SOUTH FLORIDA REGIONAL SIMULATION MODEL (SFRSM) IMPLEMENTATION: PROJECT MANAGEMENT ASPECTS

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Abstract The South Florida Water Management District (SFWMD) has undertaken an implementation of the Regional Simulation Model to the majority of South Florida to replace its existing regional modeling tool, the South Florida Water Management Model (SFWMM). Although the new generation finite volume Regional Simulation Model (RSM) has been under development for over ten years, there has been a concentrated effort to implement the model over the past two years. Alongside South Florida Regional Simulation Model (SFRSM) implementation, parallel efforts were to: develop and implement a standardized methodology for model development consistent with Capability Maturity Model (CMM) Level II standards; develop a graphical user interface for the model; and conduct required peer reviews. The overall effort was managed under the umbrella of the "RSM 2005" project. Challenges and lessons learned provide insight to applying project management to hydrologic model development and implementation.

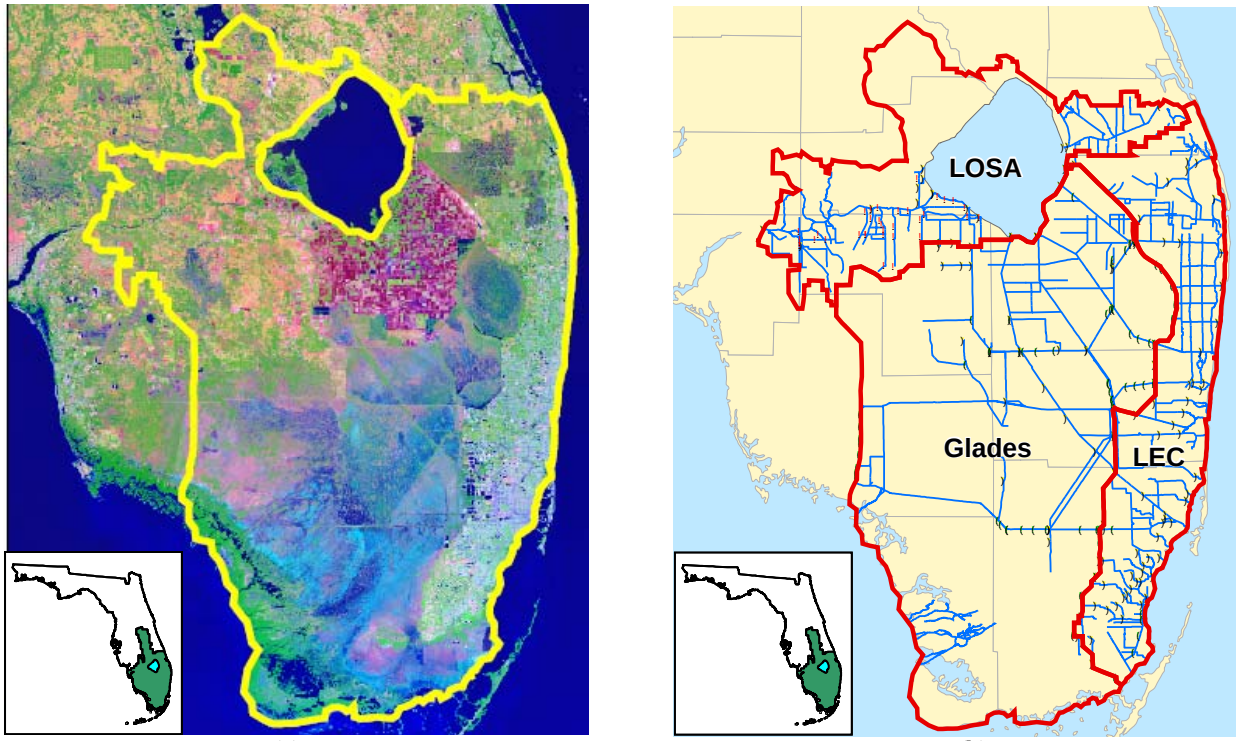
INTRODUCTION

Background Over the past decade, the Regional Simulation Model (RSM) has been under development as a future replacement to the South Florida Water Management Model (SFWMM), currently the primary regional simulation model used for planning purposes in South Florida. Although the RSM (SFWMD, 2005) has been developed to be the next generation integrated water management tool for South Florida, it is a generic tool that can be broadly applied to simulate both hydrologic and water management processes elsewhere.

The RSM is a fully coupled finite-volume surface water/groundwater model that implicitly solves for water stages (heads) as well as natural flows and managed flows through structures and canal networks. The RSM has two principal components, the Hydrologic Simulation Engine (HSE) and the Management Simulation Engine (MSE). The HSE simulates natural hydrology, water control features, water conveyance systems and water storage facilities. The HSE component solves the governing equations of water flow through both the natural hydrologic system and the man-made structures (future versions of RSM will include water quality and system ecology). The MSE component provides a wide range of operational and management capabilities to the HSE. The MSE is capable of simulating a wide range of management operations through water control features. Emphasis in the development of the RSM has been on computational efficiency, allowing application of modern automated calibration methods, and multi-decadal simulation capacity, to facilitate testing and evaluation of water resource project alternatives and system operations.

The South Florida Regional Simulation Model (SFRSM), the implementation of RSM to approximately ten thousand square miles in South Florida (Figure 1), has involved not only implementing South Florida hydrology in the model but further developing the management capability of the model to provide the ability to simulate the complexity of the South Florida hydrologic system necessary to support decision-making processes well into the future.

Challenge and opportunities To implement recommendations of a Strategic Modeling Plan [Plato, 2003], executive management at the South Florida Water Management District consolidated modeling functions and asked that the development and implementation of the South Florida Regional Simulation Model (SFRSM) be fast-tracked. This project was to adhere to project management principles, incorporate the Capability Maturity Model (CMM; Carnegie Mellon University, 1995) ideals for process standardization, and to promote a project management approach to modeling at the South Florida Water Management District. Furthermore, development of a graphical user interface for the model was initiated and a commitment made to conduct model peer review. This concentrated effort, named the "RSM 2005" project for its December 2005 deadline, required the involvement of many modelers, GIS technicians, code developers and contract staff, requiring enormous coordination and management.



(a) (b)

Figure 1 (a) South Florida Regional Simulation Model Domain on satellite image, and (b) Domain with canals subdivided into Lake Okeechobee Service Area (LOSA), Lower East Coast (LEC) and greater Everglades (Glades) model basins

The biggest challenge was the time constraint. The team was given twenty months to wrap up development of the new RSM, implement the SFRSM over an extensive area in south Florida (Figure 1), use more contractual support, cross-train in-house staff, participate in an agency-wide project management initiative with various project management training requirements and document deliverables, implement several CMM process areas, peer review the theory of the model and develop a consistent graphical user interface (GUI) to replace a wide variety of disparate tools and utilities supporting the RSM.

Although the project scope was fixed (i.e., to develop a new model to replace an aging model), there was some room for adjustment early in the project. The greatest flexibility was in resource availability. Executive management made a strong commitment to scale back other projects to allow dedication of a significant number of staff to this project, and provided funding for additional contractual support as unexpected needs arose. An experienced contractor was made available to lead project coordination. Approximately 50 people including more than 15 consultants have or are contributing to the two year accelerated project which has a budget of close to 5 million dollars.

PROJECT MANAGEMENT

Project Initiation It was very important to ensure full participation and support of the RSM 2005 team since most were undertaking other modeling projects. It was important to focus their attention early on the RSM 2005 project as their highest priority. Use of a project management approach to modeling was also new to many modelers. Team members accustomed to working on small two to three people teams were now being asked to perform on a team consisting of up to twelve sub-teams, with a fully developed chain of command and project management that included the need to communicate with sponsors and oversight committees. Project initiation was executed deliberately to acclimate individuals into a more formal large team structure and secure project support from everybody involved.

A series of scoping meetings were conducted to gain acceptance of the initial project plan and to allow team members to be involved in fully developing the scope of work, project organization and the time requirements to successfully meet the sponsor's expectations. A kick-off meeting was used to confirm the limits of the model and to fully define the project's mission statement, assumptions and develop a general approach to the project. The intent of the kick-off meeting was also to assemble the large team and allow them to work together on the preliminary project component definition. Information and decisions made at the kick-off meeting laid the groundwork for an interactive planning session conducted later to build teamwork and consensus in task planning and to sequence critical activities needed for project completion. An interactive planning session was to develop a draft schedule that was later built into a full Primavera Project Planner for the Enterprise (P3E) schedule. The interactive planning session also provided a list of key requirements to initiate immediate action in line with the long term goals of the project. The mission resulting from the kick-off meeting was defined as follows:

RSM 2005 Mission To develop and implement a calibrated Regional Simulation Model in South Florida, SFRSM, by December 2005 and include whatever management features possible towards simulating current operations of the system.

The final series of scoping meetings conducted during project initiation involved direct meetings with three project sponsor organizations, namely agency and inter-agency groups that would be the ultimate clients of modeling services using the new model. These client summits provided presentations that outlined project execution plans developed during the planning session and provided an opportunity for client groups to provide project input and confirm their desired outcomes from the project. Notes from the client summits were the foundation of the RSM 2005 client desire matrix, which categorized sponsor needs and was used at major project milestones as a basis for management decisions to focus daily work execution.

Products from the scoping meetings provided the foundation material for the Project Charter and Project Management Plan (PMP). The Project Management Plan documented the Work Breakdown Structure used to coordinate the various sub-team activities and manage the project. The PMP provided a common ground document that stakeholders and project management could use to track and evaluate project performance.

Flexible Management A flexible management strategy was adopted for the organizational structure of the team. It was determined during the preliminary project planning, kick-off and interactive planning sessions that there would be three phases (Figure 2) to the project, each requiring a different team structure to function efficiently. Due to the dynamic nature of model development and implementation, actual milestones varied from those illustrated in Figure 2. The first phase involved the use of an organizational structure that was linear in fashion with the various sub-teams being assigned the responsibility of producing various "building blocks" including regional model code development, collection and assembly of databases and development of graphical user interface tools. Strong technical coordination through phases of the projects was key to ensure coordinated development and linking of the model components. The team organization was intentionally realigned in phase 2 to effectively piece the "building blocks" together including initial calibration and finalizing the graphical user interface tool development and integration. Use of an adaptable organization structure allowed the various sub-teams to apply their skills to changing tasks rather than being constrained by a static organization structure.

A flexible communication system was also adopted to provide information both upward to sponsors and steering committee members and downward to team members so decisions could be made quickly and the team could immediately act to execute decisions. The goal of the communication plan was to give the project team the ability to seamlessly execute project course changes due to intentional project changes and be able to respond quickly to unanticipated changes so that the team's production would be minimally impacted. The communication plan centered on scheduling project level meetings sequentially each week to allow for communication of issues from lower level sub-teams to higher management level meetings for prioritization later during that same week. A project managers meeting was held at the end of every week to provide upward communication to project sponsors. This sequence of meetings through every week ensured that production speed was emphasized while still providing project status reporting to upper management.

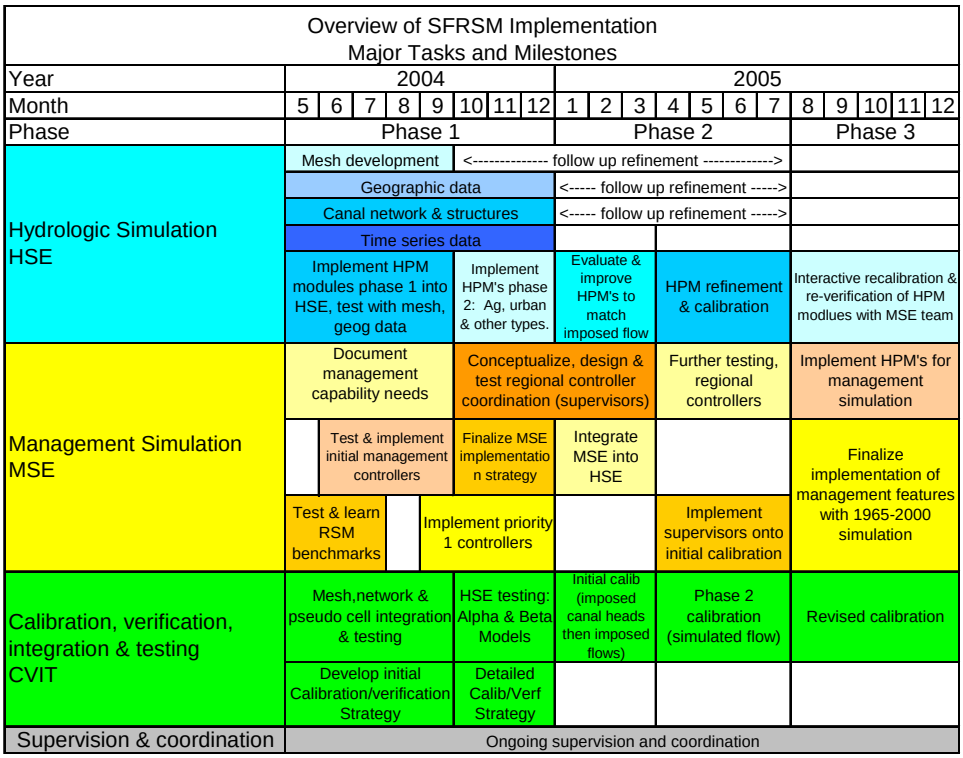


Figure 2 Conceptual "block" diagram showing planned phases of SFRSM implementation and major tasks for various sub-teams

Challenges Key challenges in managing the project have been to manage expectations, balance accelerated model development with the need for model documentation, knowing when sufficient development is enough and managing a large dynamic team with diverse personalities.

The goal of the project to complete a calibrated validated version of the SFRSM by December 2005 was clear, however the level of operational features and agency and outside expectations have not been clear and have required expectation management. A high level of interest in the project has raised expectations of some that the SFRSM would be ready for application following completion of calibration and validation in December 2005. To manage this expectation a longer term plan (Figure 3) was used to communicate that the RSM 2005 effort is the first phase of a longer effort that includes 2006 as a transition year during which time management features will be implemented and tested before the SFRSM is available for production type water resource alternative simulations.

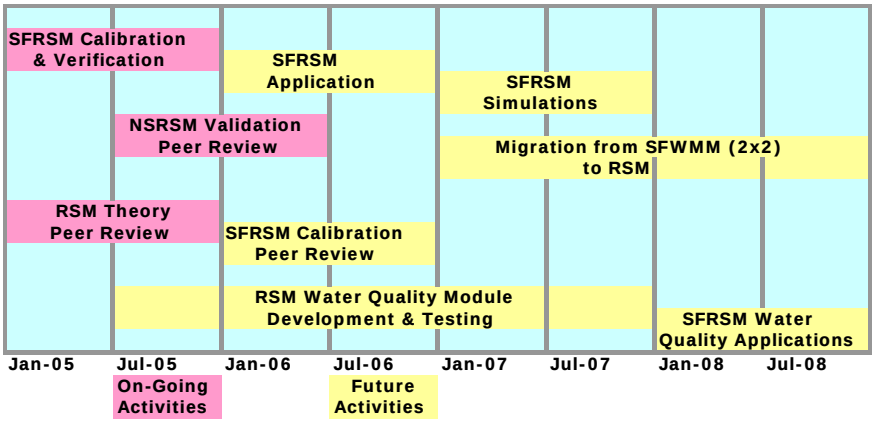


Figure 3 Overall RSM Development and Implementation Plan

Accelerated model development and implementation, to meet key milestones has resulted in documentation often lagging development or not being adequate. Although templates were developed to facilitate documentation, this is an area that could be improved. Peer review in several stages (Figure 3) has forced documentation to occur in a rush mode prior to the peer review.

In implementing a model over a large area with several teams involved in the implementation, knowing when sufficient detail or development in any one area is enough for the overall regional product has been challenging. Modelers with experience in regional model applications have helped guide teams away from getting into too much detail for a regional implementation.

Maintaining productivity and harmony within teams of very diverse people is always a challenge. To improve understanding among individuals the entire team undertook People Map training [Lillibridge, 2001]. This helped individuals understand different personalities and improved the level of communication. Knowing the personality types of the team members has helped facilitate communication in their terms. A mid-project off-site meeting held between phases 1 and 2 addressed team expectations and gave sub-teams the opportunity to report on their progress and raise concerns. Discussion focused on lessons learned, inter-team dependencies and plans to adjust schedules to achieve the project goals. Detailed project implementation plans were adjusted following the mid-term meeting.

PUTTING THE PIECES TOGETHER

Although the flexibility in structure described earlier provided the functionality to modify the sub-team structure during the implementation process, a mechanism for establishing a basis for determining and communicating project priorities between the many sub-teams was needed. A multilevel concentric organization conceptualization (Figure 4) provided the necessary mechanism to maintain focus and define the roles and working relationships among the sub-teams. The RSM 2005 project consisted of four major components, implementation of the SFRSM, development of a graphical user interface (GUI), implementation and code development in accordance with CMM principles and peer review of key aspects of the RSM. These four aspects have been referred to as GIPC, representing GUI, Implementation, Peer Review and CMM principles.

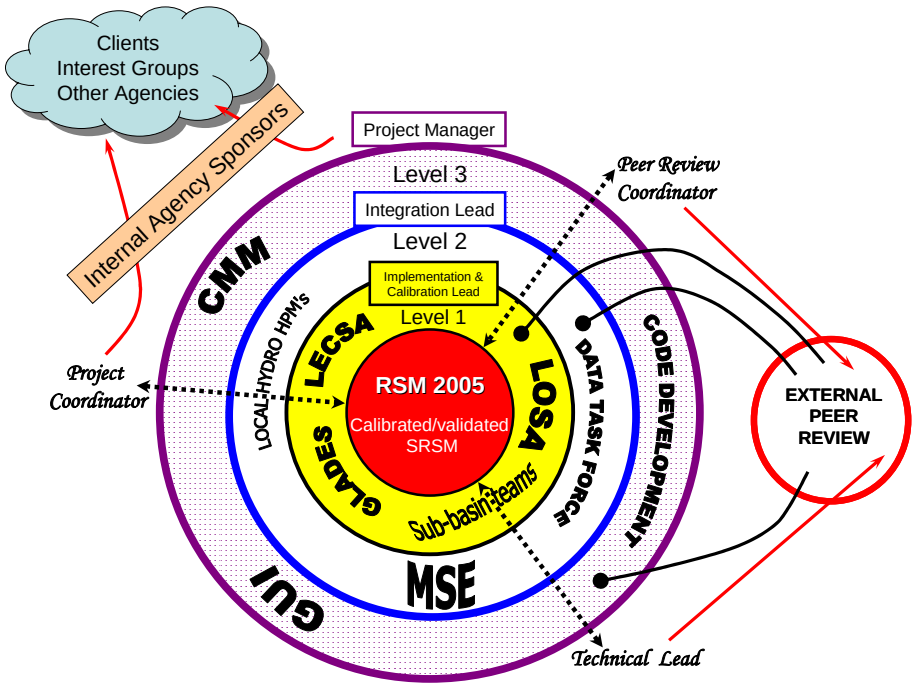


Figure 4 Project team responsibility and focus conceptualization to assist prioritization

At the center or core of the project was the need to achieve the primary goal or mission of having a calibrated validated SFRSM by the deadline. Without achieving that primary goal the other parts to the project would not be meaningful. Hence this core goal provided the target for the entire project and the focus for the four major GIPC components. Implementation formed the inner two concentric circles or bands of the project while the Graphical User Interface (GUI), CMM and code development made up the outer band (Figure 4). Leaders of several sub-teams at each level were responsible for products within their circle of responsibility from model implementation and calibration at the inner level to technical integration at the next level and overall project management at the outer level. Cross-level communication was facilitated by a project coordinator, a peer review coordinator and a technical lead who each provided input at all levels. The project manager and project coordinator also provided feedback to the internal project sponsors, project clients and other groups and individuals interested in the project. The peer review coordinator facilitated external peer review of the project at various stages providing peer reviewers with a window to all levels of the project. More detailed discussion of each of the GIPC components and their inter-relationship to meet the RSM 2005 project goals follows.

Implementation Responsibility of the inner circle or basin teams was to deliver an initially calibrated model for each of three geographical areas, the Lake Okeechobee Service Area (LOSA), an area encompassing the greater Everglades (Glades) and the Lower East Coast (LEC) Service Area or LECSA (Figures 1b and 4). As the project progressed into phase 3 (Figure 2), teams were adjusted to form the core calibration team charged with delivering the final calibrated validated model for the entire model domain.

Integration At the next level a Technical Integration (TI) team supported the activities of the inner circle. Within the TI team, the Management Simulation Engine (MSE) sub-team provided the operational functionality required in the model including control and operation of individual structures and the overall regional supervision and coordination of structure operations. Local hydrologic processes and parameters were developed and provided by the Hydrologic Process Module (HPM) sub-team, e.g. irrigation at field-scale level. Within level 2 (Figure 4), data accumulation, data checking and creation of data bases was originally undertaken by several sub-teams as part of the Hydrologic Simulation Engine (HSE) implementation (Figure 2). Later data support was provided by a data task force charged with proving ongoing Geographical Information System (GIS) support and undertaking mapping, data checking and ground-truthing as needed.

Graphical User Interface The GUI team at level 3 (Figure 4) was set up to meet the needs of sub-teams at the lower levels. Initially many different disparate software tools and utilities were being used in various aspects of model implementation. The GUI team was formed to evaluate the different tools being used, develop a standard interface to consolidate all necessary pre and post processing tools, and further develop new tools and features as required by the implementation teams. An existing enterprise GIS system was used as the primary repository for spatial data and was enhanced for generation of RSM input files. Post processing was implemented in the GUI using the widely accepted Python programming language. GUI development followed a standard software development life cycle with a traditional phased project management approach.

The RSM GUI offers a single interface to a collection of tools designed to make modelers more efficient. With the GUI, users can create, read and modify model input files, run the model and visualize output from the model. Automation of steps within the modeling processes through the GUI also helps to reduce errors.

Capability Maturity Model The Strategic Modeling Plan (Plato, 2003) developed for the South Florida Water Management District, recommended standardization through a process framework known as the Capability Maturity Model (Carnegie Mellon University, 1995). Recognition of the need for hydrologic modelers to adopt standardized processes and procedures is a paradigm shift towards modeling with a higher level of efficiency, improved quality increased repeatability and enhanced credibility, ultimately translating to a reduction in the cost of modeling.

The CMM describes an evolutionary improvement path from ad hoc, immature processes to mature, disciplined processes. The first three levels of the five level CMM can be summarized as follows.
Level 1 (Ad-hoc) An initial state where there are little or no documented processes and procedures and work has limited measurement for future success.
Level 2 (Repeatable) Several key process areas are focused on and developed to aid in creating the ability to reproduce success and weed out areas that inhibit it.

Level 3 (Defined) Key process areas are tied together to round out a business process and set up an infrastructure for continuous improvement.

Initiation of the CMM involved hiring a consultant to conduct a baseline Gap Analysis to assess the current level of process maturity. The Gap Analysis report indicated a strong CMM Level 1 organization with five Level 2 key process areas at around 30 percent maturity and a sixth Level 2 process at around 20 percent maturity. Scores for the seven Level 3 key process areas ranged from around 25 to 45 percent maturity. A goal for the RSM 2005 project was established to achieve process maturity for all six CMM Level 2 processes and achieve maturity at CMM Level 3 for peer review.

CMM progress since the Gap Analysis has included establishing a change control process and board for SFRSM data, developing several process assets and creating a process asset library to organize and maintain process assets. Furthermore a process infrastructure including an engineering process group and process area teams have been established to facilitate continuous process improvement.

Model Code Development Structured modular RSM code development using object-oriented (OO) code design has been adopted to allow the model to be flexible and adaptable to changing conditions. Recent freely available efficient numerical solvers and a flexible grid resolution have been implemented within the robust OO code design that allows model implementation using an assembly of different water management objects that can be interchanged as the model evolves. The need for clean code design and participation by multiple developers from a variety of disciplines has necessitated the regular use of test cases to routinely check code integrity using benchmark tests before each code modification is accepted.

Recent model development has focused on options to simulate water management operations. Several approaches have been adopted. To reduce uncertainty in model development, concomitant with model implementation, parallel approaches to development of water management operations have been adopted. Promising features of more than one approach or different implementation options will likely be the result of these parallel efforts.

Peer Review Since the RSM is a new generation computational tool for future use in federal and state projects, peer review is not only an important part of the development life cycle of this model but also required to establish credibility and acceptance of the model as a future replacement to current modeling tools. Peer review of the RSM was scheduled in 3 parts. Part I included a scientific peer review of RSM theory and scientific foundation that encompasses the Hydrologic Simulation Engine (HSE) and the Management Simulation Engine (MSE) components. Part II peer review will focus on the Natural Systems Regional Simulation Model (NSRSM) implementation validation, while Part III peer review will focus on the South Florida Regional Simulation Model (SFRSM) implementation covering the model calibration and validation.

Part I, completed in October 2005 (http://www.sfwmd.gov/site/index.php?id=681), was to perform a cursory review of the source code and to examine the documentation and the published manuscripts containing further information on the theoretical foundation of the model. The goal of the Part I peer review was to improve the overall quality of the RSM by identifying strengths, weaknesses, and limitations in the model theory, conceptual formulation and software.

LESSONS LEARNED

Implementing a hydrological model that is still undergoing partial code development poses a unique challenge requiring a flexible team structure and execution approach. Periodically conducting self assessment “lessons learned” sessions between project phases allows management to determine strengths and weaknesses providing insights for deliberate actions to ensure the primary objectives of the project are achieved. Lessons learned sessions for this project emphasized repeatability of approaches or activities that proved successful and adjustment to approaches where results were not as efficient as the schedule required. Major lessons the team learned follow.

Clear definition and complete acceptance of project scope at the very onset is extremely important to focus sub-team activities to efficiently meet client expectations. In this project the extent of water management features to be simulated was extremely difficult to define, and was never completely defined, because technical solutions to modeling operations were still under development. Without clear definition of implementation scope, client

expectations tended to be based on what they immediately wanted the model to do rather than be controlled by a structured schedule of deliverables. In areas other than simulation of operations, gathering of client needs and management of their expectations was very successful. The key lesson is to fix the scope early and ensure that every aspect of client expectations are defined and progress towards meeting these expectations is regularly communicated.

Project management flexibility was a strength of the team which made rapid changes to team structure and activity when needed to maintain progress towards meeting project milestones. Flexibility in approach was also a strength of the technical teams who approached extremely difficult technical challenges from numerous angles until a suitable solution was developed.

Good documentation is essential for future repeatability, but also enhances successful model peer review. A constant challenge to the team was to balance time spent documenting modeling implementation and development versus actually spending time undertaking model implementation and development. It would be wise to develop simple documentation methods such as modeling diaries or documentation templates to facilitate later more formal documentation.

During the peer review process, the team initially kept a running list of suggested model enhancements or modifications required for documentation. As this list grew, these "lessons learned" were categorized and distributed to other project teams undertaking peer review to pass on the knowledge gained from lessons learned. This list of lessons learned was transferred it to the agency's formal standard for documentation and lessons learned were formally presented to the entire organization.

CONCLUSIONS

The overall scope of the project was to provide a tool to simulate the hydrology and manmade water control features of South Florida. The SFRSM predicts the intricate results of implementing physical and operational alternatives being considered to address changing water management priorities and issues. Two major implementation phases of the project are complete. The first phase included assembly of model components and the second phase included calibration and validation. Future phases will include model application through 2006 and transition from the SFWMM to the SFRSM for production in 2007. The Project Team consisted of a strong central leadership group guided by a Steering Committee with input from major model clients. The Project Management Team led and coordinated efforts of project delivery teams adopting rigorous reporting procedures yet remaining flexible to address challenges as they arose. The CMM team ensured that software development standards were followed during the implementation process. Discussion of challenges, approaches adopted to project management and lessons learned, provide valuable information to hydrologic modelers that may undertake similar endeavors.

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