Designing and Testing Modeled Hydrological Performance Measures

U.S. Fish & Wildlife Service
Arthur R. Marshall
Loxahatchee National Wildlife Refuge

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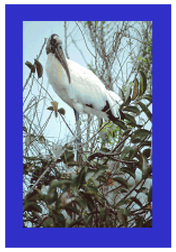
Arthur R. Marshall Loxahatchee National Wildlife Refuge

• Established in 1951 under the Migratory Bird Act of 1929 "for use as inviolate sanctuary, or for any other management purpose, for migratory birds."

• A 50-year license agreement between the USFWS and the South Florida Water Management District allows the USFWS to manage Water Conservation Area 1 as a National Wildlife Refuge

• Purpose within license agreement is to "… to promote the conservation of wildlife, fish, and game, and for other purposes embodying the principles and objective of planned multiple land use."



What is a Performance Measure?

A performance measure (PM) in other disciplines is also termed a figure-of-merit, or objective function. Modeled PMs may be applied as design constraints or as objectives to be maximized or minimized, and are often applied in support of selecting a preferred alternative. Performance measures quantitatively clarify project objectives, benefits, and impacts.

What were the project objectives and study plan?

Previous work by Dr. Laura Brandt, and others has attempted to better define Refuge water needs to meet ecological requirements. Here, alternative PMs for adequacy of meeting ecologically beneficial high stage conditions in the Arthur R. Marshall Loxahatchee National Wildlife Refuge are examined. We analyzed two alternative PMs using three modeling approaches:

a) The first PM, designated PM 1a, is based on the number of days during each annual high-water period that stage exceeds 5.18 m (17 feet) NGVD 29.
b) A second measure, designated PM 1b, annually aggregates a daily index that varies in a piecewise linear fashion from zero at and below 5.00 m (16.4 feet), to one at and above 5.30 m (17.4 feet).

These PMs were tested using:

1. The Simple Refuge Screening Model (SRSM),
2. A model applying the commercial MIKE-FLOOD model, and
3. The South Florida Water Management Model (SFWMM).

The three models performed similarly in predicting historical values of the PMs, and it is concluded that the simpler model, the SRSM, is likely the most efficient model choice for many modeling studies utilizing these PMs.

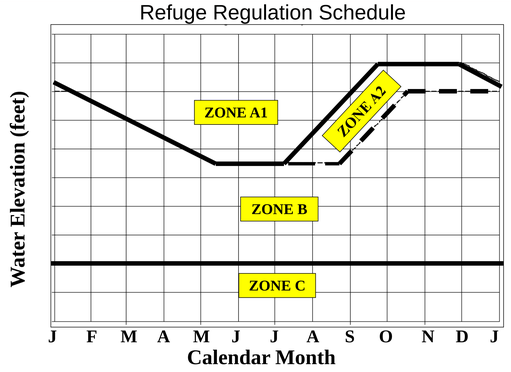
Meeting Refuge Hydrologic Needs?

- Total annual inflow statistics are problematic
  - Inflow and rainfall are correlated so there is a danger of improper conclusions
  - Timing is VERY important
  - Higher inflow years dominate statistics of central tendency
  - Higher inflow years often simply have larger releases
  - Operational decisions are important
- Conclusion – Use performance measures (PMs) based on stage not inflow
- A suite of PMs may be developed for use in assessing restoration alternatives

History, and What We Know

- Refuge regulation schedule controls only Refuge releases
- There have been 4 regulation schedules in Refuge
- 1975-1994 schedule had high-stage too low
- Refuge regulation schedule was revised in 1995 to raise stage
- Refuge has had higher Oct-Jan stages since 1995
- 1995-2001 high-stage conditions were likely adequate; no studies show that stages were excessive
- In 2001, S-6 pump was diverted
- 2001-present high-stages reduced in magnitude & duration

Refuge Regulation Schedule



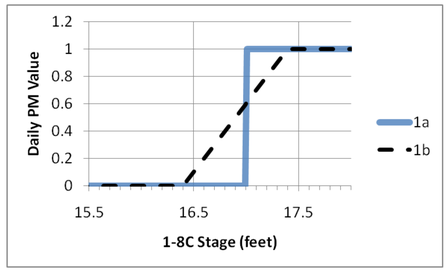
Definitions

Annual High Water #1 PMs –
Sum daily scores through each water year

a. Number of days in Florida water year that stage exceeds 17 feet
   – that is, daily score is 0 when stage is below 17 ft, 1 otherwise – target 3-4 weeks in 3 in 4 or 4 in 5 years

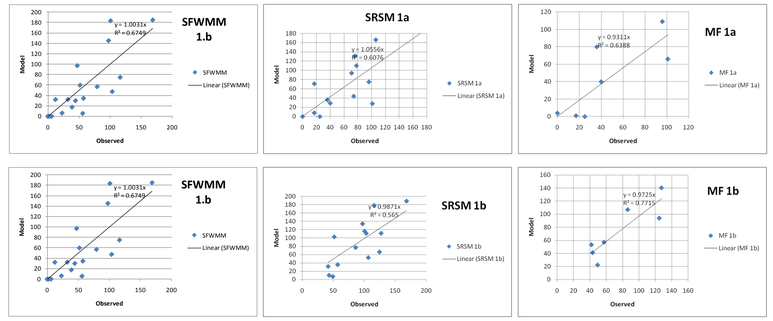
b. Alternative smooth transition similar to a.
   – days above 17.4 ft score 1, days below 16.4 ft score 0, otherwise score = stage-16.4 ft – target derived from relationship to 1.a target

Daily Scores for 1.a and 1.b



All 3 models performed better in predicting PM 1.b than PM1.a

South Florida Water Management Model | Simple Refuge Screening Model | DHI MIKE-FLOOD



Recommendations and potential applications for PM 1.b

- Use PM 1.b as first metric for Refuge alternative water management analysis for any proposal affecting Refuge stage
  - Criterion: PM 1.b annual index should exceed 55 at 25th annual percentile (longer than 4 year return)
  - No upper constraint is known
- Any provisionally selected alternative affecting Refuge stage should be further reviewed for other objectives & unanticipated impacts
- Projects that are likely to affect inflow or high stage might appropriately use this PM – judgment is required in any use
- Additional PMs will be developed for other aspects of Refuge hydrological needs
- Potential applications of this PM include alternative analysis for the River of Grass Project, STA and upstream impoundment designs, management alternatives for the S-10 gates under current or revised regulation schedule

Conclusions and Future Developments

We conclude that:

1.Traditional model calibration statistics do not necessarily correspond to the model's capability to simulate historical PMs.
2. Reliability of a model in projecting PMs is reduced for PMs that are dependent on very rare events over the simulation period.
3.Reliability of a model in projecting PMs is reduced for PMs that are based on a single trigger level or discontinuity.
4.Criteria for acceptability of model calibration in applications projecting PMs for alternatives may necessarily be less stringent than traditional model calibration evaluation.

Work reported here focuses on only high-stage water needs. Future work will focus on application of this and other Refuge hydrological PMs related to reversals and recession rate.

Acknowledgements and Disclaimer

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