

**Office of Modeling
Statement of Work (SOW)
for Part I of III Scientific Peer Review of the
Hydrologic Simulation Engine (HSE) and
Management Simulation Engine (MSE)
of the Regional Simulation Model (RSM)**

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Project Name: Independent Scientific Peer Review of Version
2.2.9 of the Hydrologic Simulation Engine (HSE)
and Management Simulation Engine (MSE) of the
Regional Simulation Model (RSM)

Date: May 16, 2005

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Statement of Work Summary

This Statement of Work (SOW) defines services to perform Part I of III of a scientific peer review on the Regional Simulation Model (RSM) theory, including the Hydrologic Simulation Engine (HSE) and the Management Simulation Engine (MSE) components. The Part II peer review will occur in 2005 and will focus on the Natural Systems Regional Simulation Model (NSRSM) implementation validation, and Part III peer review will begin in late 2005 and will focus on the South Florida Regional Simulation Model (SFRSM) implementation calibration. This work will be detailed in separate SOWs.

RSM has been created and is maintained by the South Florida Water Management District (SFWMD) in West Palm Beach, Florida. This model is a new generation computational tool that can be used to simulate a wide variety of hydrologic situations. As part of the development life cycle of this model, a scientific panel of experts will be chosen to evaluate and scrutinize the theoretical and the conceptual formulations and to examine the documentation and the papers that have been published which contain further information on the theoretical foundations of the model. The purpose of this work is to improve the overall quality of the RSM by identifying the strengths, weaknesses, and limitations in the model theory and conceptual formulation.

The panelists' scope of work shall consist of the tasks specified in section 3. These tasks include:

1. Reading the RSM Theory Manual, journal and conference papers, and white papers.
2. Preparing questions or editorial comments on this information prior to the interactive planning and training session in West Palm Beach.
3. Participating in the interactive planning and training session during June 22-24 2005, in West Palm Beach, Florida.
4. Assisting in the organization and development of a draft panel report.
5. Writing the final panel report after receiving comments from the District on the draft report.

1.0 Introduction

By December 2005, the SFWMD (aka "the District") will complete a two-year project of finalizing numerical model development (the RSM) and an initial regional model implementation for South Florida. This implementation is titled the South Florida Regional Simulation Model (SFRSM).

The numerical model code used to solve the SFRSM implementation has been under development for approximately ten years. This model code is titled the Regional Simulation Model (RSM) and is currently composed of two principal components that include the Hydrologic Simulation Engine (HSE) and the Management Simulation Engine (MSE). The HSE and MSE are coupled within the RSM C++ object-oriented

code and do not exist as separate models. User input dictates if MSE components are used in conjunction with an HSE simulation. At this time, the RSM model is running only on the Red Hat Linux 9.0 platform, while pre- and post-processing codes run on both the Linux and Windows platforms.

The HSE simulates the coupled movement and distribution of groundwater and surface water throughout the model domain. With significant testing completed, the HSE source code is now considered to be in maintenance mode. The less-mature MSE provides methods that can simulate operational decisions and/or alternative management decisions for the regional water distribution system. Although the MSE is undergoing development at this time and is less mature than the HSE, it will be included in this peer review. The project scope and goals of the RSM Development and Implementation Project are discussed below, followed by a discussion of the peer review goals.

1.1 RSM Project Scope

The scope of the RSM Development and Implementation Project is to develop a flexible and powerful numerical model that can be used to accurately simulate a natural hydrologic system on a regional scale, including the effects of the water control structures present in South Florida. The HSE is capable of simulating the natural hydrologic system effectively, whereas new code is still being written for the MSE to simulate the management of man-made water control structures.

During the past year, an initial technical review of the HSE was completed by the Jacobs Engineering Center of Modeling Excellence in Oak Ridge, TN. This review evaluated the governing equations and numerical approximations used to simulate all hydrologic objects in the model. The review also developed additional documentation for the model, and performed some numerical testing of the HSE. This work was completed partially to prepare the HSE for external peer review. One of the goals of this work was to identify possible deficiencies in the theory and formulation of the RSM. Results and technical information from this review can be accessed on-line [at the RSM Peer Review web site](#).¹

The RSM is a regional model that will be used to predict the hydrologic responses to planning and operational scenarios while considering competing water management priorities and issues. This model represents the next generation of integrated water management modeling and provides the ability to simulate the complexity of the South Florida hydrologic system and is necessary to support decision-making processes well into the future.

1.2 RSM Model Components

The RSM is composed of several parts. The two main parts are:

- The Hydrologic Simulation Engine (**HSE**), which simulates the hydrology of the modeled area, including the canals, structures, levees and other barriers to flow.

¹ http://gwmftp.jacobs.com/Peer_Review/web_page/peer_review_sfwmd.htm

- The Management Simulation Engine (**MSE**), which simulates different operational heuristics and regulation schedules to give water managers a decision making tool for planning, water management and operation of the water resources system.

The RSM “toolbox” also includes tools still under development (and therefore not part of this review), such as:

- The Graphical User Interface (**GUI**), which provides a simple, easy to use tool for setting up a model run and providing a mechanism to view results graphically, as well as providing a mechanism for batch processing sensitivity runs.
- A **Geodatabase**, which provides a convenient storage and retrieval facility of spatial data for the modeled area. This is especially useful in model domains with many thousands of cells, as input dataset updates can be automated as spatial data changes.

1.3 RSM Project Goals

One of the primary goals of the RSM is that it must be both flexible and adaptable to changing conditions within South Florida. With the expansive planned changes to the South Florida basins under the Comprehensive Everglades Restoration Plan (CERP) and new water supply strategies, it is necessary to develop a model that can be adapted to simulate whatever new conditions develop. It is imperative that this model be easier to use than the existing water management model, South Florida Water Management Model (SFWMM), with shorter learning curves and improved documentation and examples. The object-oriented design of the RSM allows an implementation to consist of an assembly of different water management objects that can be interchanged as the model evolves. There will be no hard-wiring of site or operational conditions within the RSM or its implementations to allow maximum flexibility in model application. The following provides a list of the primary hydrologic processes that can be modeled in the RSM:

- Two-dimensional overland flow over arbitrary water bodies.
- Two-dimensional or three-dimensional groundwater flow coupled to surface water bodies.
- One-dimensional diffusion flow in canal networks.
- Independent layouts of 2-D meshes and 1-D flow networks overlapping fully or partially. The model can be used to simulate overland flow, canal flow, lake flow or any combination of them. The model is fully integrated, and all the equations for regional flow are solved simultaneously.
- Constant or variable storage coefficients that can describe soil storage capacity varying with depth. The variation can be described using lookup tables.

- Various overland flow conveyance behaviors based on Manning's equations, wetland flow equations and look-up table type functions with values varying with depth.
- Various transmissivity functions for confined and unconfined aquifers including lookup table type functions with values changing with depth.
- Reservoirs, or large water bodies, in full interaction with aquifers.
- Ponds or small water bodies residing within meshes but in full interaction.
- Many common types of structures, weirs, pipes, bridges etc. with more than one flow regime. All the structure types used in National Weather Service (NWS) models and the CASCADE model are available for use. Some of the USACE models are available as well.
- Virtual water movers based on 1-D, 2-D, or water level difference based lookup table functions. These water movers can move water from any water body to any other water body controlled by state variables in a third water body. A lookup table is used as a mapping function. A number of pumping and flood control conditions can be simulated using these lookup tables.
- Full three-dimensional simulation of groundwater flow, with any number of layers. Different numbers of layers can cover different parts of the horizontal domain.
- Water budget features that can track the movement of water throughout the model.
- A feature known as Hydrologic Process Modules (HPMs) that can capture a wide variety of local hydrologic functions associated with urban and natural land use, agricultural management practices, irrigation practices, and routing.
- Features capable of simulating detention storage and unsaturated moisture within HPMs.

To achieve these project goals, the RSM computational engines need to be peer-reviewed by subject matter experts. The peer reviewers will try to identify the strengths, weaknesses, and necessary enhancements in the model conceptualization/formulation and in the software implementation.

2.0 Peer Review Panelist Expectations and Guidelines

The objective of this work is to perform a peer review and to improve the overall quality of the RSM. This will be accomplished by a scientific panel of subject matter experts in the relevant topics described in Section 2.1. This review will consider the conceptual and mathematical framework of the model and the prospects for successful applications of the model.

The peer review panelists will be chosen by Jacobs Engineering from a list of qualified

candidates that have appropriate education and experience in the topics listed in section 2.1. Jacobs Engineering is assisting the SFWMD in conducting the peer review and will fulfill a role of unbiased and independent facilitators of the review. Jacobs Engineering has been chosen for this role because they are familiar with the model after having completed the preliminary technical review of the code. Jacobs has not been on the development team for RSM and therefore does not have any conflict of interest in this peer review.

All panelists will receive a fixed-price honorarium for their participation on the review panel. From this panel, one individual will be selected as the chairperson, to be a single point of contact between Jacobs and the panel. The chairperson will have additional duties compared to normal panel members and will therefore receive a larger honorarium. It is anticipated that each panelist will have areas of expertise that will be utilized to more fully evaluate specific parts of the RSM. The panel as a group will evaluate the entire model but certain sections of it will be scrutinized in more detail by individuals specializing in that subject matter. Each panelist will be assigned certain responsibilities by the chair during the on-site interactive planning and training session (IPTS).

All panelists will be expected to attend a two-day on-site interactive planning and training session (IPTS) in West Palm Beach, Florida, in June 2005. This session will help the panelists gain a better understanding of the RSM, its capabilities, and its existing applications. The panelists are expected to collectively define additional, specific goals of the peer review. These specific goals will include assigning topics for each panelist to evaluate more thoroughly. It will be expected that once individuals have been selected to the panel and have accepted their position, they will begin studying the model documentation to prepare themselves for the IPTS that will occur after the panel is finalized.

During the IPTS, RSM demonstrations will be provided to educate the panelists. Topics to be covered may include the theoretical basis for the HSE and MSE, model XML input and output, site-specific model assembly, discussions of benchmarks, and an overview of the printed and internet model documentation. The training sessions will be conducted by RSM developers and implementation specialists so that the panelists can have access to the people responsible for developing and using RSM. To maximize the benefit of the IPTS, all panelists should be prepared to take notes and ask questions about RSM.

The SFWMD has organized the peer review process in accordance with typical scientific review practices. Care will be taken by Jacobs Engineering in selecting the panel members to assure that reviewers are independent of the District. Panelists should have no substantial personal or professional relationship with the District. The panel can therefore be reasonably assumed to be objective in evaluating materials presented in the model and documentation. Such objectivity is the cornerstone of any true peer review process.

Panel review, as opposed to review by individual experts, is done by a group which reviews the model and documentation independently and then interacts with one another to formulate opinions on the state of the model. The panel will collaborate to author

recommendations and proposed changes to the model and/or documentation. Based on this collaboration, a draft report to the District will be prepared so that the RSM development team can respond and comment on the panel's findings. The panel chair will then write a final report incorporating District responses and the panel's final conclusions.

This Statement of Work will serve as the task instructions for the panel until the IPTS. Any questions need to be submitted in writing to Jacobs, and no private discussion between panel members is allowed before the IPTS. The Peer Review Panel will communicate initially during the IPTS. Subsequent to this meeting, a web board will be used as the only medium for the panelists to exchange questions and comments and to document their progress. This web board will allow panel interactions to be conducted in accordance with Florida 'government in the sunshine' statutes. Jacobs Engineering will provide a set of instructions for using the web board at the IPTS. The public can stay informed by reviewing [the RSM Peer Review web site](#)² and may wish to interact with the panel throughout the peer review process.

2.1 Peer Reviewer Areas of Expertise Requested

People selected to be peer review panelists must have demonstrated education and experience in one or more of the following areas:

- Surface water modeling, with 2D overland flow
- Watershed modeling
- Numerical simulation of coupled surface water and groundwater systems;
- Numerical techniques (including the finite volume method) used to simulate flow within and between natural and man-made objects such as lakes, canals, dams, weirs, pumping wells, etc;
- Local hydrology modeling
- Model applications that simulate water flow in flat-lying topographic settings, which are similar to conditions that exist in South Florida;
- Application of regional models for the purposes of water resources management and planning, water supply allocation, flood prevention, drought management, environmental restoration, and local-scale (sub-regional) model boundary condition specifications,
- Optimization methods, control theory, adaptive and feedback control, and other methods that can be used in operational control and water management.
- A working knowledge or familiarity with the following computer software and data storage methods: Linux, XML, C++, Python, GMS, DSS, and NetCDF files.

Additional expertise is beneficial in the following areas: auto-calibration techniques, calibration of regional models, numerical model error analysis, and innovative model post-processing techniques.

² http://gwmftp.jacobs.com/Peer_Review/web_page/peer_review_sfwmd.htm

2.2 Peer Review Goals

Although the peer review panelists will be instrumental in expanding the goals of the review during the IPTS, several peer review goals have already been determined. The focus of the review is on finding strengths, weaknesses, and possible applications. Recommendations for resolving clearly defined problems are desired. These goals include:

1. Determining if proper and sound scientific approaches were used in the development of RSM, making sure that a self-correcting open process is in place;
2. Evaluating if the conceptual framework of the model contains all of the important hydrological processes necessary to do regional scale modeling in South Florida;
3. Determining the appropriate use of the model in South Florida conditions;
4. Making suggestions on modifications and future improvements to the model, including any suggestions for improved computational methods, and future model expansion ideas;
5. Making suggestions on the usefulness of the model documentation, including whether the level of detail is sufficient or more is needed, whether the conceptual framework is clear, etc.
6. Suggesting any additional tests that may be desired to further validate RSM;
7. Suggesting tests for the HPM approach to simulating local hydrology and making recommendations for improvement or expansion of the approach; and
8. Evaluating whether the model is suitable for meeting client goals.

2.3 Anticipated Benefits

The final collaborative peer review report will guide the SFWMD modeling group toward a higher quality model that is scientifically defensible, more reliable, and easier to use and maintain. Benefits likely to result from the peer review process are:

- Confirmation on the use of the governing equations and the theoretical foundation used in RSM to be appropriate for South Florida conditions and the SFWMD mission.
- Confirmation on the use of RSM as a framework for regional model implementation at SFWMD.
- Better documentation, making the model easier to understand and modify.
- Development of an open environment to incorporate new and evolving modeling concepts for changing conditions

2.4 Additional Peer Review Resources

The Jacobs [RSM Peer Review web site](http://gwmftp.jacobs.com/Peer_Review/web_page/peer_review_sfwmd.htm)³ will contain useful information for the Peer Review panelists to help guide their work and shorten their RSM learning curves.

³ http://gwmftp.jacobs.com/Peer_Review/web_page/peer_review_sfwmd.htm

3.0 Scope of Work (Duties and Tasks of Panelists and Chair)

During this project, panelists and the Chair will be asked to conduct the following work:

1. **Read the introductory materials packet sent to you by the Peer Review Facilitators.** This packet will include the RSM Theory Manual and important papers considered “Required Reading”.
2. **Read the HSE and MSE additional references** to determine if they are adequate for the purposes intended, or to identify their limitations and make recommendations if enhancements are necessary. This includes the RSM Theory Manual, four published papers, and two white papers. Documents are provided on the Jacobs [RSM Peer Review web site](#)⁴.
3. **Prepare questions or editorial comments on all information prior to the IPTS.** It is expected during the IPTS that specific portions of the documents will be assigned to individual subject-area experts. Panelists should also prepare brief written comments on the materials for which they are primary reviewers and submit these to the Panel Chair. These comments can be incorporated into the panel report. The Panel Chair will organize such written products and will guide their submission onto the Web Board.
4. **Participate in the Interactive Planning and Training Session During June 22-24, 2005, in West Palm Beach.** Panelists will participate in the IPTS to learn about the model and to ask questions about it. It is expected that all panel members will have studied the model papers and documentation by the time the IPTS begins.
5. **Assist in the organization and development of a Draft Panel Report.** Panelists and the Chair will work collaboratively to complete the report which addresses the goals of this peer review as well as the goals determined by the panelists, using a Web Board as their means of communication.
6. **With organization by the Chair, the panel will collaborate in writing the Final Panel Report after receiving comments from the District on the Draft report.** The Panel Report will include a summary, conclusions and recommendations. The Panel Chair will organize the compilation and editing of the final report and will use the Web Board to communicate with the panelists.

3.1 Payment for Services

An honorarium will be paid to the panelists for participating in the meeting and panel report preparation.

⁴ http://gwmftp.jacobs.com/Peer_Review/web_page/peer_review_sfwmd.htm

Table 1: Peer Review Project Schedule and Responsibilities

Task	Responsible Party	Date Range
Contact and Select Panel Members	Jacobs	1/1/2005 to 4/15/2005
Execution of Purchase Orders	SFWMD Procurement	5/13/2005
Read RSM Documentation and prepare preliminary comments and questions. (DELIVERABLE #1)	Panelists	5/18/2005 through 6/21/2005
Attend 2-day Interactive Planning and Training Session (IPTS) in West Palm Beach, Florida	Panelists	6/22/2005 and 6/23/2005
Attend an optional helicopter and airboat tour to review field conditions	Panelists	6/24/2005
Submit sections for draft report—panelist conclusions, recommendations and narrative (DELIVERABLE #2)	Panelists	7/1/2005 through 7/15/2005
Draft Panel Report Assembly	Panel Chair	7/15/2005 through 7/29/2005
District Response to Draft Report	Jacobs, SFWMD	8/1/2005 through 8/19/2005
Panelists final input to Chair	Panelists	8/22/2005 through 8/31/2005
Final Report Submitted to SFWMD (DELIVERABLE #3)	Panel Chair, Jacobs	9/9/2005