A.R.M. Loxahatchee National Wildlife Refuge

Refuge Modeling Development and Application – Status Report: June 2009

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Status – In cooperation with the University of Louisiana-Lafayette, the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) is developing and applying a suite of hydrology and water quality models. The models are formulated with varying levels of spatial resolution. The water quality model with the least spatial resolution has three concentric marsh cells and a single canal cell; the highest spatial resolution model represents the marsh as 3,494 active computational cells. These models improve our quantitative understanding of mechanisms affecting timing and levels of water depth, and water quality throughout the Refuge canal and marsh. Each model has specific advantages and limitations. Professional judgment is essential in using any model. Version 1 of our simplest model was freely available for download in June 2007, and versions of all models are currently available upon request.

At present, we are nearing the end of our intensive model development efforts which have produced a suite of four hierarchical models predicting stage (water surface elevation) and water quality (chloride, sulfate, and total phosphorus). The modeling team is completing responses to comments and incorporating suggestions provided by the Technical Advisory Panel in May 2009. Release of final model versions is expected to follow soon after these comments are addressed (Table 1). Future modeling team efforts will focus on model application and model maintenance after release of final versions.

Table 1. Summary and status of models.

MODEL	Version / Status	Final Version Release	Canal Cells	Marsh Cells	Stage	Water Quality[a]
SRSM[b]	4.0 Completed, under review	July 2009	1	1 / 3[c]	√	√
9-Box	1.0 Completed, documentation in preparation	August 2009	3	6	√	√
39-Box	1.0 Under development	August 2009	11	28	√	√
Mike-Flood Hydrodynamic	2.0 Completed, under review	July 2009	269	3,494	√	
Mike-Flood Advection-Dispersion	2.0 Completed, under review	July 2009	269	3,494		√

[a] Includes chloride, sulfate, and total phosphorus concentrations.
[b] SRSM is the Simple Refuge Screening Model.
[c] Aggregates marsh into a single cell for stage simulation, and 3 cells for water quality.

Background – At the July 24, 2003 TOC meeting, the committee forwarded recommendations to the Consent Decree principals that included an enhanced monitoring and modeling program for the Refuge. In FY04, Congress funded our modeling program which was implemented via a work plan (Brandt et al. 2004). A cooperative agreement was established with the University of Louisiana – Lafayette (Principal Investigator Dr. Ehab Meselhe), to provide model development and application. A separate cooperative agreement with Tennessee Tech University (Principal Investigator Dr. Vince Neary) provides for an independent Technical Advisory Panel. Although the Refuge's modeling project is broader than the 2003 TOC recommendations, it remains consistent with those recommendations.

Agency and public involvement – Prior to selecting the models for use, public meetings were announced to interested agency representatives and stakeholders, and to the TOC. Attendees included representatives from the South Florida Water Management District, Florida Department of Environment Protection, US Environmental Protection Agency, US Geological Survey, the Miccosukee Tribe, and members of the public. Later, in 2005, the Technical Advisory Panel first met in a public session.[1] Again, attendees represented diverse agencies as well as the public. The panel held their third review and advisory meeting at the Refuge on May 11, 2009. The panel meeting again was open to the public, and meeting time was provided for public questions and discussion of model issues with the modeling team and advisory panel. In addition, since 2005, three modeling workshops have presented details of modeling efforts and accomplishments to a broad range of agency representatives and the public.

Applications – The models have been used already by the Refuge for several applications to better understand Refuge needs for inflow quantity and timing. For example, modeling was applied to an analysis of alternatives proposed in the EAA Regional Feasibility Study. This analysis revealed that proposed diversion would reduce the period of inundation (hydroperiod) for much of the Refuge. Modeling also was used by the TOC sub-group on Refuge water needs to extend the range of modeling scenarios beyond those available using the South Florida Water Management Model. Sulfate modeling, undertaken to test, constrain, and add credibility to the hydrodynamic model formulations, additionally has provided understanding of how sulfate transformation within the Refuge is related to sulfate concentration and loading. Quantification of sulfate kinetics will improve our understanding the related process of mercury methylation in the Refuge and throughout the Everglades.

It is important that model users understand the basis of model formulations (e.g., a report on model kinetics is available on the website), their capabilities, and their limitations. Application of the highly aggregated SRSM can examine quickly a broad range of alternatives, but is not appropriate for site-specific projections. Even site-specific model results of the Mike-Flood model must be interpreted with an understanding of the uncertainty introduced by local topography and other local conditions beyond the resolution of the model input data. While the models reasonably mimic phosphorus fate and transport in the Refuge, users need to be aware that these models are deterministic, which means that they do not simulate statistical

[1] Agendas and presentations from advisory panel meetings and these modeling workshops are available at http://loxmodel.mwaldon.com/.

probabilities of occurrences. Direct application of model results to statistically derived properties, such as the Refuge total phosphorus levels defined in the Consent Decree, therefore would not be appropriate. The suite of models can, however, provide insight and understanding of conditions that are common at times of excursions.

Future use – We anticipate that these models will have a broad range of applications. The modeling team has identified a list of possible applications and the specific models that may be used:

- Given a projected inflow condition, project the temporal and spatial pattern of Refuge water depths. Determine the area of the Refuge that will have suitable conditions for wading bird foraging and estimate duration (Mike-Flood HD model).
- Analyze benefits and impacts of revisions to the Refuge regulation schedule. This analysis may include changing zone boundary stages or the sequence in which water supply make-up water is delivered (models at all levels of aggregation).
- Analyze changing the temporal and spatial distribution of outflow for water delivery to WCA-2 and the urban areas to the east (models at all levels of aggregation).
- Analyze the benefit of balancing inflows between STA-1E and STA-1W. Is it important, as far as practical, to synchronize discharge to minimize canal water intrusion? (Mike-Flood models)
- Test operational alternatives for pumps and outflow structures to find ways to reduce effluent intrusion (models at all levels of aggregation).
- Estimate the long-term impact on interior chloride concentration resulting from STA discharge (models at all levels of aggregation).
- Test changes in hydroperiod and water quality resulting from possible alternative designs for CERP projects (Mike-Flood models).
- Estimate water quality improvement at interior stations that would result from meeting the numerical criterion for phosphorus at all inflows (models at all levels of aggregation).
- Estimate the long-term impact (spatial extent) on interior TP concentration resulting from STA discharges that exceed the numerical phosphorus criterion (e.g., STA-1W outflow of 100 ppb) (Mike-Flood models).
- Estimate the spatial impact of STA bypass (untreated water) on the Refuge (Mike-Flood models).
- Analyze the benefit of diverting part or all urban water supply flows around the Refuge (Mike-Flood models).
- Explore other operational changes that reduce the impact of external loads on interior stations (models at all levels of aggregation).

For further information

(1) Presentations and publications related to the Refuge monitoring and modeling project are listed at http://docs.google.com/Doc?id=dm48k35_2hdcpdhgq.

(2) The SRSM home page is viewable at http://docs.google.com/Doc?id=dm48k35_8dmzdgtmj. This page reviews the SRSM model version history, and provides links to documentation and files.

(3) The Refuge Mike-Flood home page (under construction) is viewable at: http://docs.google.com/Doc?id=dm48k35_9gwjwjnd2. This page provides information on the Refuge Mike-Flood version history, and provides links to documentation.