attributes within the hse.dtd. In this example, <mesh_bc> is an element of <mesh> block and <well> is an element of <mesh_bc>. The <well> requires input attribute data in the form of a constant flow, periodic rulecurve, or a time series. A cellid is required to apply the well values to the model. The other attributes are optional, but are useful for creating monitors to produce output from the model.



There are currently 19 possible blocks of input XML data in an RSM implementation. The yellow blocks make up the core components of the HSE. Additional waterbodies (blue) may be added as these features are required. The multilayer block includes the components necessary to implement a 3D version of the RSM. Additional blocks are used to provide input for the Management Simulation Engine.



There are five sources for finding the specific syntax of an RSM function:

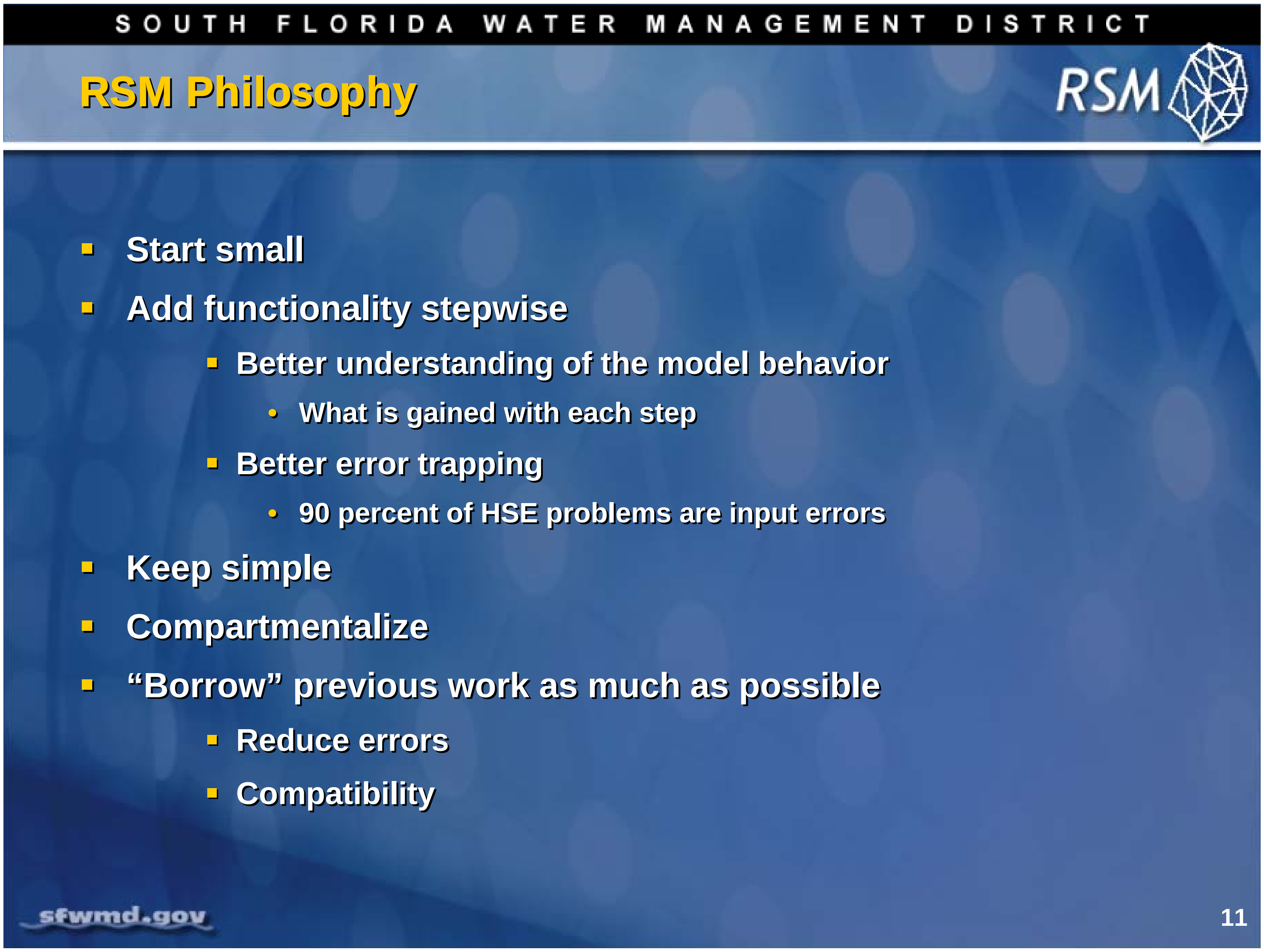
- The HSE User Manual (which has the basic documentation)
- The benchmarks (which have the basic implementation)
- The hse.dtd (which has the most current list of attributes, default values and tags)
- The source code (which has the specific attribute usage and spelling)*
- The existing subregional model implementations (which have working versions of the code which show the actual implementation of each function with appropriate parameter values).

* Although the written documentation should be accurate, there are typographical errors in the documentation. The source code is exactly what the RSM uses. The source code, which contains documentation, is the primary location for authoritative information. Become familiar with the source code because as new functions are periodically added to the model, attributes may change slightly.

For a thorough review of the XML syntax, review the XML parsing source code files found in the “/trunk/src” directory. These files contain the code for parsing the XML file and populating the mode parameters.

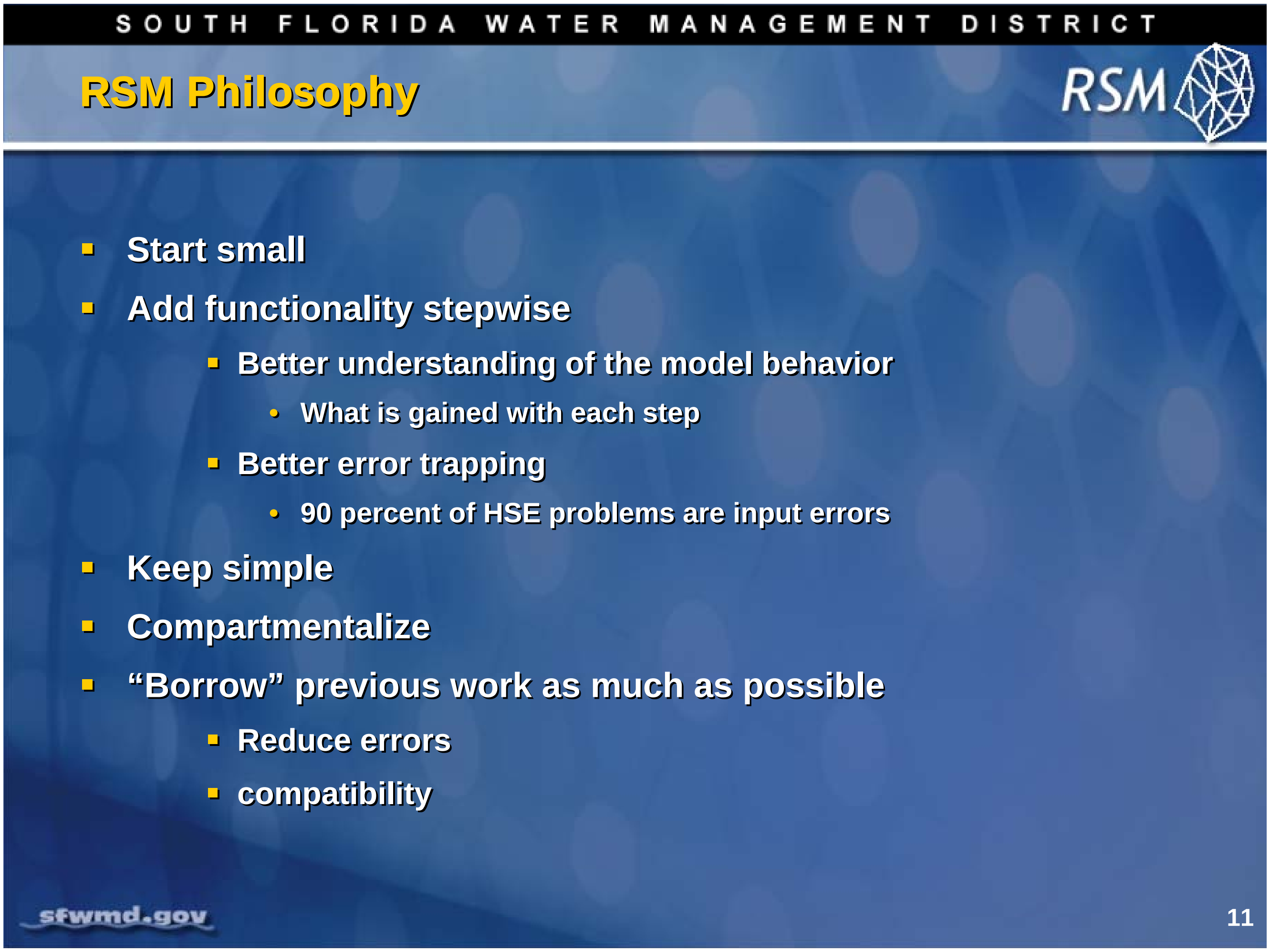
The RSM model was developed using components of the Extreme Programming (XP) methodology. In this methodology, functionality is added to the model as it is needed and the success of the model is built on continued testing of the source code using benchmarks and testbeds. Although there is an overall architecture for the RSM, it has not been built following a detailed design. As a result, the best documentation of the RSM is in the source code.

The source code can be accessed best using the Unix (and Linux) “grep” command. Grep can be used to search all of the source code files (*.cc) to find the variables or element of interest. The –n switch provides the line number within each file.



Start Simple: The RSM development philosophy is to start small and build stepwise. It is important to start small and verify that the model simulates the primary processes correctly. This requires a good conceptualization of the water management system to be simulated as well as the performance measures (PMs)* that the model results are expected to achieve. Model conceptualization includes deciding density of the mesh and the network, which structures to simulate, and which structures to use as internal boundary conditions where historical data are available, and the level of detail to be simulated in the local hydrology.

* Performance measures are model outputs that are used to evaluate alternative water resources management policies or projects. Properly developed PMs have estimates of uncertainty and target values.



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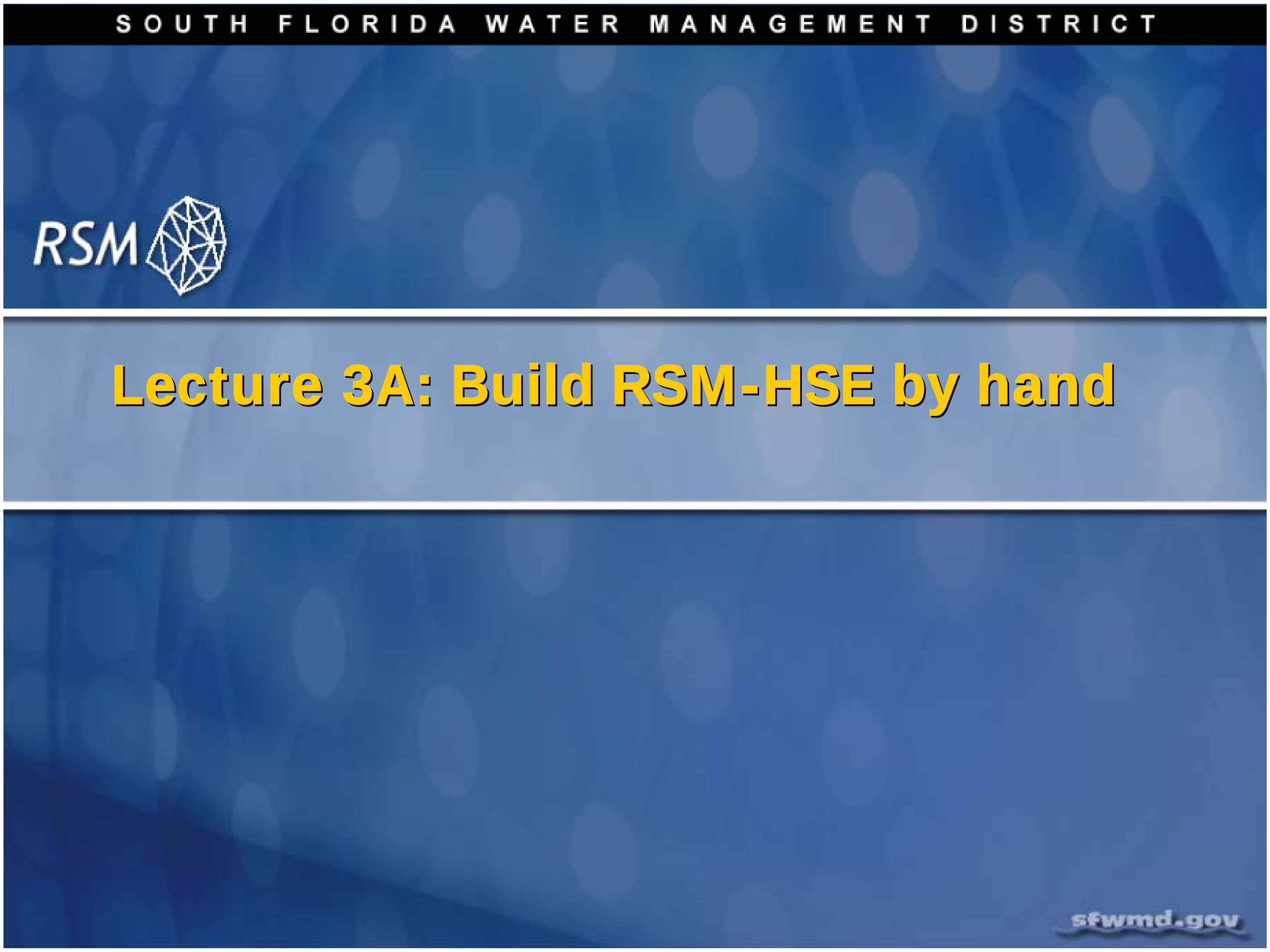
Stepwise development:

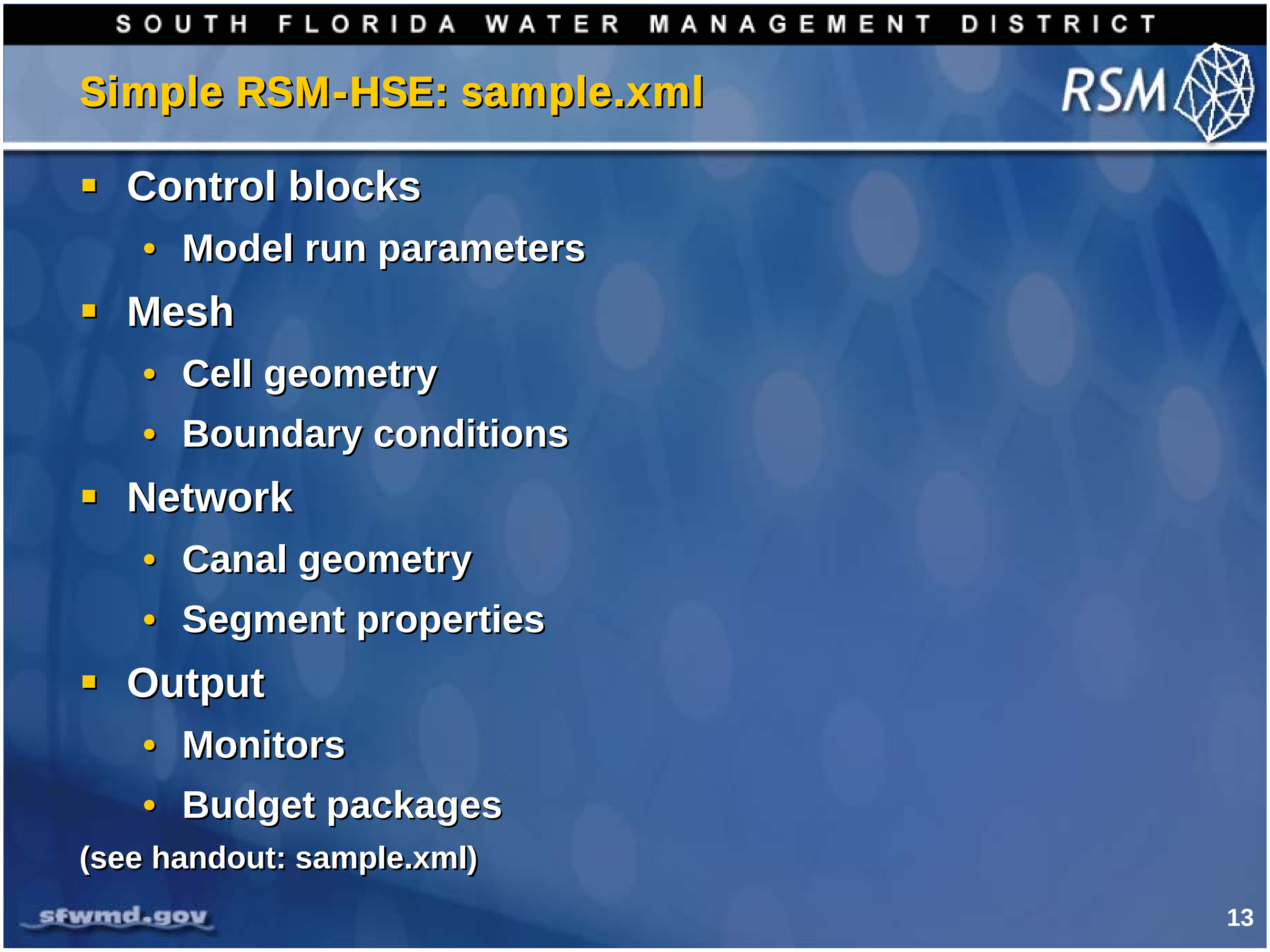
It is possible to build a simple RSM implementation and add complexity as necessary, which is a key difference with this model. After adding additional functions, the results can be compared to previous runs to determine if there has been an improvement in the performance measures.

It is tempting to create a complete RSM implementation on the first attempt, but experience has taught us that this will likely fail due to typographical errors in the input or incorrect application of the model functions. Errors in the input data files, either typographical errors or incorrect values, are difficult to identify. The XML schema can be used to check syntax, but it does not check input values. Future versions may do this.

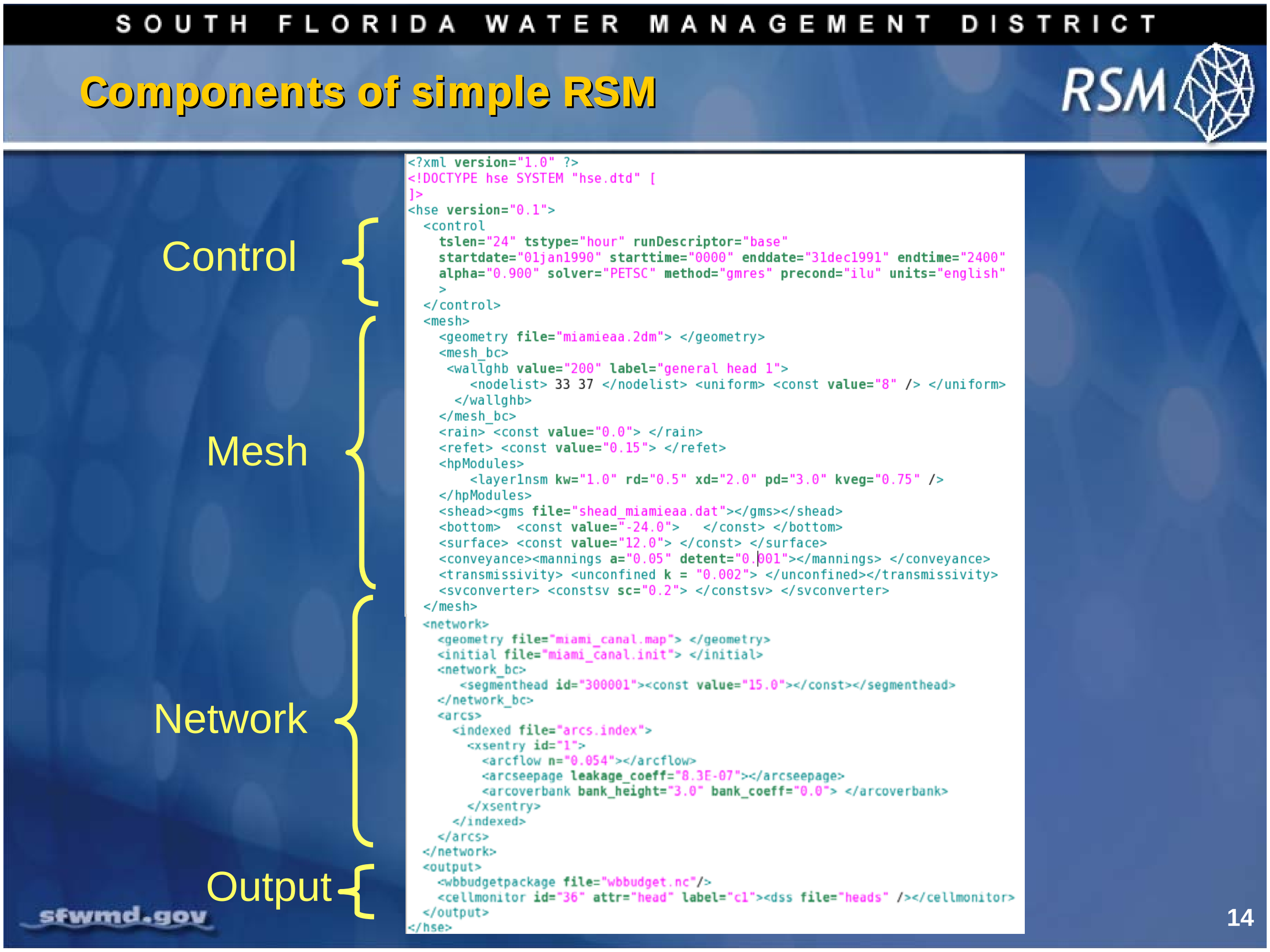
Additions of incorrect or inappropriate structures are more difficult to identify. The appropriateness of each addition can be evaluated on an individual basis. This approach will capture errors in the function implementations.



Manually building a simple RSM application is one of the best ways to learn the model components, as well as how to run the RSM and how to view the typical results.



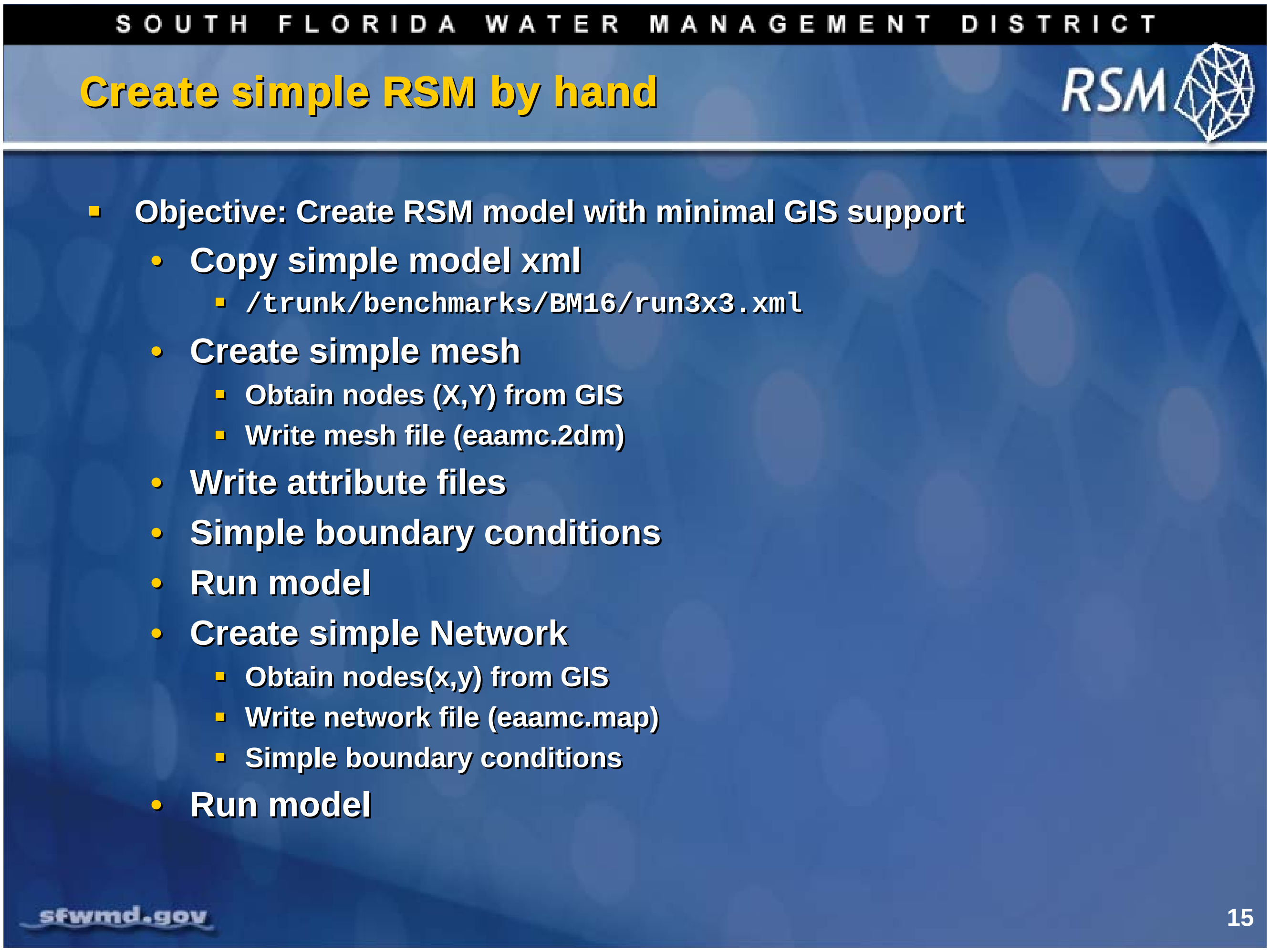
A simple RSM application will include these blocks and the appropriate input data. The sample.xml file provided in the **`labs/lab3_simple_RSM`** directory contains the detailed elements of each block. Each block is discussed on the following pages.



This is the content of a typical RSM implementation xml input file. The details of each of these elements are available in the *User Manual for the Hydrologic Simulation Engine*. The control block defines the primary characteristics of the model run; and, includes the start and stop date:time, timestep, and characteristics of the implicit solver.

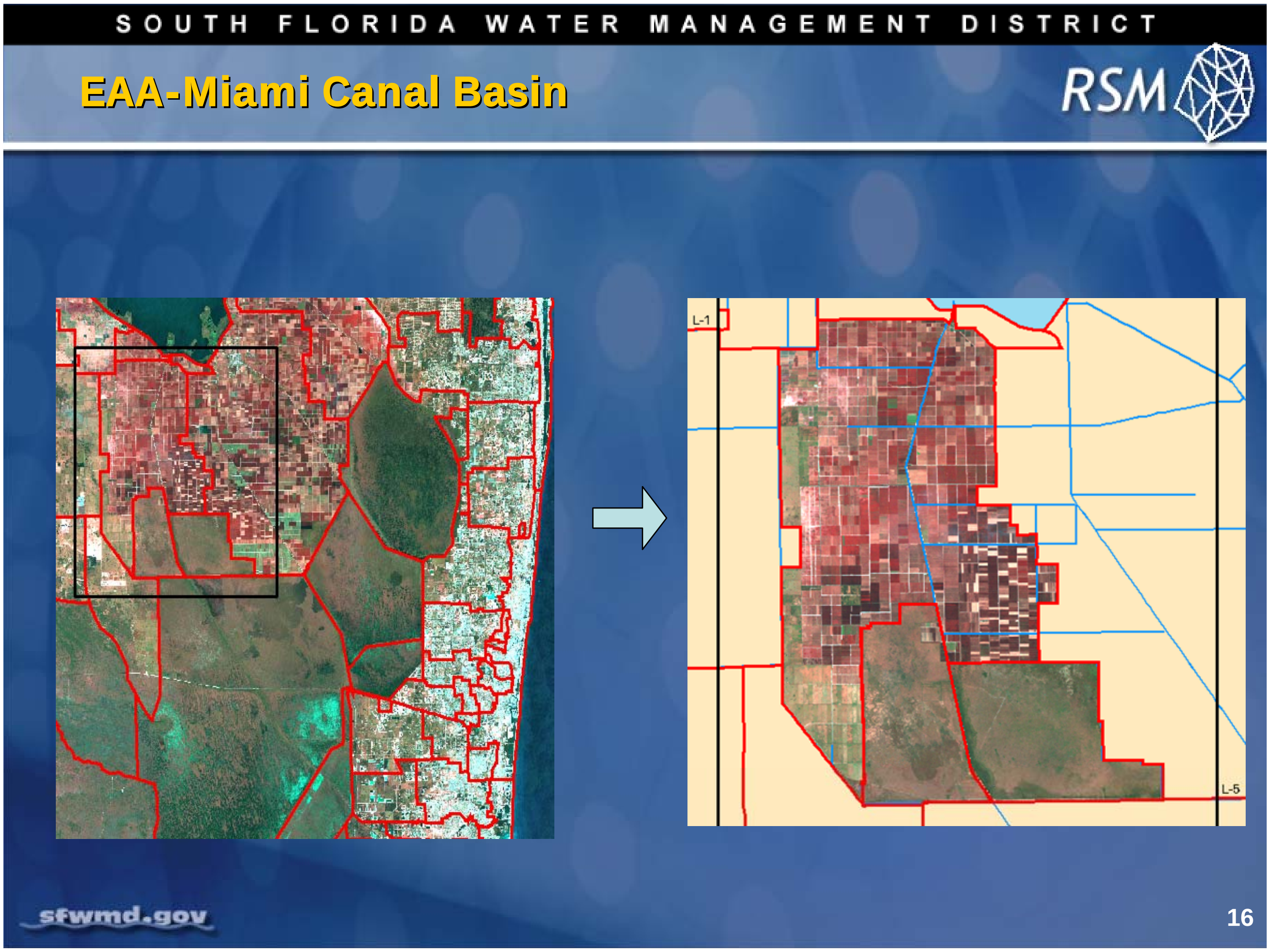
Setting the units in the model is an option available in the control block. The default units for the model are "American standard," which are defined as "English". Some of the benchmarks are set up to run using the Metric system, while others are set up to run using the American standard. This is important to know because there are conversion factors used as multipliers for each of the boundary conditions and inputs that must correctly convert from the input time series to the model units.

The "runDescriptor" option in the control block is useful for assigning an attribute to "part f" of the .DSS time series files produced by the model. This option can be used to define different model runs.

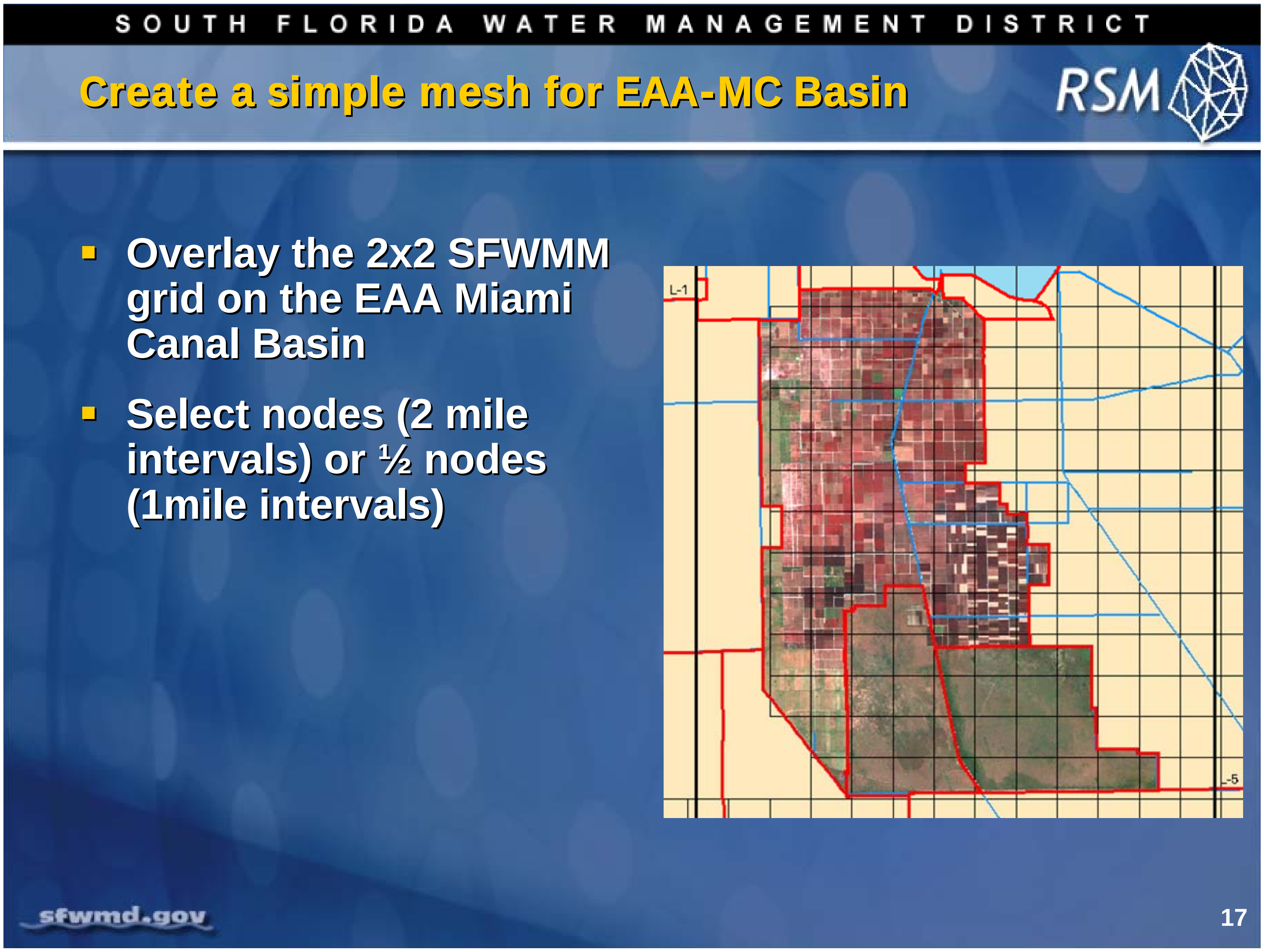


The best way to understand an RSM implementation is to build a simple implementation manually (without the use of GIS tools for creating the mesh, network and attribute files).

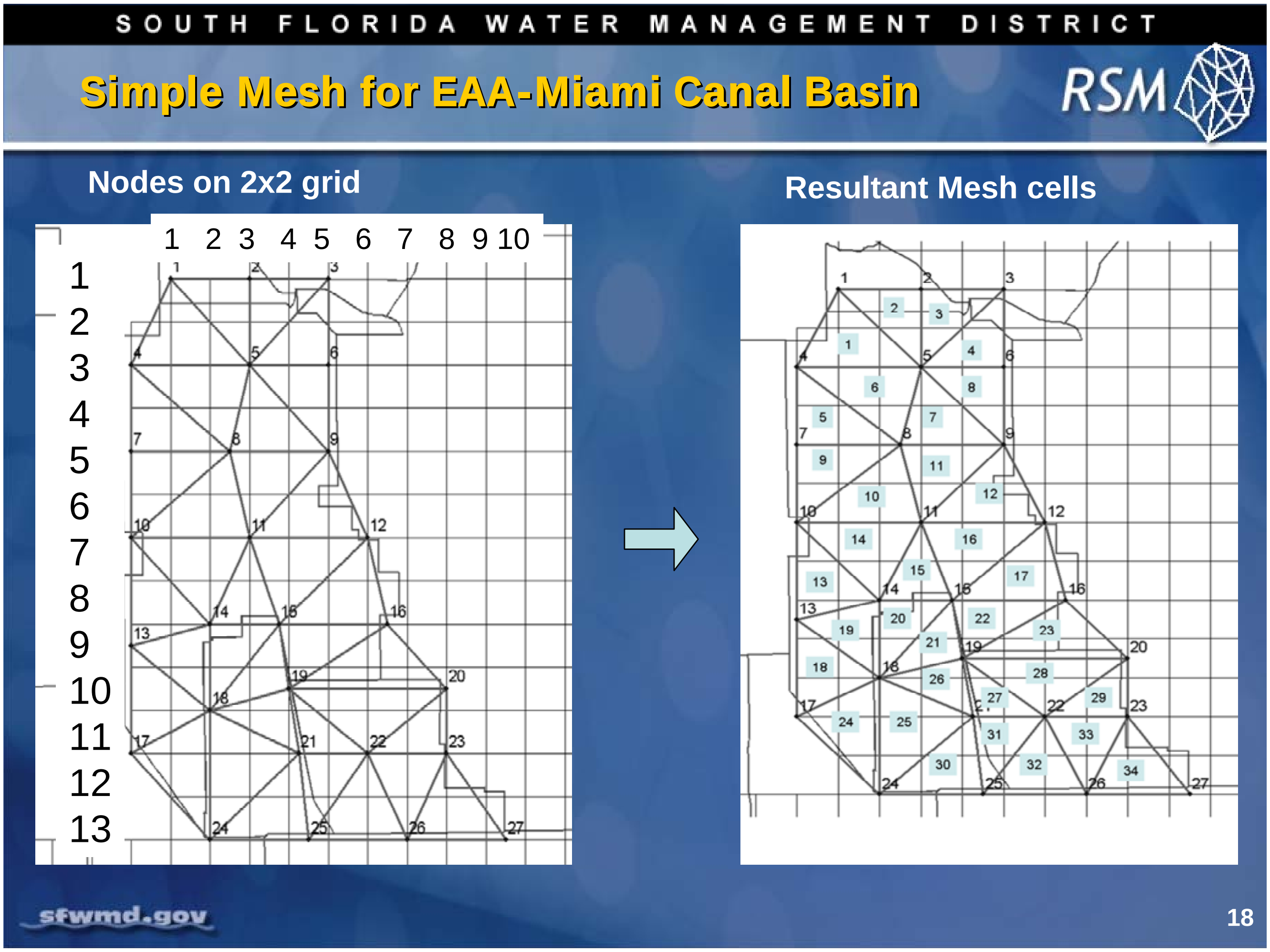
1. Copy a run3x3.xml which has a mesh and a network from Benchmark 16 $RSM/trunk/benchmarks/BM16 to $RSM/labs/lab3_simple_RSM. (This provides the basic components for a HSE simulation.)
2. Create a simple mesh.
3. Create simple output elements.
4. Run the model
5. Create a simple network
6. Run the model



The EAA-Miami Canal Basin was selected for this exercise. It consists of three subbasins; the S3-S8, the Rotenberger and the Holey Land. There is one major canal, the Miami Canal, and several smaller canals. The primary landuse is sugar cane agriculture in the S3-S8 and native scrub and marsh in the Rotenberger and Holey Land.

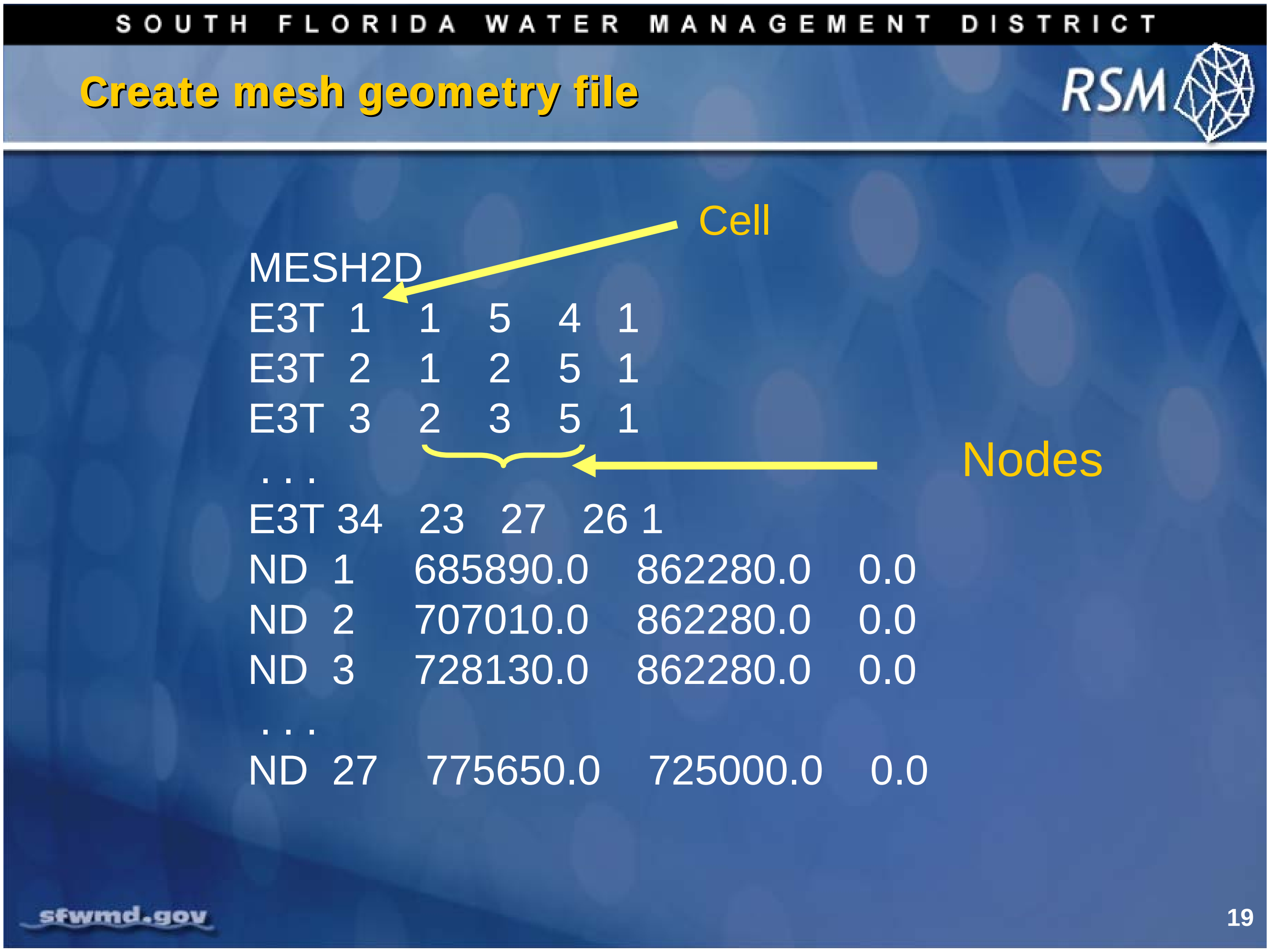


A simple mesh can be created for the EAA-Miami Canal Basin by overlaying the 2-mile x 2-mile grid from the South Florida Water Management Model (SFWMM) and selecting a number of nodes that will create 20-30 cells. Selecting the nodes from a grid on even intervals makes it easy to obtain the (x,y) coordinates.



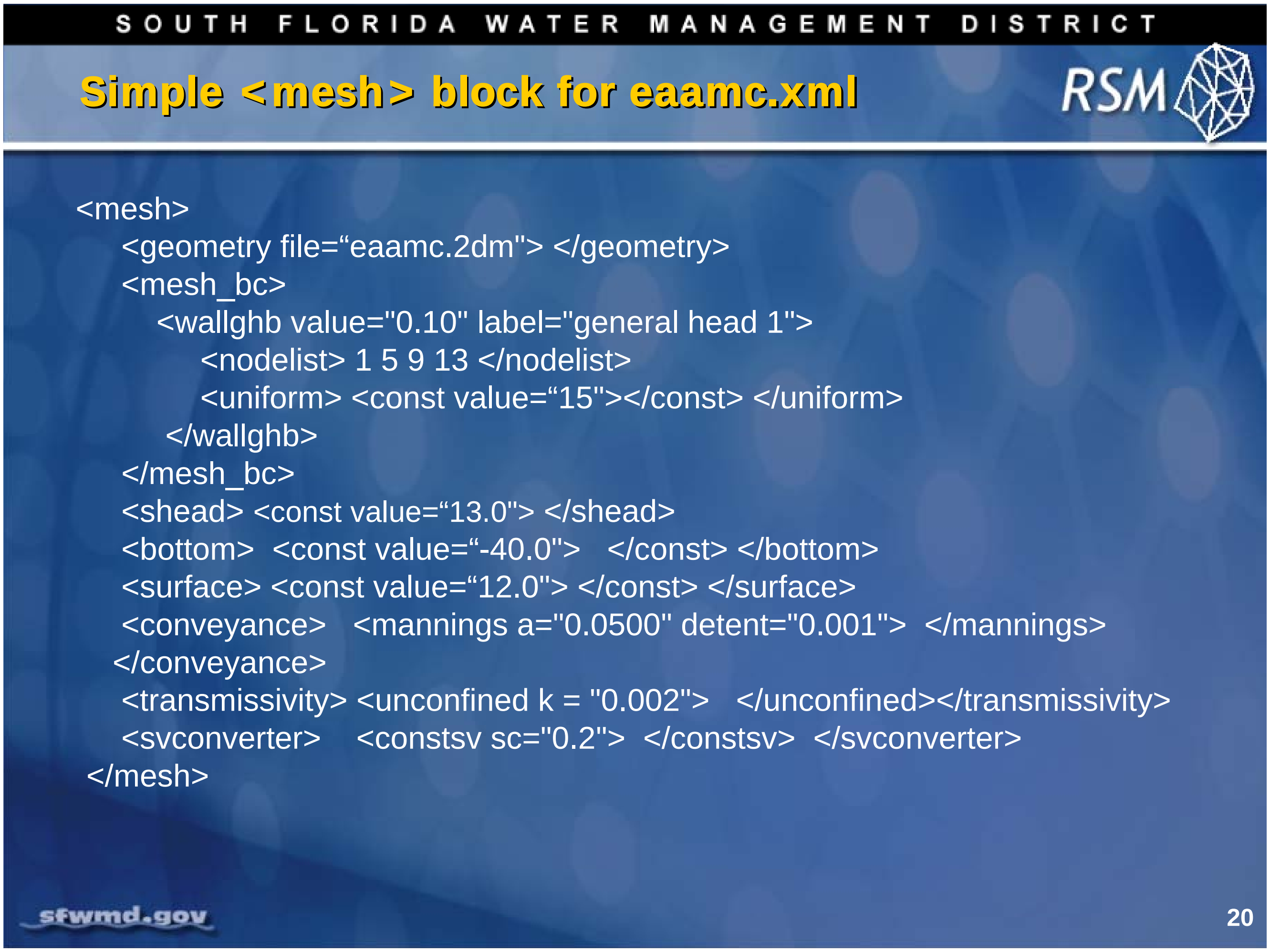
The simple mesh is created by selecting appropriate nodes from the 2x2 SFWMM grid and drawing a simple triangular network using care not to create oblique triangles. An Excel spreadsheet can be used to calculate the x and y coordinates based on the row and column numbers.

Label the cells after the nodes are defined.



The mesh geometry file (*.2dm) describes the cell connectivity and the node locations using the GMS format created by the US Army Corps of Engineers (refer to Groundwater Systems Modeling http://chl.erdc.usace.army.mil/).

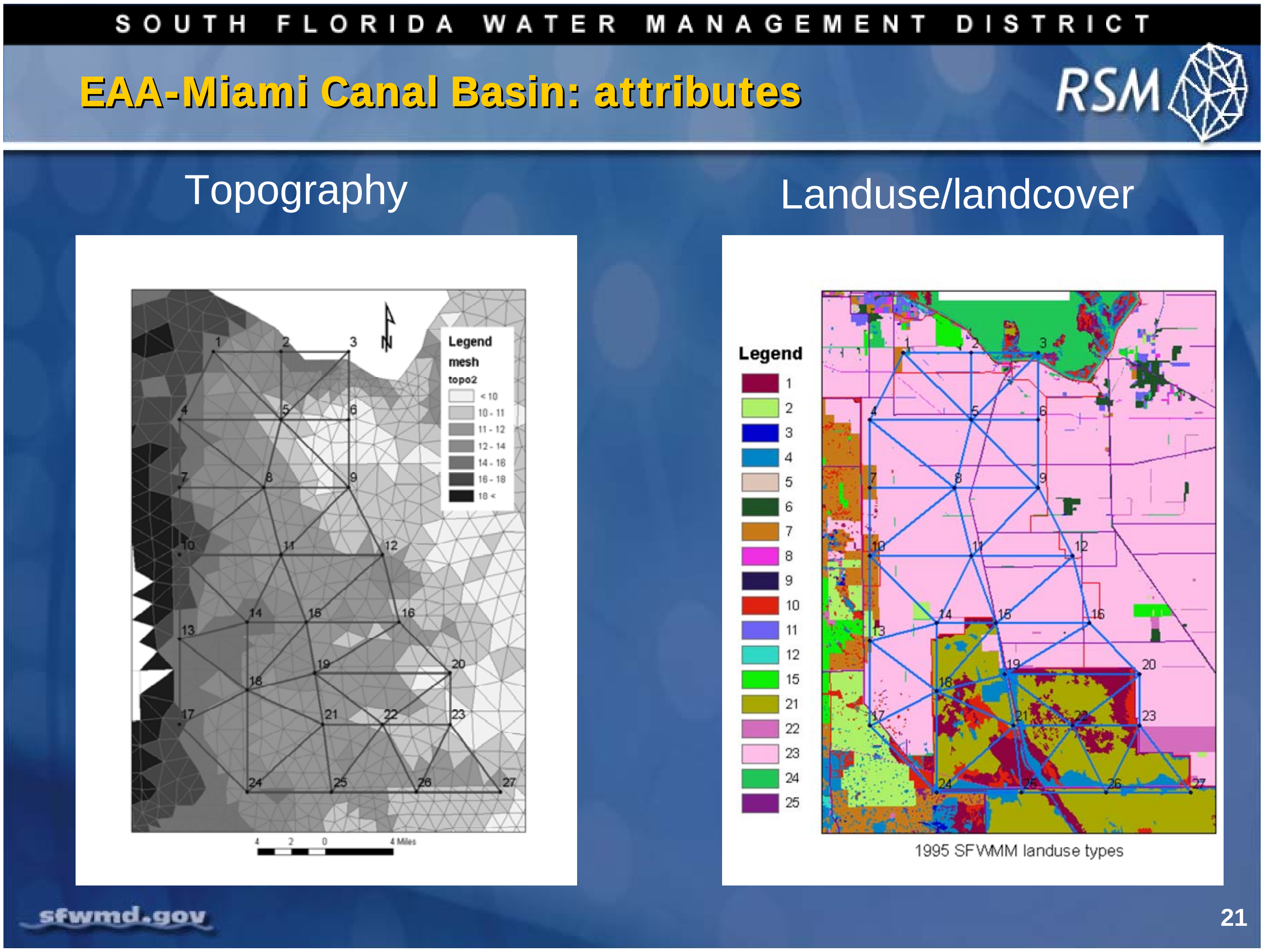
The header "MESH2D" is required as well as the line headers "E3T" and "ND". The cell connectivity identifies the cell number followed by the nodes that define the cell. The list of cells is followed by the node list which includes the (x,y,z) coordinates. We set z=0.0 for all nodes. In this example there are 27 nodes and 34 cells.



The mesh block contains the basic components of the mesh, including the:

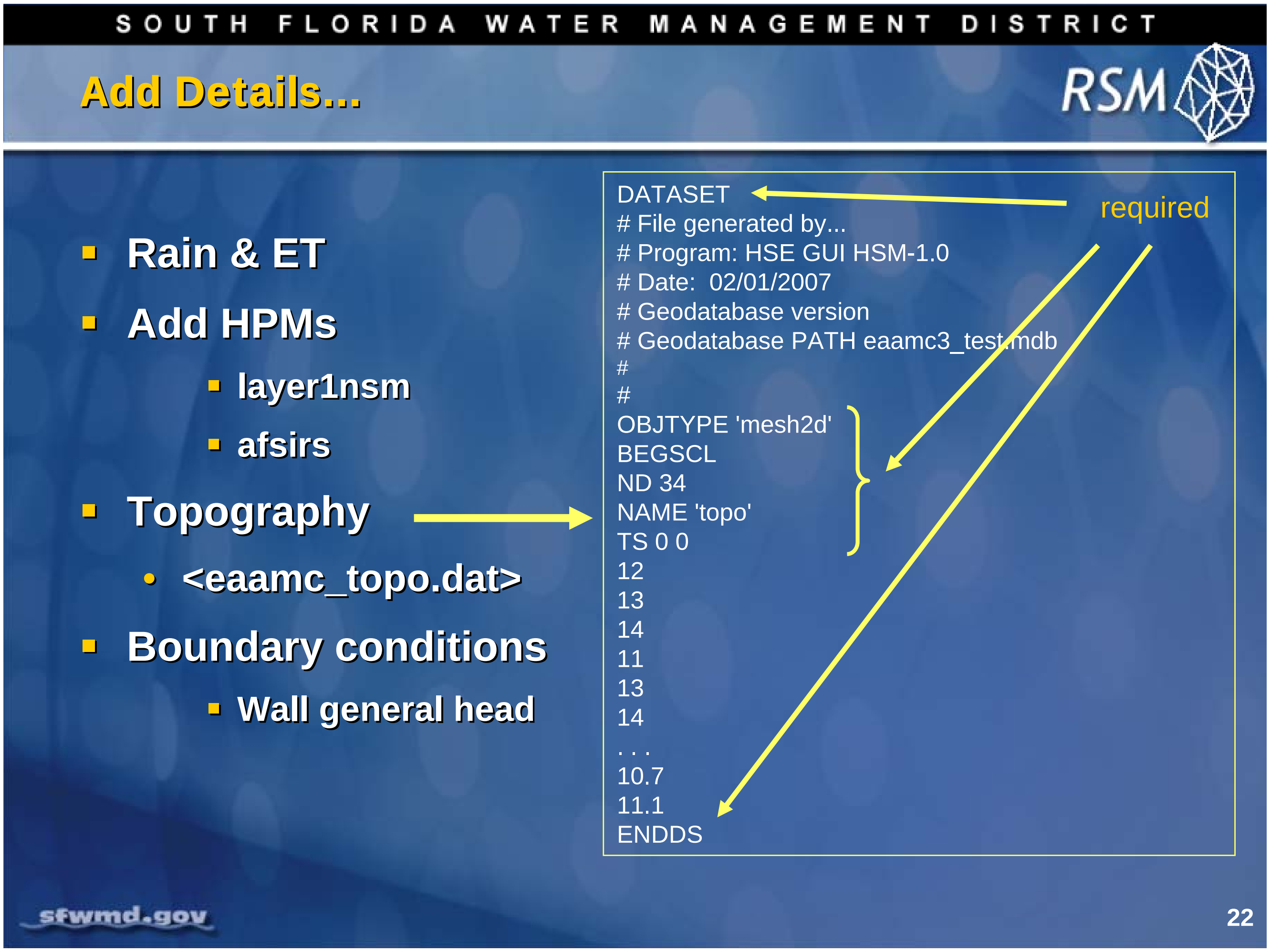
- Initial head <shead>
- Bottom elevation of the aquifer
- Surface elevation
- Roughness coefficient for calculating over land flow <conveyance>
- Hydraulic conductivity or transmissivity for calculating groundwater flow <transmissivity>
- Specific yield of the aquifer for the stage-volume conversion <svconverter>

Each of these attributes can be input as a constant value or as spatially distributed values.



The attribute values for topography, landuse and soils can be obtained from the SFWMD's geodatabase. The attribute values for landuse are necessary for <hpModules> and <conveyance>, <bottom> and <transmissivity> elements. The attribute values for soils are useful for <svconverter>.

For the simple model, the map shown on the left can be used to estimate the average cell value to create a simple indexed entry file for topography. The 1995 landuse/landcover map (on the right) can be used to obtain average cell values for landuse.



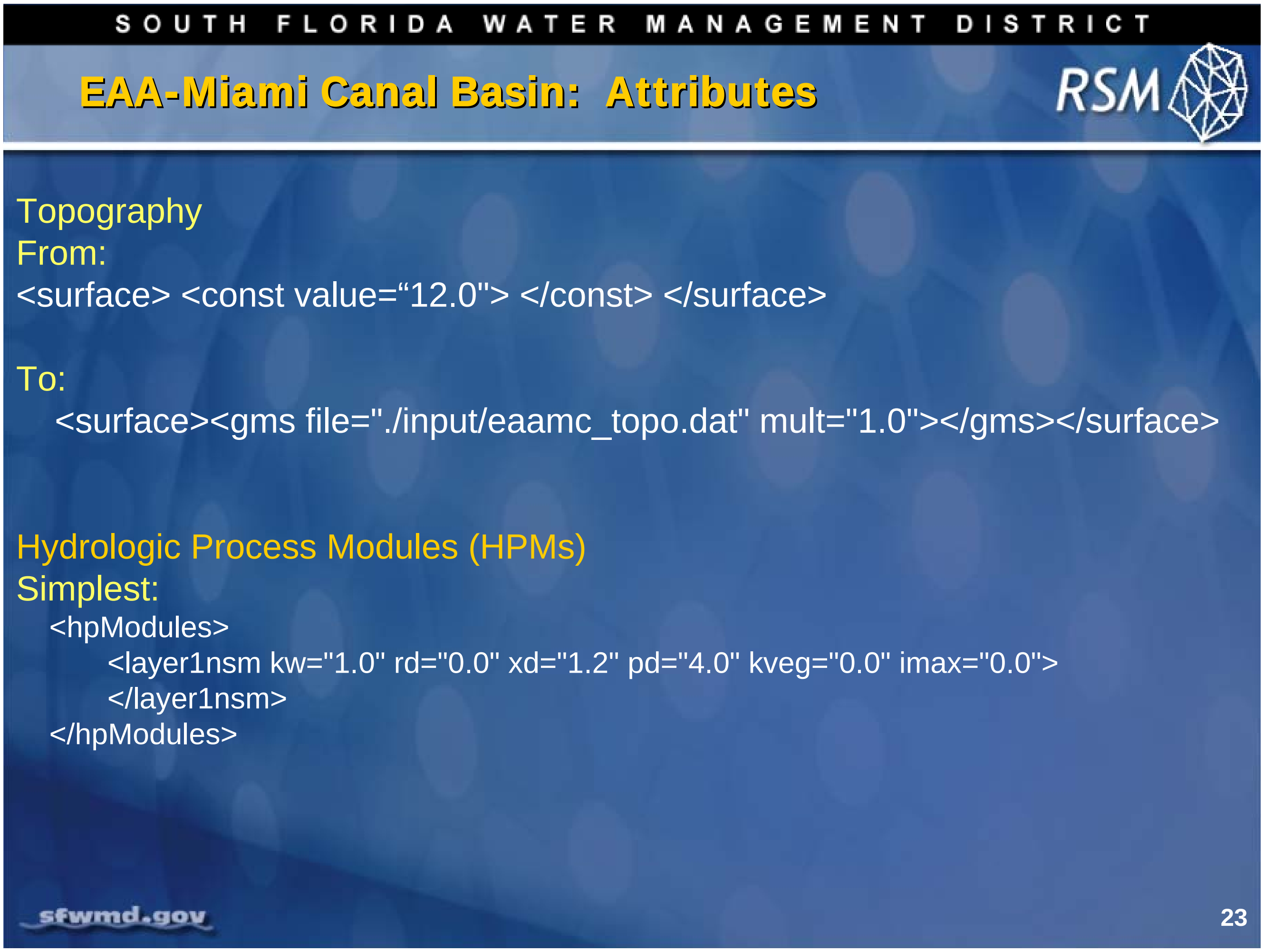
Add details to complete the Model:

Once the mesh is created spatially variable attributes can be applied to the model. The SFWMD has developed extensive geographic data resources (which are reviewed in Lab 5) that provide the spatial data for developing the attribute files.

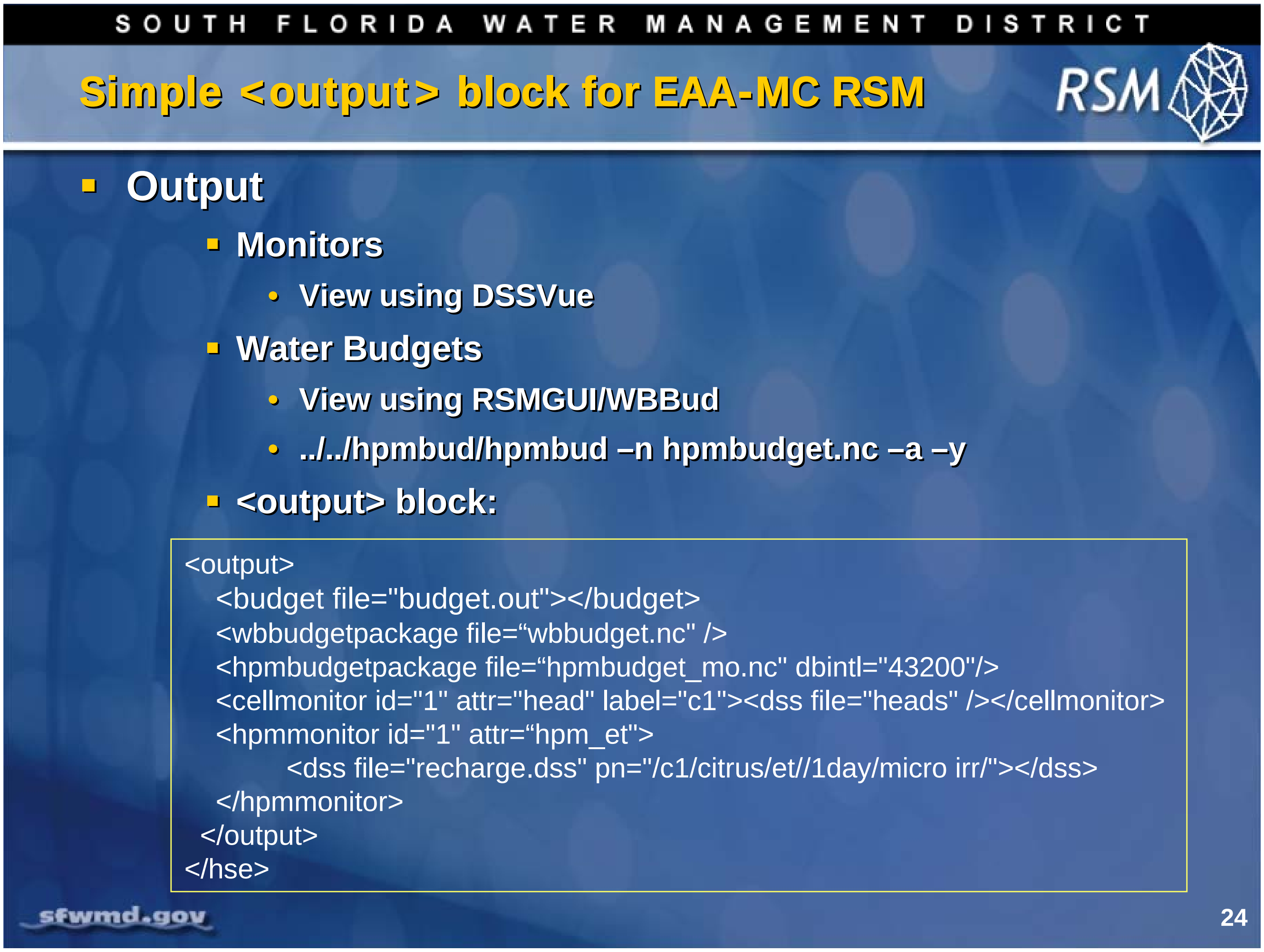
The spatial data for each mesh attribute are typically provided as cell-ordered data in the format presented here.

The typical mesh attribute file is presented here for topography. It begins with DATASET followed by several comments which are useful metadata.

The number of values is provided with ND 34, which represents the number of cells.



In a simple example, a constant value can be used for topography. This can be modified by creating an indexed value file for topography. For this simple RSM model, a single wetland HPM can be used to model the surface hydrology.



As previously discussed, there are three types of output available for the RSM: Monitors, budgetpackages and globalmonitors.

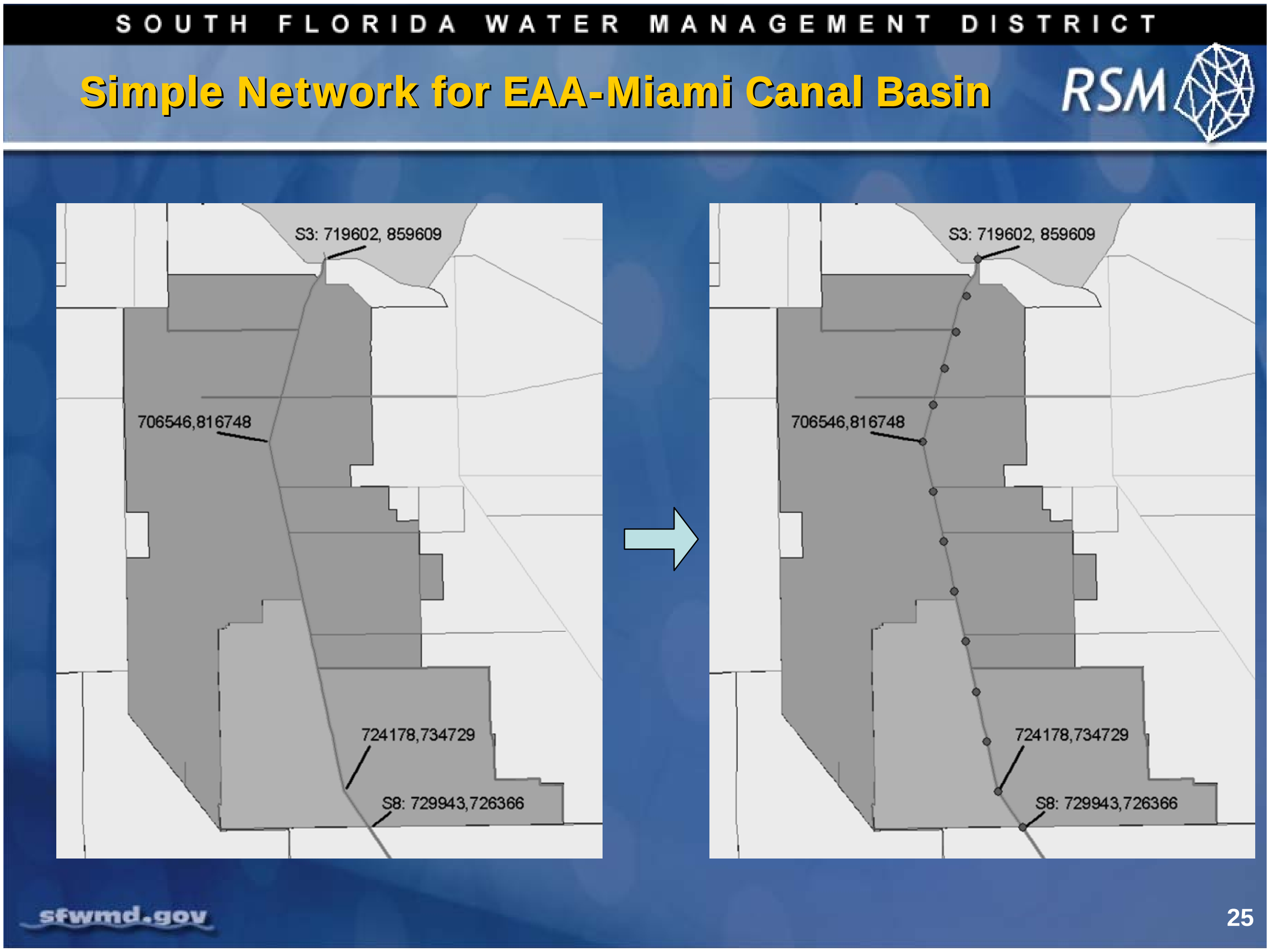
Monitors are used to output time series data for any state value or variable in the model.

There are three types of budgetpackages:

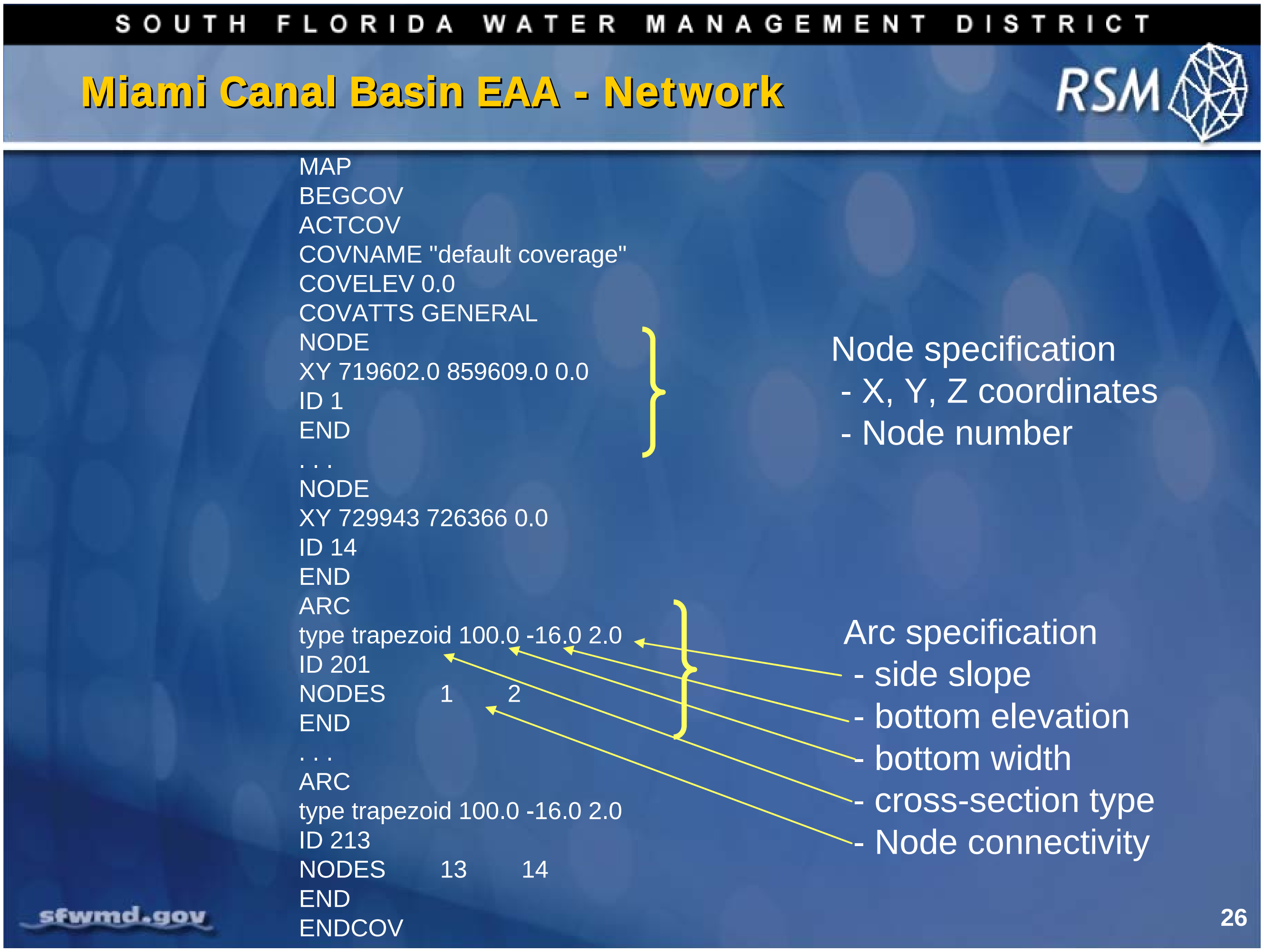
- <budget> which reports the water budget for each waterbody at each time step;
- <wbbudgetpackage> which reports information necessary to create the water budget for any group of waterbodies
- <hpmbudgetpackage> which reports the information for creating a water budget for any group of HPMs

The time series output can be viewed using the DSSVue utility or the HEC-DSSVue utility from the RSMGUI toolbar.

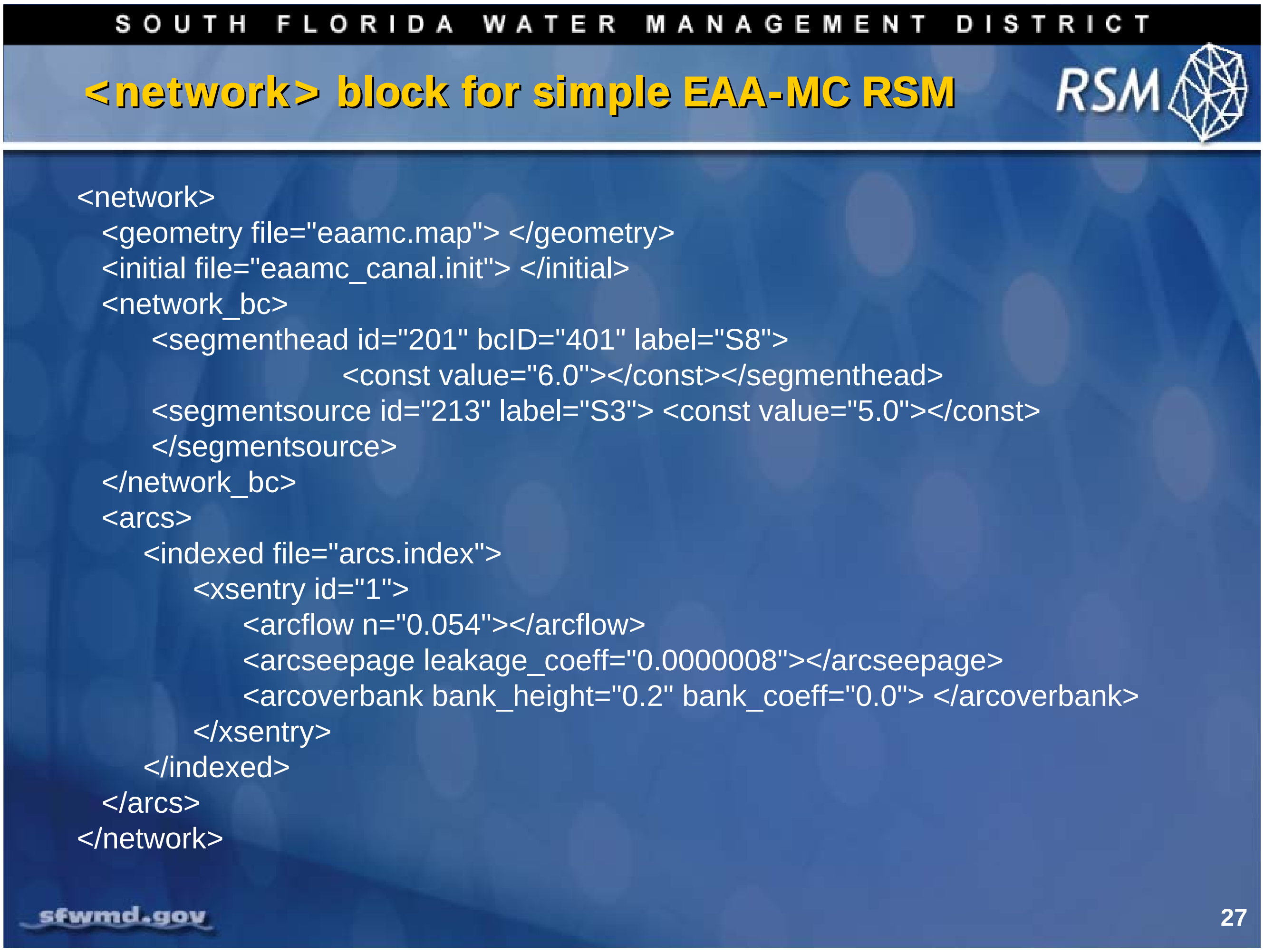
The water budgets for waterbodies are created using the "WBBud" utility in the RSMGUI. The water budgets for the HPMs are created using the hpmbud utility at the command line.



A simple network for the EAA-Miami Canal Basin may include only the Miami Canal. The coordinates of the end points of the Miami Canal for this model can be obtained from the structure locations for the S-3 and S-8 pump stations. The inflection points can be estimated by overlaying the canal with the 2x2 SFWMM grid. The interior nodes for the network can be obtained by importing the known nodes into a spreadsheet and dividing up the distance into even intervals.



The network geometry file (*.map) describes the nodes and arcs that make up the network following the GMS file format. The map file contains the node locations, node connectivity and the arc cross-section properties.



The simple network block contains:

- network geometry file,
- initial segment heads,
- boundary conditions
- and the necessary properties for each of the segments

The boundary conditions are typically set as an upstream source and a downstream head condition.

The segment properties include the:

- roughness coefficient
- stream bottom seepage coefficient
- overbank flow coefficient

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Network Boundary Conditions

RSM

Simple BCs

```
<segmentghb>
    <segmenthead id="1"><const value="15.0"></const></segmenthead>
</segmentghb>
```

Complete BCs

```
<segmentghb id="310459" bcID="5701" kcoef="1.0e-5" label="S8(GHB)">
   <dss file="./input/eaa_obs_canal_stage.dss“
         pn="/SFRSM/S8H/STAGE//1DAY/OBS/“
         units="FT" type="PER-AVER" mult="1.0">
   </dss>
</segmentghb>
```

Downstream stage

```
<segmentsource id="310390" bcID="5502" label="S3">
  <dss file="./input/flow_v5.0_09292003.dss“
        pn="/SFWMM/S3/FLOW//1DAY/HISTORICAL/"
        units="cfs" type="PER-AVER" mult="1.0">
  </dss>
</segmentsource>
```

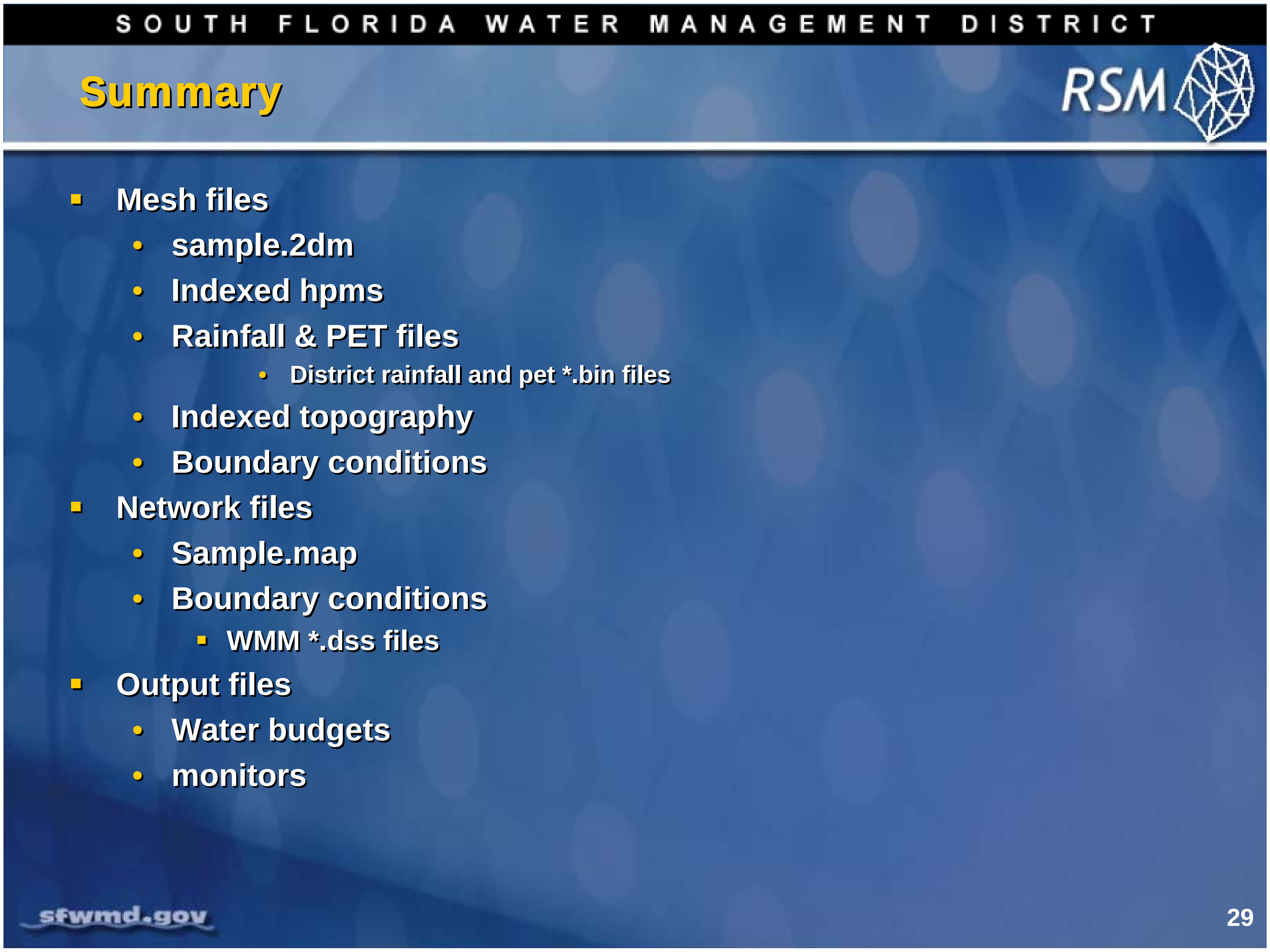
Upstream flow

sfwmd.gov 28

The simplest boundary condition is the constant value, which is an acceptable first approximation when setting up the RSM implementation. In a simple model, poor results due to simple boundary conditions are obvious.

In a subregional RSM implementation where there are many complex features, beginning with simple boundary conditions is a good first step. More realistic boundary conditions can be created by applying a time series of historical observations to the canal end segments.

At the downstream end the time series of canal stages are applied to the last segment. On the upstream end, the time series of structure inflows are applied to the first segment.



In this lecture we reviewed the steps for creating an RSM implementation without the benefit of GIS. This session highlights the construction and content of the key files used to create an RSM input dataset.

Knowledge Assessment

1. What is the purpose for using XMLs?
2. What is the advantage of using the Xemacs or similar editor?
3. What are the essential components of XML used in RSM?
4. What are the key XML blocks used in RSM?
5. What are the best sources of syntax for implementing features in RSM?
6. How does indexed input work?
7. What are the key principles to follow in development of a new RSM implementation?
8. What are the components of a *2dm* file?
9. What are the necessary elements of a mesh block?
10. What are the common three ways to represent topography?
11. Two common types of RSM output?
12. What are the components of a *.map* file?

Answers

1. The Extensible Markup Language is used to provide a portable, complete input schema that provides error checking capability.

2. Xemacs and similar editors are context sensitive and can be used with the hse.dtd file to provide only the input elements and attributes that are appropriate for each input block.

3. The RSM uses blocks, elements and attributes to define the model input parameters.

4. The key XML blocks are the following: Control, Mesh, Network and Output.

5. The syntax for RSM can be found in the HSE User Manual and for new features: benchmarks, hse.dtd and the source code. The input files from current RSM implementations can be borrowed to avoid typing errors.

6. The index input file follows the GMS format for header information followed by an ordered list of attribute values for each cell or segment. There are no segment or cell identifiers.

7. It is important to start small and add features stepwise. Only add complexity as necessary. Compartmentalize the XML input and the model features. Borrow input syntax such as HPMs, boundary conditions and network features from previous implementations.

8. The 2dm file contains the mesh_node connectivity and mesh_node locations.

9. <geometry>, <shead>, <surface>, <bottom>, <conveyance> and <transmissivity>

10. Topography can be entered as a constant, an indexed file or a gms file.

11. The two types of output are “monitors” and budget data in netCDF files.

12. The *map* file contains: node connectivity, cross-section properties, segment connectivity.

Lab 3: Frameworks, Meshes and Networks

Time Estimate: 1.5 hours

Training Objective: Build a simple mesh and network

To understand how the Regional Simulation Model (RSM) behaves it is appropriate to build a simple RSM manually. This will provide the user with a basic understanding of the information used by the RSM to create the objects that run the model.

Although a simple RSM model can be built manually, a subregional model requires Geographic Information System (GIS) tools to construct the necessary input files of spatially distributed data. There are automated tools used to create the necessary input files, which will be presented in Labs 6 and 7.

The first two spatial input files created for the RSM are a mesh file and the network file. In this lab, you will create a small mesh file and a small network file, and run a simple RSM implementation.

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>
```

Modelers at the District should use the following NAS path:

```
/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
```

Training files are currently located in the following directories:

```
INTERNAL_TRAINING
|
|____data
|        |__geographic
|        |__C111
|        |__rain+et
|        |__glades_lecsa
|        |__losa_eaa
|        |__BBCW
|
|____trunk
|        |___benchmarks
|        |___hpmbud
|
|____labs
```

Files for this lab are located in the **`labs/lab3_BM3`** directory. Additional materials in the directory include:

`sample.xml`

Activity 3.1: Manually create a simple mesh and network for the EAA-MC Basin RSM

Overview

Activity 3.1 includes two exercises:

- **Exercise 3.1.1** Create a mesh for the EAA-MC Basin
- **Exercise 3.1.2** Create a network for the EAA-MC Basin

You will manually create a mesh and network for the Everglades Agricultural Area-Miami Canal (EAA-MC) Basin (see **Fig 3.1**)

Exercise 3.1.1 Create a simple mesh for the EAA-MC Basin

First, examine the content of a simple benchmark mesh file (**Fig. 3.2**). The mesh.2dm is an ASCII file that contains two sections:

1. The cell connectivity section that has a row for each cell containing the cell id and the three nodes that form each cell in clockwise order
2. The node coordinate location section that has a row for each node containing the node id and the x-y-z coordinates for that node including a zero-coordinate value for the z-axis.

The cell connectivity section of the mesh.2dm file contains an additional parameter which is not used, but set to 1.0. The format for the mesh.2dm is a standard mesh format from the Groundwater Modeling System (GMS) package (which is discussed in **Lab 6**).

To create any mesh in south Florida, start with the simple two-mile by two-mile grid used for the South Florida Water Management Model (SFWMM) (**Fig. 3.3**). The 2x2 grid is useful because we have a substantial amount of hydrologic information from the SFWMM associated with this grid.

For the EAA-MC Basin select a set of nodes that will result in 20–30 triangular cells that are approximately the same size and acute, with no angle greater than 90 degrees. Use the portion of the grid that includes the EAA-MC (**Fig.3.3**).

The lowest **y-coordinate** of the EAA-MC grid is ***725000*** and the lowest **x-coordinate** is ***675330***. Make the mesh conform to the Rotenberger Subbasin and the Holeyland Subbasin.

3. Using the intersects of the SFWMM grid in **Fig 3.3**, create nodes for the RSM triangular mesh.(Your resulting nodes should be distributed in a manner similar to the nodes as they appear in **Fig. 3.4a**)
4. Number the nodes and connect the nodes creating the cells. Number the cells. (Your results should look like the results in **Fig. 3.4c**.)
5. Determine the coordinates of the nodes using a spreadsheet. (Remember: the node locations are multiples of two mile intervals.) As an example, see:

   `$RSM/labs/lab3_simple_RSM/lab3_mesh.xls`

6. Create the first part of the **eaamc.2dm** file.
   - In a text editor such as “gedit” or “nedit”, create the connectivity of the cells using the following template:

Header	**cell**	**node1**	**node2**	**node3**	**value**
E3T	1	1	6	2	1

7. Create the second part of the **eaamc.2dm** file.
   - Save the contents of the spreadsheet in the format shown in a comma-separated-value file (**eaamc.csv**).

Node	No.	x-coordinate	y-coordinate	z
ND	1			0.0

   - Open the **eaamc.csv** file in the text editor and replace the commas with the appropriate spacing.
   - Copy the nodes into the **eaamc.2dm** file.
   - Your file should look like the output in **Figure 3.5**
8. Check the connectivity of the **eaamc.2dm** file:
   - Edit **$RSM/../labs/lab3_simple_RSM/sample.xml**
   - Edit the correct geometry file name: **file=“eaamc.2dm”**
   - Modify the list of nodes in the **<nodelist>** to match the nodes for your mesh boundary
   - Using the RSM Graphical User Interface (RSMGUI), run RSM using **sample.xml**
   - Make sure the reference to the **hse.dtd** file is correct

   Take care not to transpose the node values, which is a common user error. If the file is correct the model will run.
9. Plot the heads from Cell 1 and Cell 30 using HecDssVue from RSMGUI.
   - How are the head time series different?

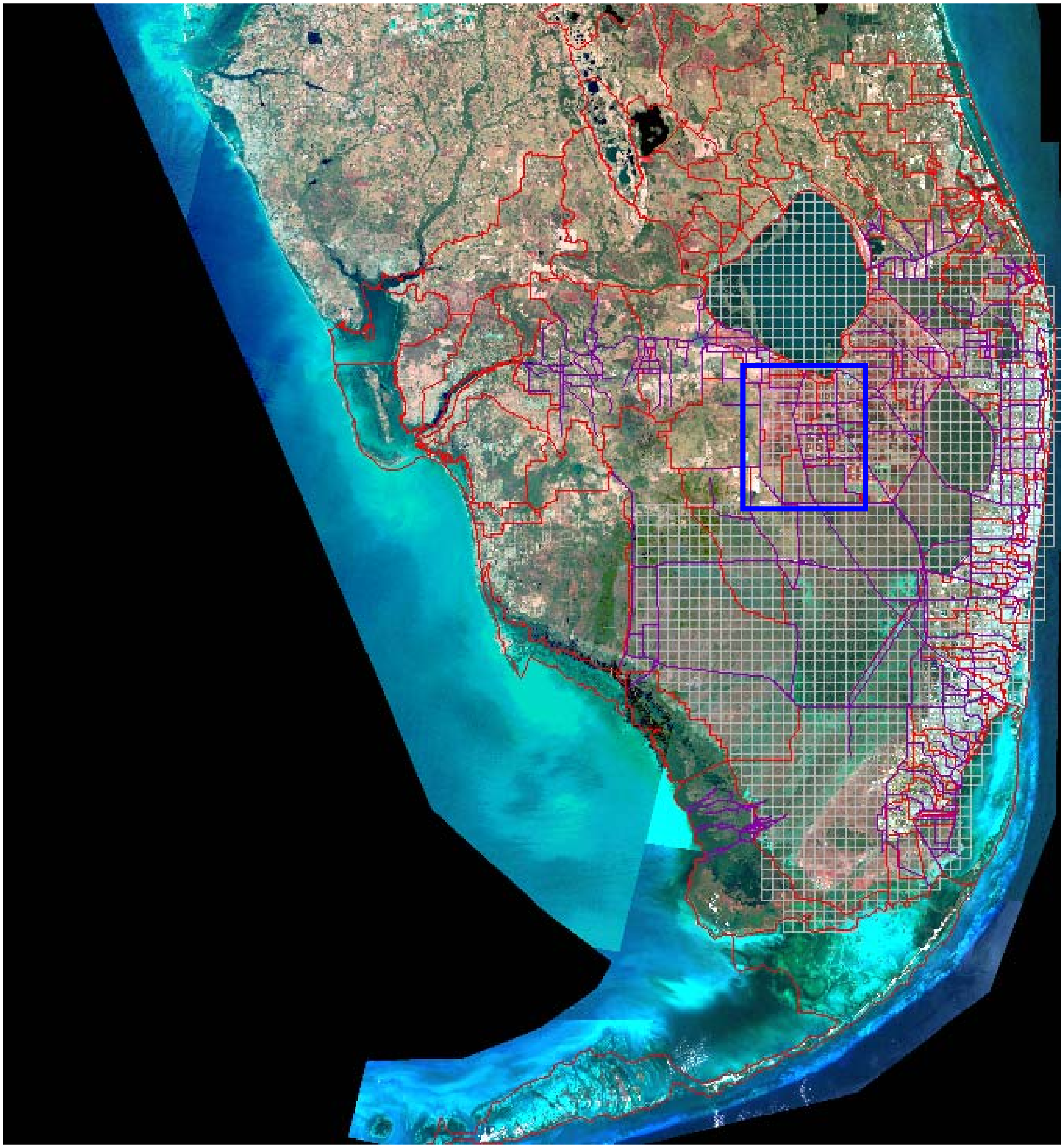


Figure 3.1. The canal network of the Central and Southern Florida Flood Control Project (C&SF Project) overlain by the mesh from the South Florida Water Management Model (SFWMM). The location of the Everglades Agricultural Area-Miami Canal (EAA-MC) Basin is identified.

```
MESH2D
E3T     1    1     6     2     1
E3T     2    2     7     3     1
E3T     3    3     8     4     1
E3T     4    5    10     6     1
E3T     5    6    11     7     1
E3T     6    7    12     8     1
E3T     7    9    14    10     1
E3T     8   10    15    11     1
E3T     9   11    16    12     1
E3T    10    1     5     6     1
E3T    11    2     6     7     1
E3T    12    3     7     8     1
E3T    13    5     9    10     1
E3T    14    6    10    11     1
E3T    15    7    11    12     1
E3T    16    9    13    14     1
E3T    17   10    14    15     1
E3T    18   11    15    16     1
ND  1        0.000      15000.000 0.
ND  2     5000.000      15000.000 0.
ND  3    10000.000      15000.000 0.
ND  4    15000.000      15000.000 0.
ND  5        0.000      10000.000 0.
ND  6     5000.000      10000.000 0.
ND  7    10000.000      10000.000 0.
ND  8    15000.000      10000.000 0.
ND  9        0.000       5000.000 0.
ND 10     5000.000       5000.000 0.
ND 11    10000.000       5000.000 0.
ND 12    15000.000       5000.000 0.
ND 13        0.000          0.000 0.
ND 14     5000.000          0.000 0.
ND 15    10000.000          0.000 0.
ND 16    15000.000          0.000 0.
```

Figure 3.2 Cell connectivity and node coordinates for the standard benchmark 3x3 mesh (`mesh.2dm`)

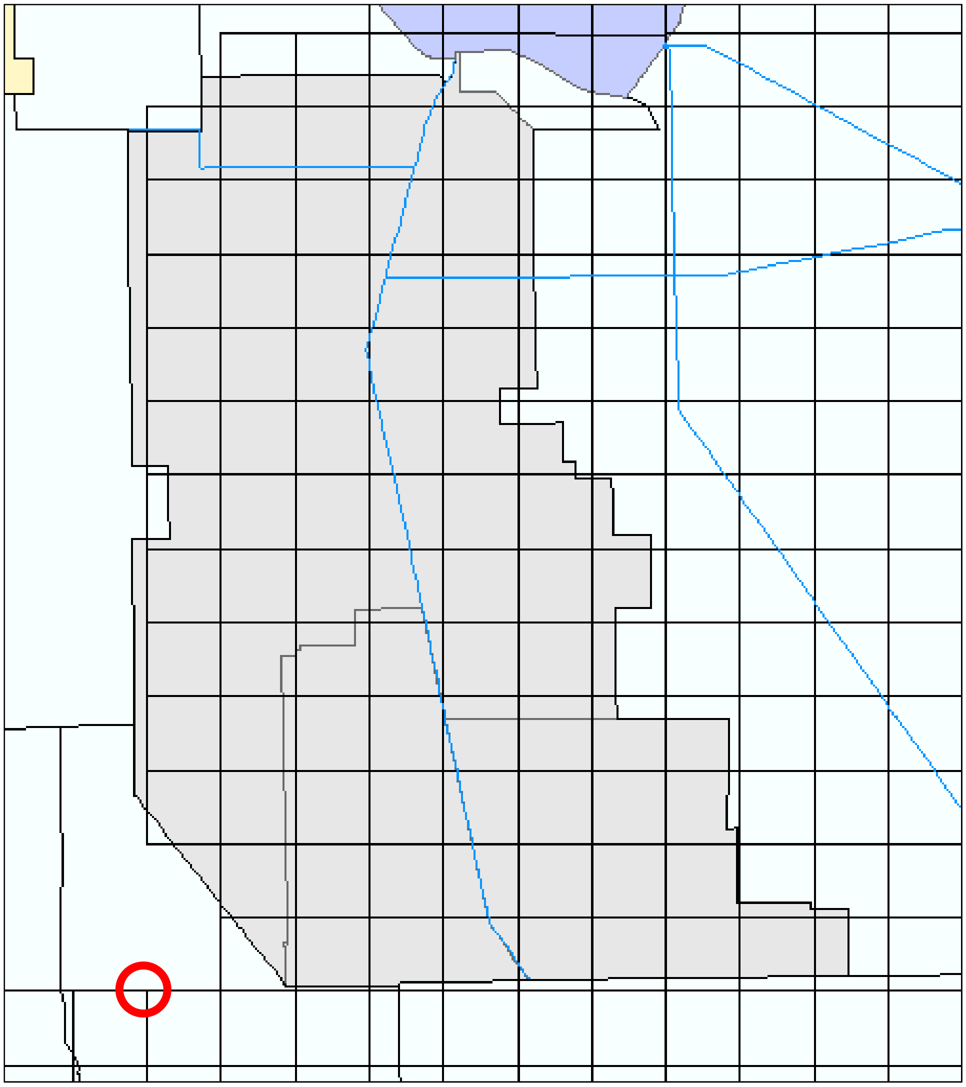
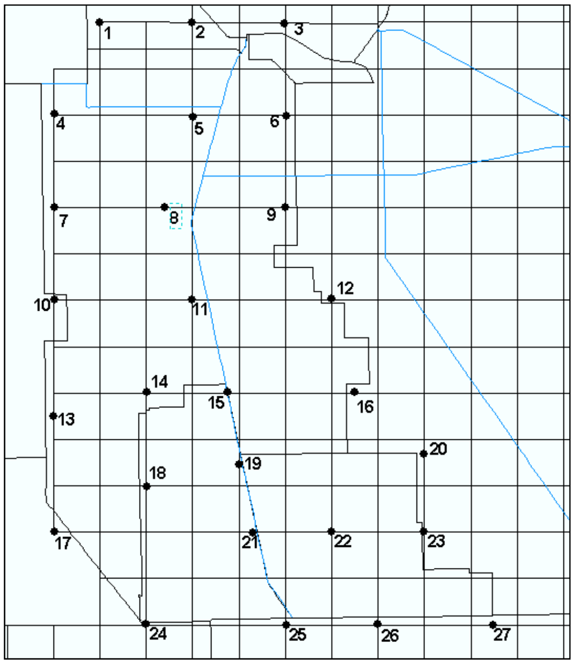
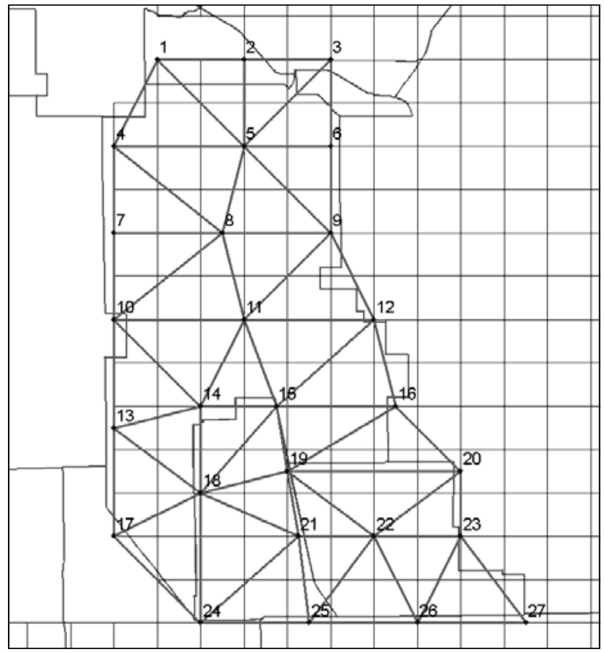


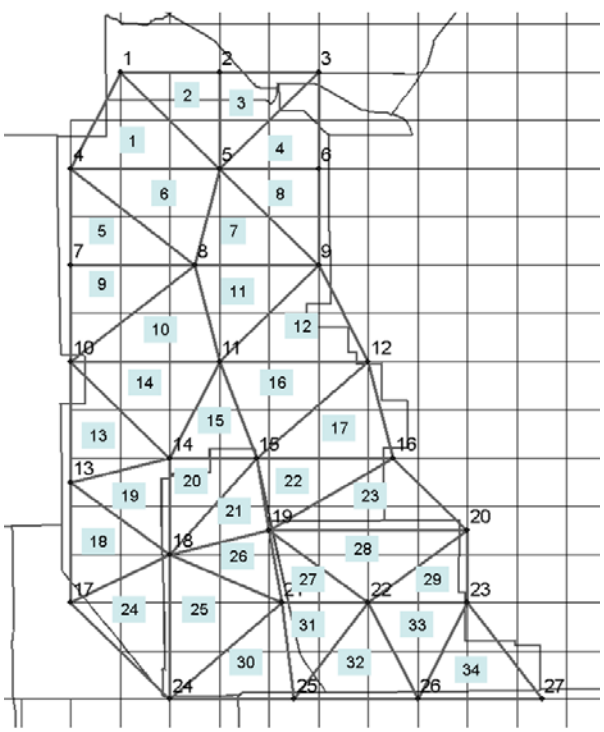
Figure 3.3. Everglades Agricultural Area-Miami Canal (EAA-MC) Basin overlain with two-mile by two-mile grid used by the South Florida Water Management Model (SFWMM). The starting point for the EAA-MC grid is circled (675330.0, 725000.0).



a) Locate 20-30 nodes in EAA-MC basin



b) Create 20-30 acute triangular cells



c) Label the mesh cells

Figure 3.4 A simple irregular triangular mesh for the EAA-MC basin

```
MESH2D
E3T  1    1    5    4 1
E3T  2    1    2    5 1
E3T  3    2    3    5 1
E3T  4    3    6    5 1
E3T  5    4    8    7 1
E3T  6    4    5    8 1
E3T  7    5    9    8 1
E3T  8    5    6    9 1
E3T  9    7    8   10 1
E3T 10    8   11   10 1
E3T 11    8    9   11 1
E3T 12    9   12   11 1
E3T 13   10   14   13 1
E3T 14   10   11   14 1
E3T 15   11   15   14 1
E3T 16   11   12   15 1
E3T 17   12   16   15 1
E3T 18   13   18   17 1
E3T 19   13   14   18 1
E3T 20   14   15   18 1
E3T 21   15   19   20 1
E3T 22   15   16   19 1
E3T 23   16   20   19 1
E3T 24   17   18   24 1
E3T 25   18   21   24 1
E3T 26   18   19   21 1
E3T 27   19   21   22 1
E3T 28   19   20   22 1
E3T 29   20   23   22 1
E3T 30   21   25   24 1
E3T 31   21   22   25 1
E3T 32   22   26   25 1
E3T 33   22   23   26 1
E3T 34   23   27   26 1
ND  1     685890.0    862280.0    0.0
ND  2     707010.0    862280.0    0.0
ND  3     728130.0    862280.0    0.0
ND  4     675330.0    841160.0    0.0
ND  5     707010.0    841160.0    0.0
ND  6     728130.0    841160.0    0.0
ND  7     675330.0    820040.0    0.0
ND  8     701730.0    820040.0    0.0
ND  9     728130.0    820040.0    0.0
ND  10    675330.0    798920.0    0.0
ND  11    707010.0    798920.0    0.0
ND  12    738690.0    798920.0    0.0
ND  13    675330.0    772520.0    0.0
ND  14    696450.0    777800.0    0.0
ND  15    714930.0    777800.0    0.0
ND  16    743970.0    777800.0    0.0
ND  17    675330.0    746120.0    0.0
ND  18    696450.0    756680.0    0.0
ND  19    717570.0    761960.0    0.0
ND  20    759810.0    761960.0    0.0
ND  21    720210.0    746120.0    0.0
ND  22    738690.0    746120.0    0.0
ND  23    759810.0    746120.0    0.0
ND  24    696450.0    725000.0    0.0
ND  25    722850.0    725000.0    0.0
ND  26    749250.0    725000.0    0.0
ND  27    775650.0    725000.0    0.0
```

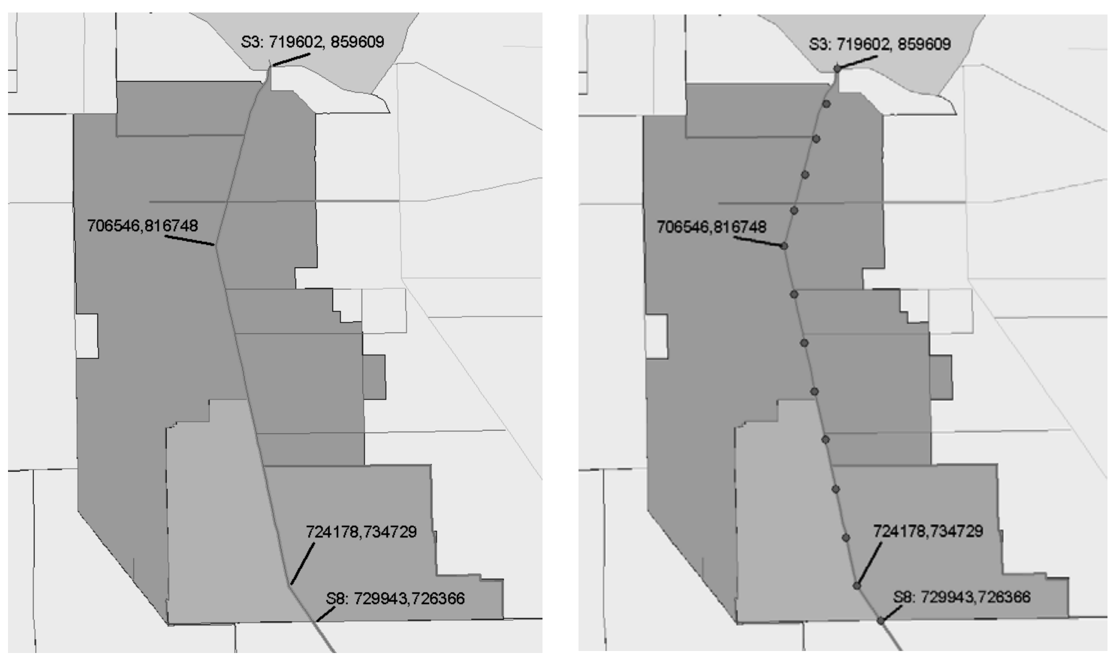
Figure 3.5 The contents of the **eaamc.2dm** file for a simple mesh

Exercise 3.1.2 Create a network for the EAA-MC Basin

Using a map of the Everglades Agricultural Area-Miami Canal (EAA-MC) Basin, create a simple network. The EAA-MC basin has a few canals of the primary system, but we are only interested in the Miami Canal.

It is reasonably easy to obtain a copy of key coordinates for the canal system using the SFWMM 2x2 grid or structure locations. Four points have been identified along the Miami Canal. The end points are the S-3 and S-8 structures. The two additional points were extrapolated from the SFWMM grid.

Using all four points and assuming a straight canal between the points, nine additional points can be located at even intervals between these points using a simple spreadsheet interpolation routine. It is important to select canal segments that lie completely within the mesh and end within a mesh cell. If the segments lie outside the mesh they will create a water leak. Typically, segments should be one to five miles in length, which is a function of the slope dimensions, roughness, and simulation time step as these variables affect the stability of the simulation. The segments should be large enough to process water without drying out but not too large as to have small changes in head.



a) Initial coordinates **b)** Final canal nodes

Figure 3.6 The nodes of the Miami Canal for the simple RSM model

Once the coordinates of the canal nodes are obtained, create a canal **`*.map`** file using the example in **Fig. 3.7** as an example. The **`*.map`** file is composed of two sections: the node identification and the segment characteristics.

10. Create a node section using the x and y coordinates from the spreadsheet. Replace the x and y values while retaining the remaining syntax.
11. Create the segment section by selecting segment ID values (beginning with the number **`300001`**, so the segment waterbodies do not conflict with the cell waterbodies) and determine the cross-section for each canal segment. The typical cross-section has a trapezoidal profile followed by the bottom width, bottom elevation and side slope: type trapezoid **`100.0 498.0 0.0`**
    - The bottom elevation for the Miami Canal can be set to **`-16.0 feet`** for all segments. (The bottom elevation should be set sufficiently deep so that the canal never dries out during the simulation.)
    - The bottom width is **`100 feet`**
    - Sideslope is **`2:1`**. The canal is relatively flat through the Everglades Agricultural Area.
12. Create a file "**`eaamc_canal.init`**" that contains the initial head for each canal segment. The first line will have "netinit" and the remaining lines will have the head values ordered by segment id, one value per line. Set all initial heads = "**`9.0`**".
13. Create an "**`avcs.index`**" file to assign the appropriate segment (**`avc`**) definition to each segment. In this example, there is only one **`avc`** type defined, "**`1`**". The first six lines are defined as the following with **`ND`** equal to the number of segments:

```
DATASET
OBJTYPE   "network"
BEGSCL
ND 13
NAME           "segment index"
TS 0 00
```

    This is followed by a list of arc assignments ordered by segment id, one value per line.

14. Save the segment file as **`eaamc.map`**. The resulting file should look like the file in **Fig. 3.8**.
15. Using the RSMGUI, test the map file by running **`sample_eaa_net.xml`**.
16. Using HEC-DSSVue from the RSM GUI, plot the heads for cells 1, 7 and 30.
    - Why are the head time series different?

```
MAP
BEGCOV
ACTCOV
COVNAME "default coverage"
COVELEV 0.0
COVATTS GENERAL
NODE
XY 2.501E+3 2.501e3 0.0
ID 1
END
XY 5.001e+3 5.001E3 0.0
ID 2
END
NODE
XY 7.501e+3 7.501e3 0.0
ID 3
END
NODE
XY 1.001e+4 1.001e+4 0.0
ID 4
END
NODE
XY 1.2501e4 1.2501e4 0.0
ID 5
END
```

Canal type, bottom width, bottom elevation, side slope

```
ARC
type trapezoid 100.0 498.0 0.0
ID 19
NODES        1        2
END
ARC
type trapezoid 100.0 498.0 0.0
ID 20
NODES        2        3
END
ARC
type trapezoid 100.0 498.0 0.0
ID 21
NODES        3        4
END
ARC
type trapezoid 100.0 498.0 0.0
ID 22
NODES        4        5
END
ENDCOV
```

Figure 3.7 Typical **`canal.map`** file from the RSM benchmarks.

```
MAP
BEGCOV
ACTCOV
COVNAME "default coverage"
COVELEV 0.0
COVATTS GENERAL
NODE
XY 719602 859609 0.0
ID 1
END
NODE
XY 716990.8 851036.8 0.0
ID 2
END
NODE
XY 714379.6 842464.6 0.0
ID 3
END
NODE
XY 711768.4 833892.4  0.0
ID 4
END
NODE
XY 709157.2 825320.2 0.0
ID 5
END
NODE
XY 706546 816748 0.0
ID 6
END
NODE
XY 709064.8571 805031 0.0
ID 7
END
NODE
XY 711583.7143 793314 0.0
ID 8
END
NODE
XY 714102.5714 781597 0.0
ID 9
END
NODE
XY 716621.4286 769880 0.0
ID 10
END
NODE
XY 719140.2857 758163 0.0
ID 11
END
NODE
XY 721659.1429 746446 0.0
ID 12
END
```

Figure 3.8 Complete network geometry file (**`eaamc.map`**) for simple EAA-MC Basin model

```
NODE
XY 724178 734729 0.0
ID 13
END
NODE
XY 729943 726366 0.0
ID 14
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300001
NODES        1        2
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300002
NODES        2        3
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300003
NODES        3        4
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300004
NODES        4        5
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300005
NODES        5        6
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300006
NODES        6        7
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300007
NODES        7        8
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300008
NODES        8        9
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300009
NODES        9        10
END
```

Figure 3.8 Complete network geometry file (**`eaamc.map`**) for simple EAA-MC Basin model (cont)

```
ARC
type trapezoid 100.0 -16.0 2.0
ID 300010
NODES       10        11
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300011
NODES        11        12
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300012
NODES        12        13
END
ARC
type trapezoid 100.0 -16.0 2.0
ID 300013
NODES        13        14
END
ENDCOV
```

Figure 3.8 Complete network geometry file (**`eaamc.map`**) for simple EAA-MC Basin model (cont)

Answers for Lab 3:

Exercise 3.1.1

7. How are the head time series different?

The initial head for cell 1 is about 11.9 ft and drops to 10.1 ft by April, then goes asymptotic to a head of 10.0 ft. The head in cell 30 quickly goes to 8.0 ft and then stays constant throughout the run period.

Exercise 3.1.2

5. Why are the head time series different?

These time series are different because of the difference among the cell's proximity to the canal. The head in the canal is significantly lower than that of the cells so water gradually seeps into the canal from the surrounding cells (this is a default watermover). The closer the cell is to the edge of the canal, the more quickly and lower the head will drop over time, as evidenced by the heads in these cells.

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