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

Loxahatchee Hydrologic Performance Measures

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Acknowledgements

- Data compilation and modeling of Refuge water and constituents is led by Dr. Ehab Meselhe (PI), University of Louisiana-Lafayette. His efforts, and the efforts of other UL-Lafayette faculty, staff, and students is gratefully acknowledged.
- Refuge PM development is ongoing. Colleagues have reviewed the work shown here, and given constructive suggestions.

Example PMs

- Many examples of PMs in common use – Stock market index, Sports, …
- Ecology (and gardening) uses **degree-days**
  - Definition

    sum of daily (T – Tbase)
  - Uses

Design of Performance Measures (PMs)

A habitat PM is a calculated value that is:

- Strongly related to a desirable or undesirable habitat characteristic
- Quantifiable
- *and May be* - constant , time variable, spatially variable (map), both spatial and time variable

Design of Performance Measures (PMs)

A habitat PM:

- may have a value relative to alternatives
- or have a set target where above the target
  - All alternatives are equally acceptable (constraint)
  - Acceptable alternatives are ranked by PM

Application of PMs

- Assessment (historical, retrospective)
  - Use monitoring data
  - May use modeling to establish a target, or reduce variability from extraneous factors
- Evaluation (hypothetical alternative)
  - Use models to calculate PMs
  - Models should be demonstrated to be reliable in predicting PMs

General Refuge hydrological needs

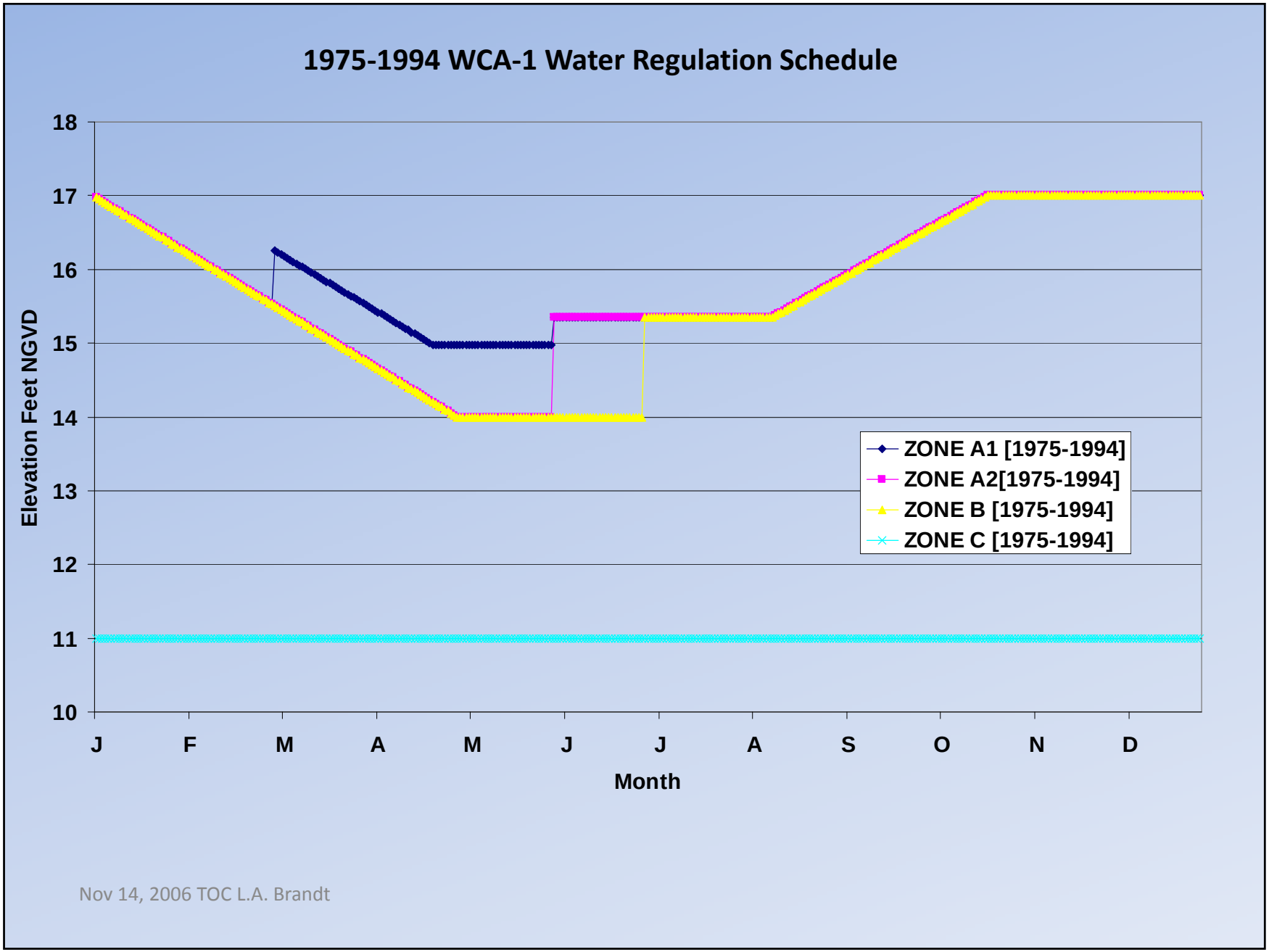
- Marsh stage to be at top of regulation schedule 3-4 weeks 4 out of 5 years
- Appropriate stage recession each year between January and April to encourage wading bird foraging success without excessive drying
- Limit stage reversals during this time
- Interannual stage variability that mimics natural patterns as much as possible

How can we measure meeting Refuge hydrologic need?

- **Total annual inflow** as a PM is 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 is being developed for evaluating alternative inflow scenarios under the current regulation schedule

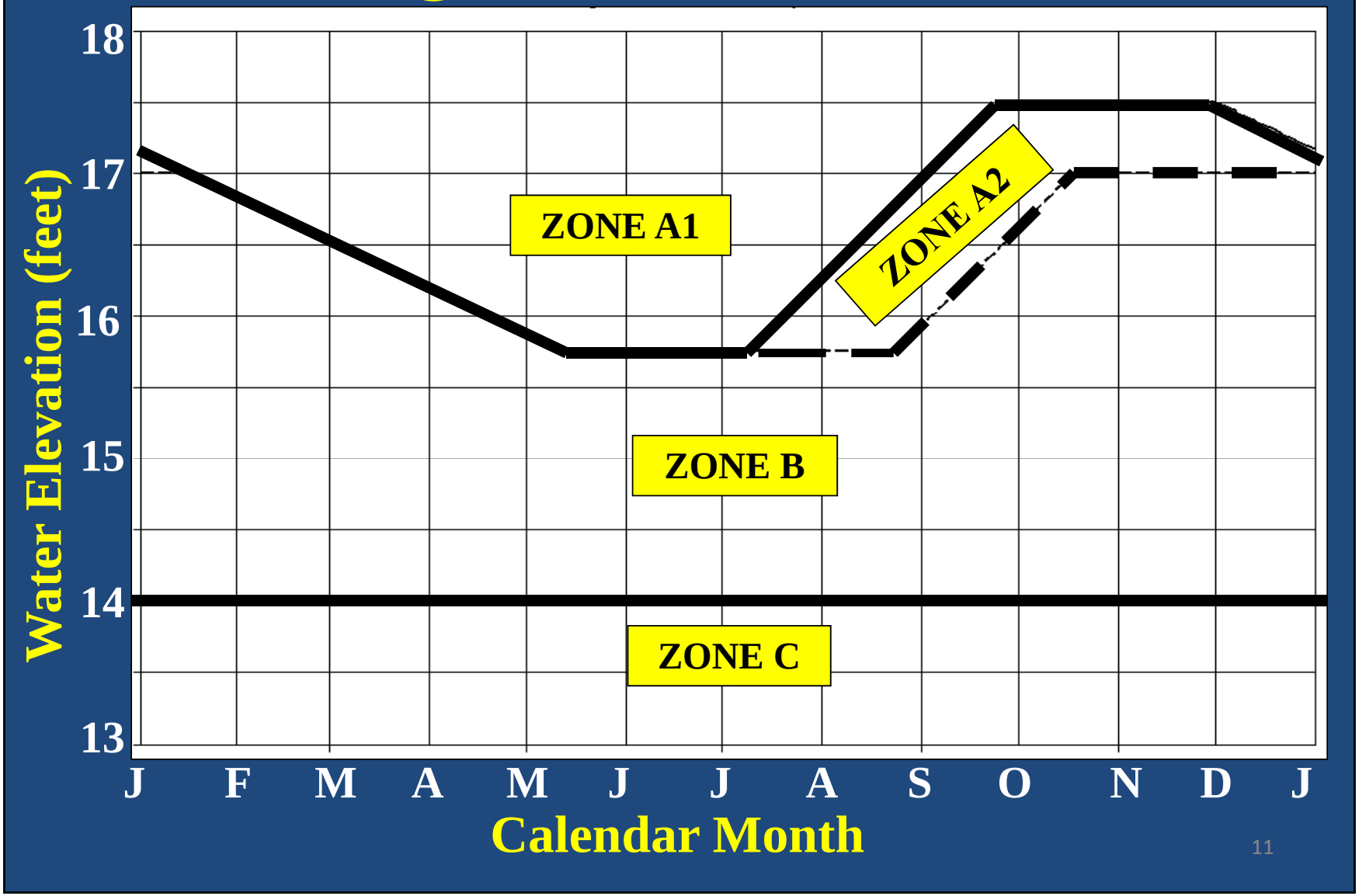
More History, and What We Know

- 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 highest 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



Nov 14, 2006 TOC L.A. Brandt

Regulation Schedule



Refuge Hydrologic Performance Measures

- PM suite currently proposed measure
  1. Reaching & holding high-stage (most years)
  2. Nesting Season Stage Target (appropriate recession)
  3. Reversals
- Select #1 as primary PM to identify potentially acceptable alternatives (i.e. PM 1 is a constraint)
- Other PMs then are used to rank alternatives that are acceptable under PM 1

Narrative: PM 1 – High-Stage

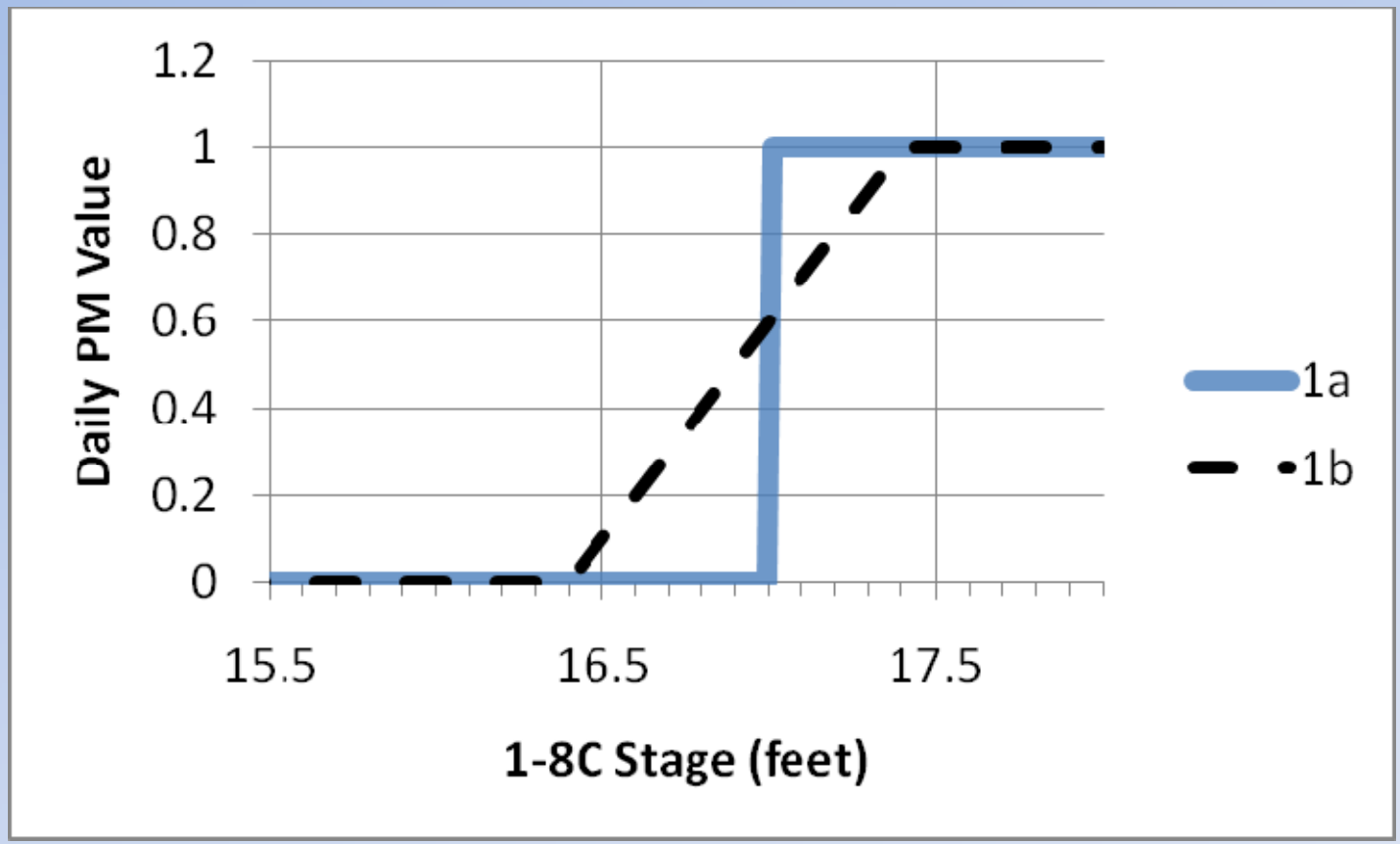
- Higher water (Oct-Jan) needed to:
  - Mimic natural hydropattern in timing & duration
  - Inhibit woody plant expansion in marsh
  - Inhibit wet prairie encroachment into slough
  - Inhibit expansion of non-native plants
  - Store water for ecological & water supply needs
  - Reduce canal water intrusion
  - Reduce phosphorus concentration
- Constraint: For most of the Refuge most years
  - depth>½ ft 3-4 weeks (21-28 days) in almost all of Refuge
  - Occur at least 3 out of 4, or 4 out of 5 years

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

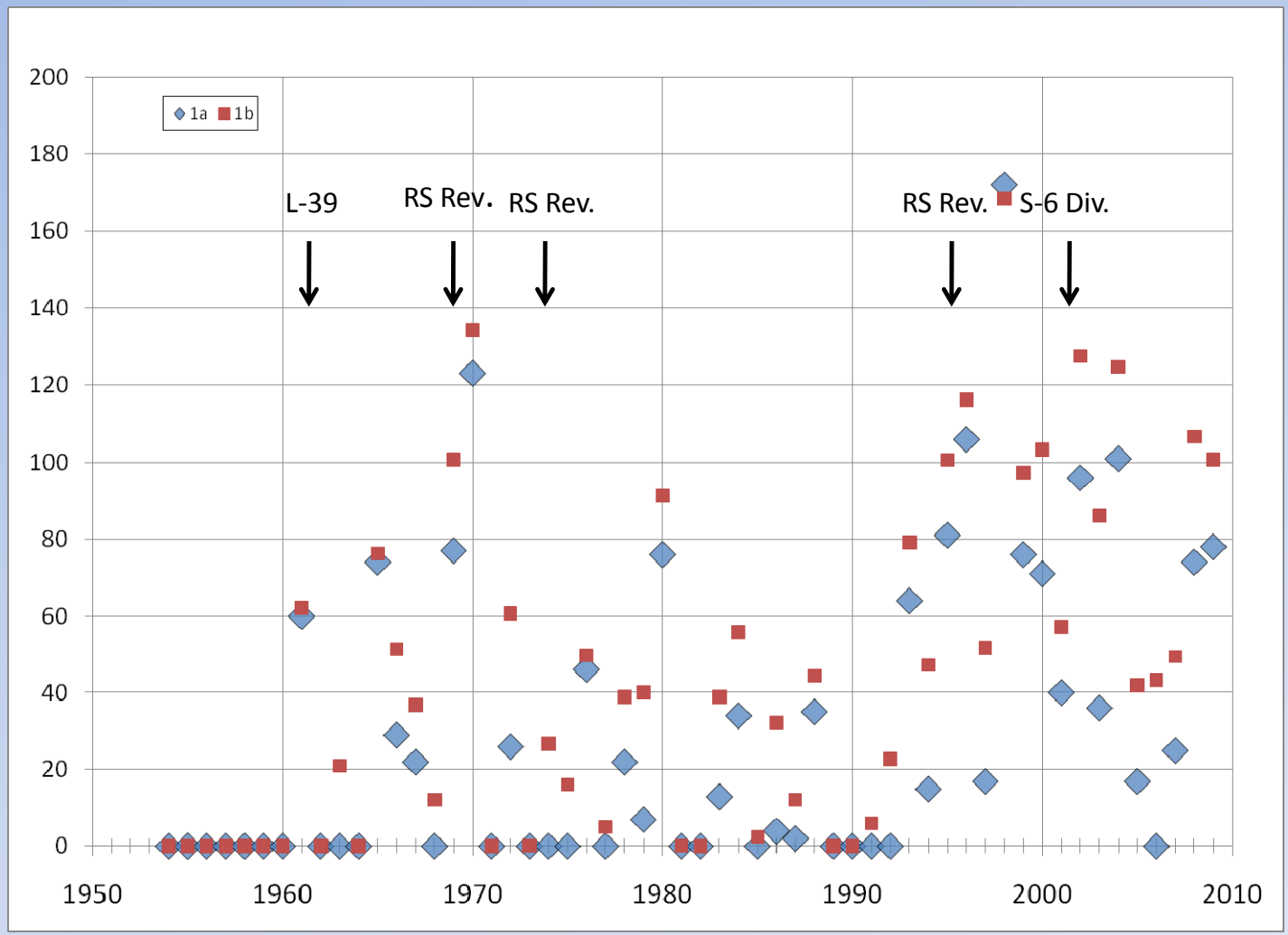
a. Number of days in Florida water year that stage exceeds 17 feet
   - that is, daily score is 0 when stage is below 17 ft, 1 otherwise – target 3-4 weeks in 3 in 4 or 4 in 5 years

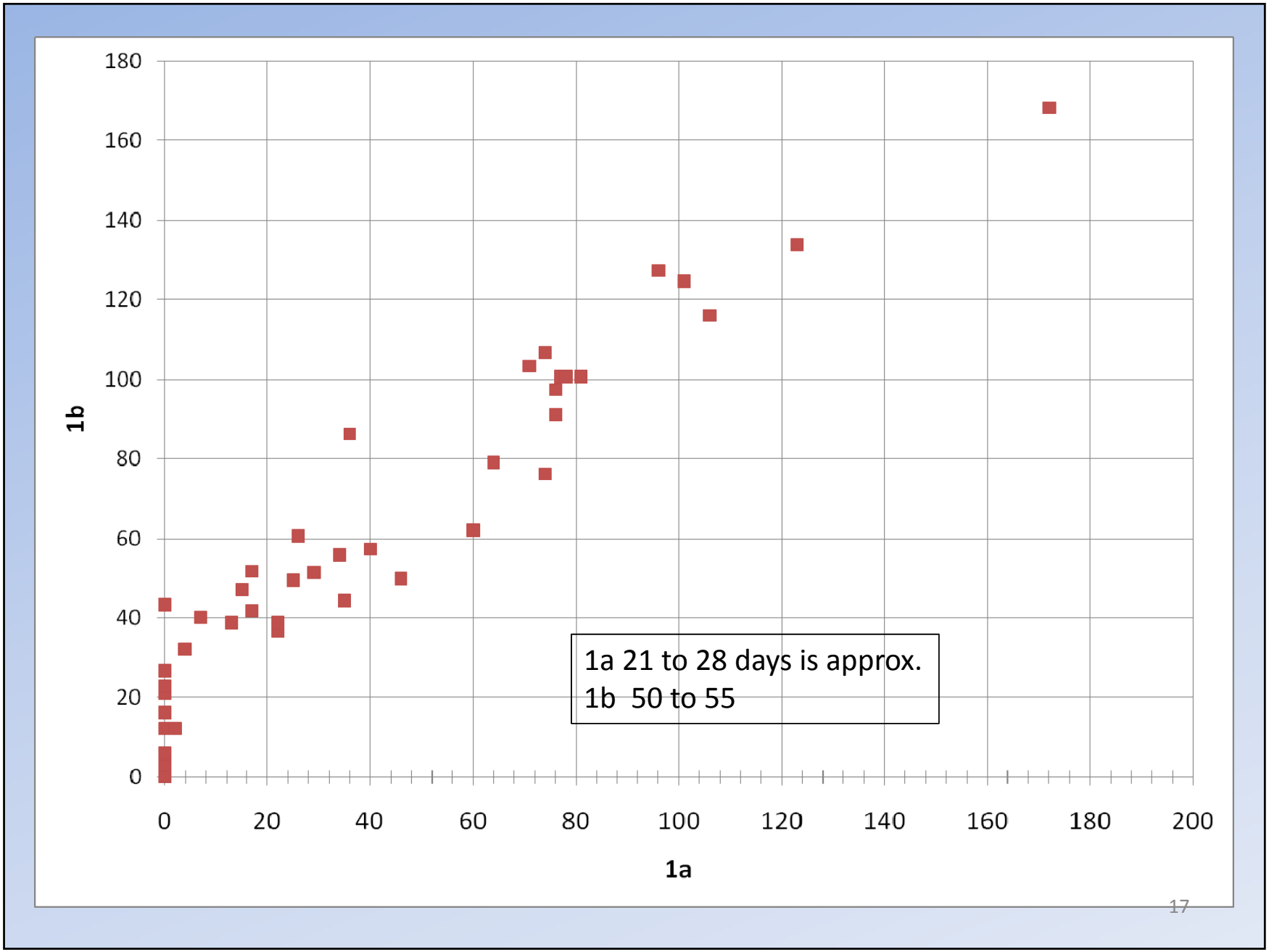
b. Alternative smooth transition similar to a.
   - days above 17.4 ft score 1, days below 16.4 ft score 0, otherwise score = stage-16.4 ft – target derived from relationship to 1.a target

Daily Scores for 1.a and 1.b



Annual PMs from Observed Canal Stage




180
160
140
120
100
80
60
40
20
0
1b
0
20
40
60
80
100
120
140
160
180
200
1a
1a 21 to 28 days is approx.
1b 50 to 55
17

PM 1.b Percentile Target

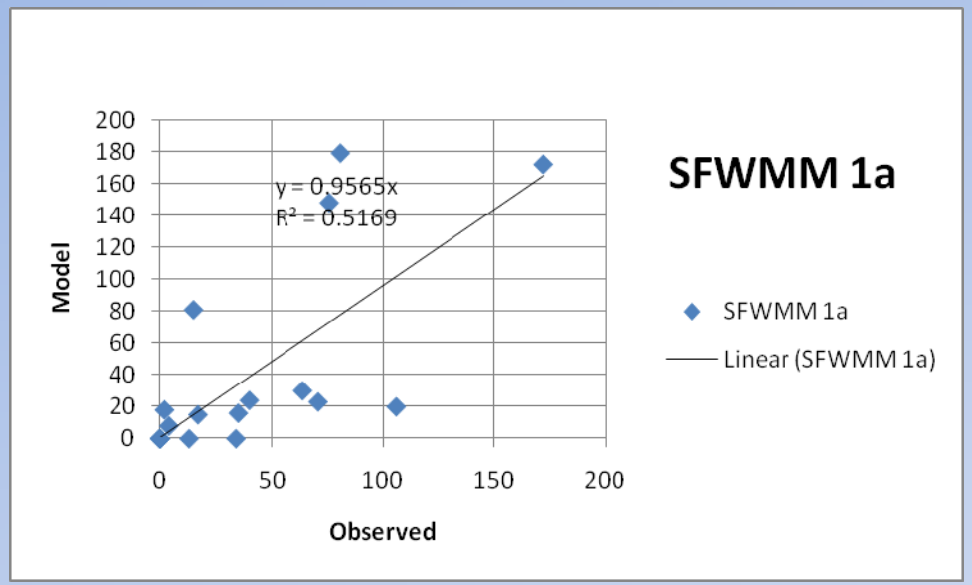
From analysis of historical data:
Target: PM 1.b –
4 year return (25 percentile) > 55

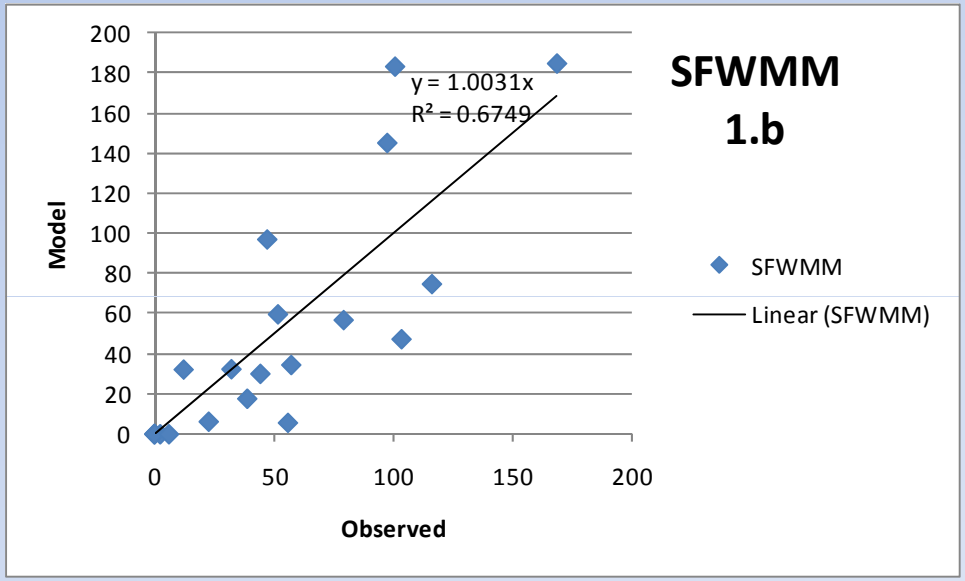
Model Performance Testing

Before using models to evaluate inflow alternatives for the Refuge, we should test if the models' predicted PMs reliably match observed PMs.

Evaluate 3 Refuge models:

- SFWMM – South Florida Water Management Model v5.4
- SRSM – Simple Refuge Screening Model v4
- MF – DHI MIKE-FLOOD Refuge model v2


SFWMM 1a
y = 0.9565x
R² = 0.5169
Model
Observed
SFWMM 1a
Linear (SFWMM 1a)
0
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200


SFWMM 1.b
y = 1.0031x
R² = 0.6749
Model
Observed
SFWMM
Linear (SFWMM)
0
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200

Conclusion – Use High Stage PM 1.b

- PM 1.b provides values which are consistent with qualitative assessments
  - The one historic period believed to have adequate stage is above target
  - Other periods are below target
- Model results are more reliable for 1.b than 1.a
- Various models acceptably project PM 1.b

Recommendation - alternative evaluation

- Use PM 1.b as first metric for alternative evaluation as a constraint
  - Exceed 55 at 25th annual percentile (longer than 4 year return)
  - No upper constraint is known
- Provisionally acceptable alternatives should be further reviewed using other PMs & professional judgment

Conclusions

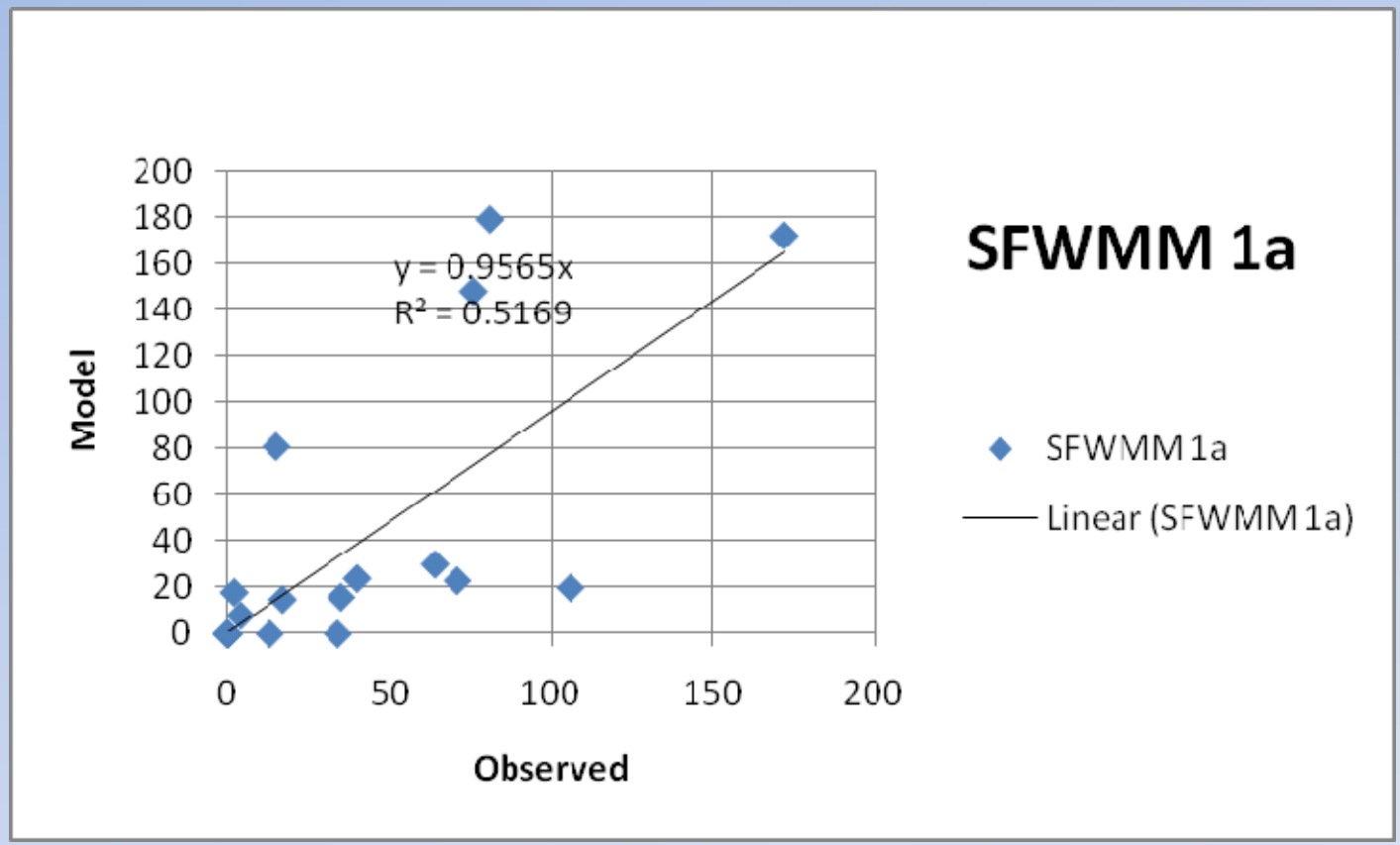
- The intended use for a PM should guide its design
- Evidence that PM measures desired habitat characteristics
- Evaluation and assessment PMs are often different
- Reliability of model prediction should be demonstrated for proposed evaluation PMs

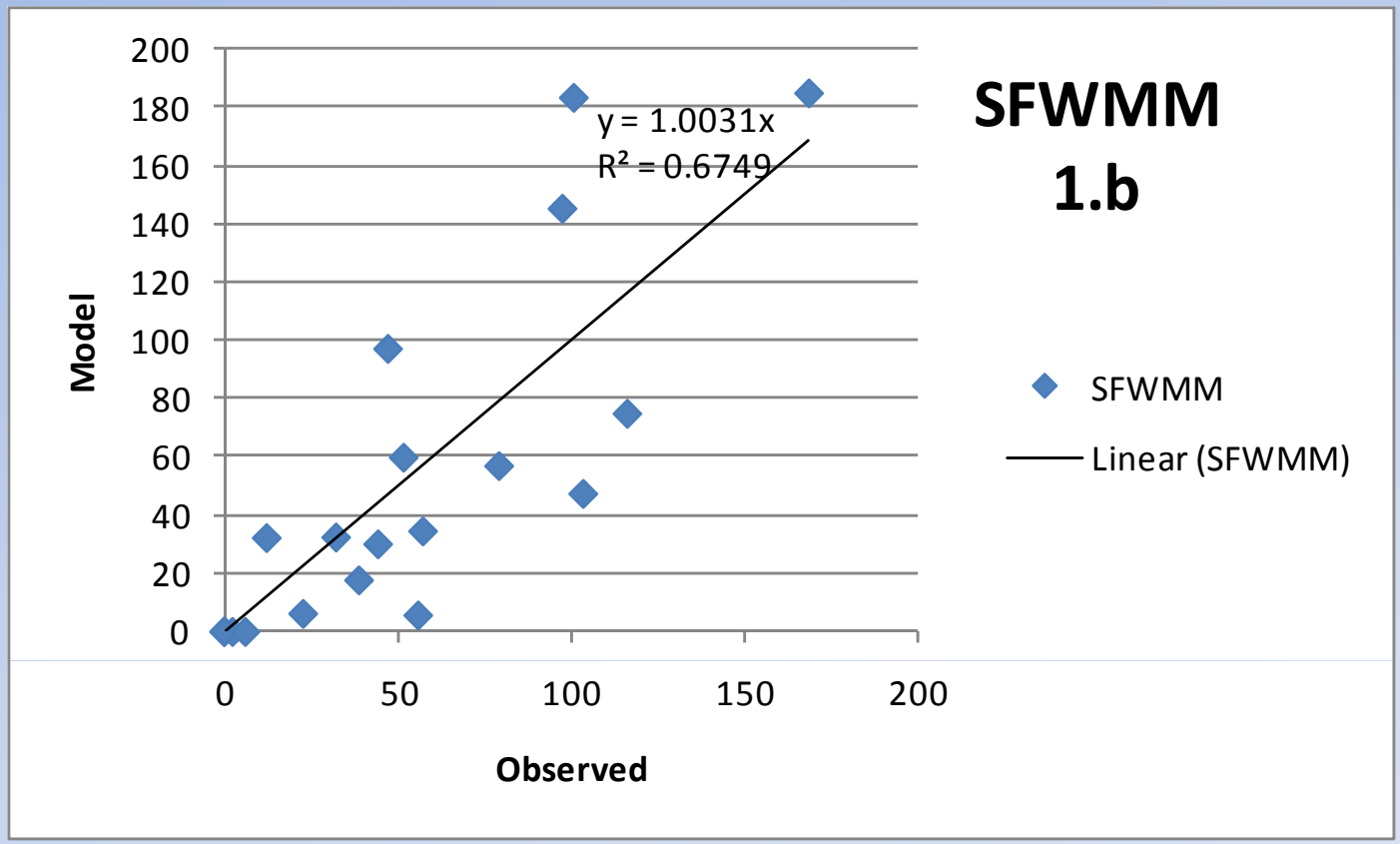
Questions?

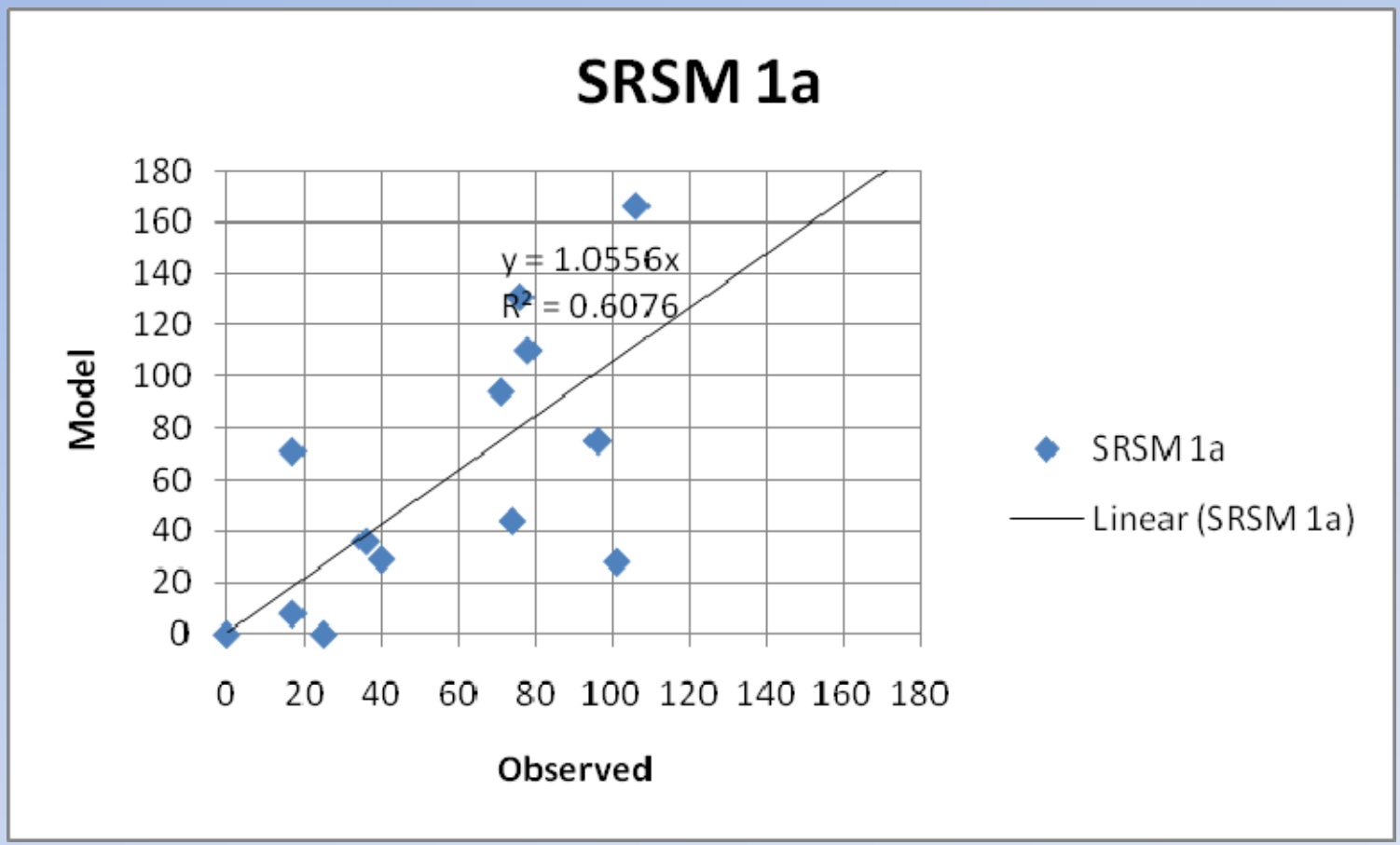
Appendix – Model PM Evaluation

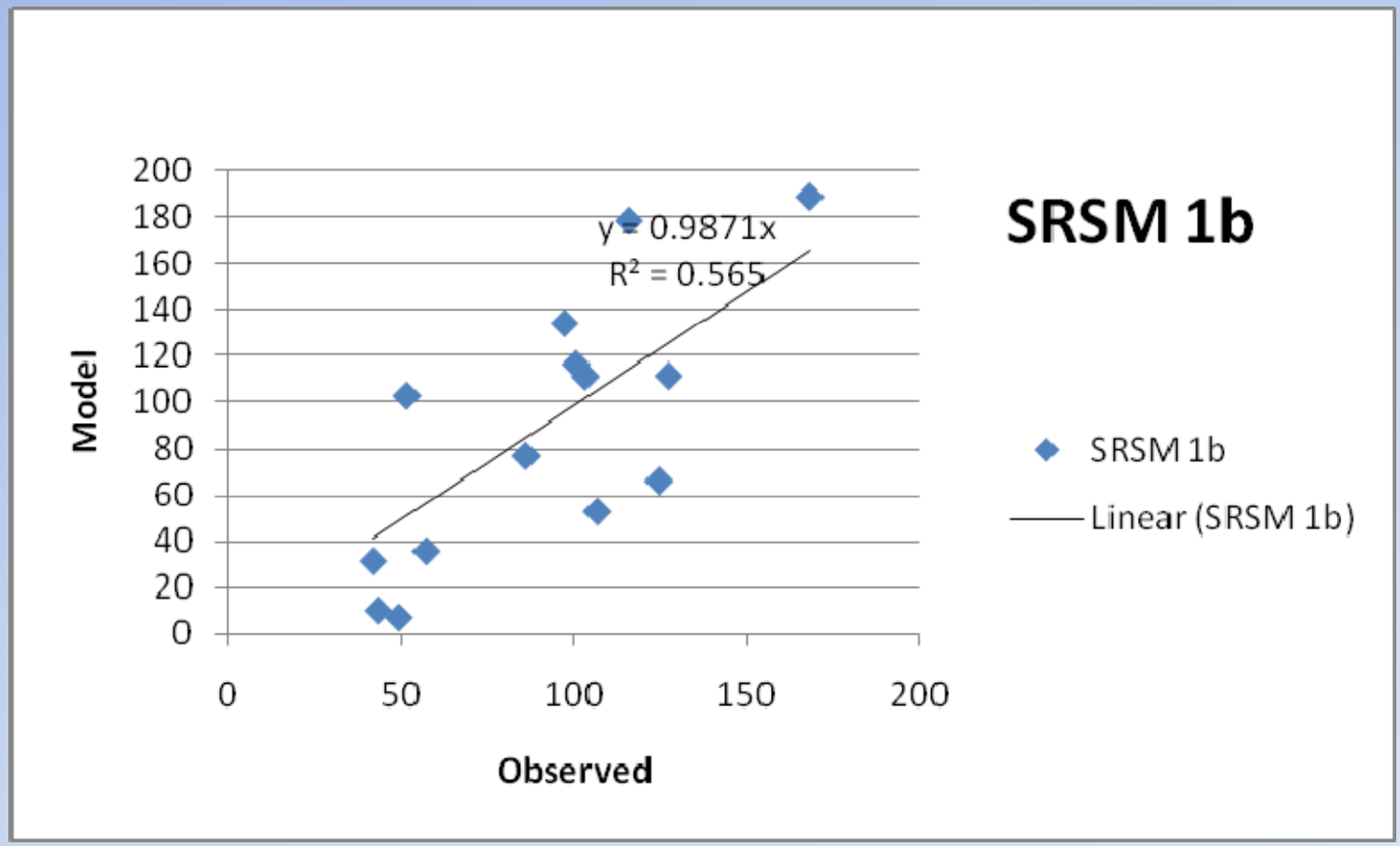
Comparison of Model Predicted to Observed Performance Measures –

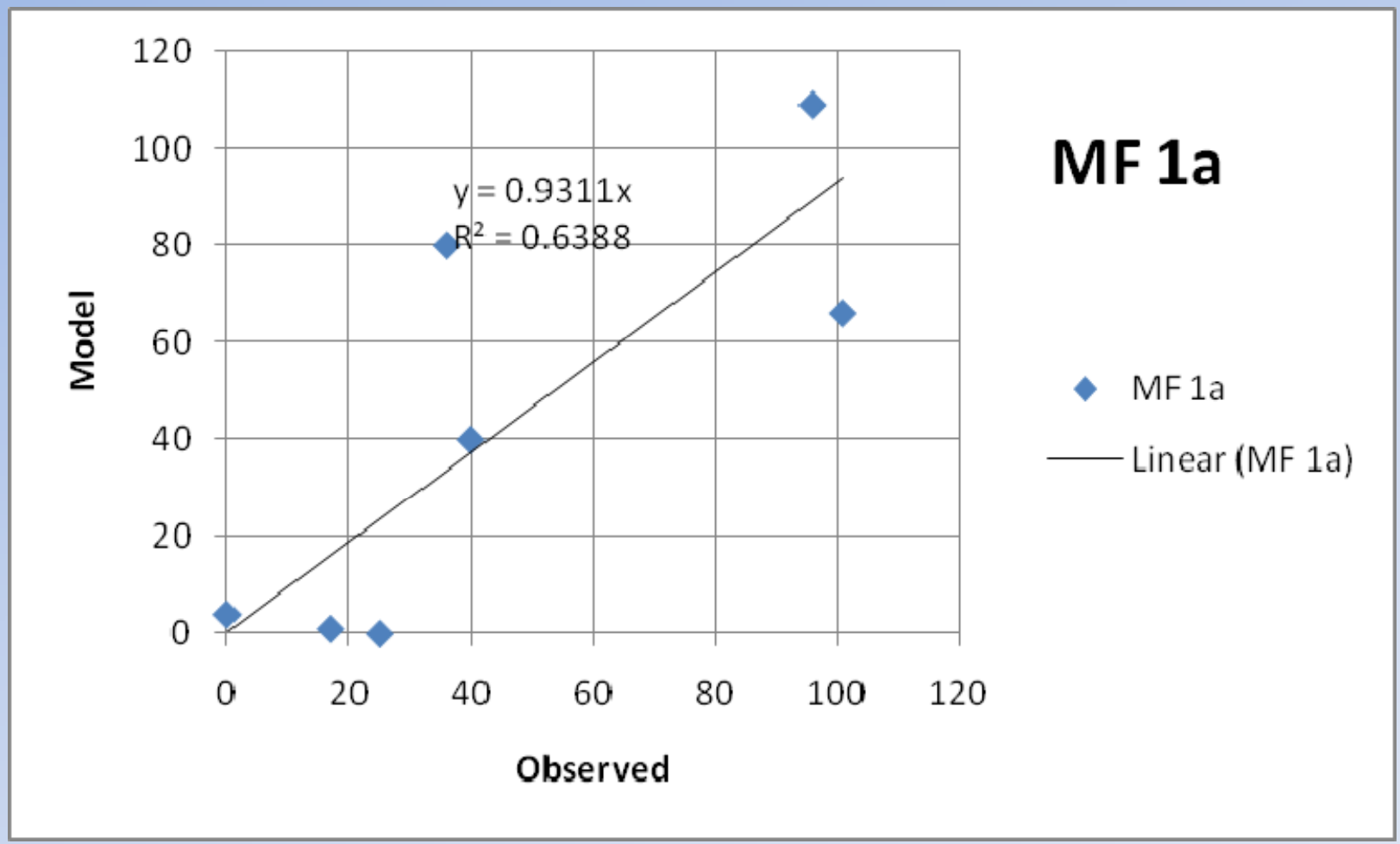
SFWMM, SRSM, and MF

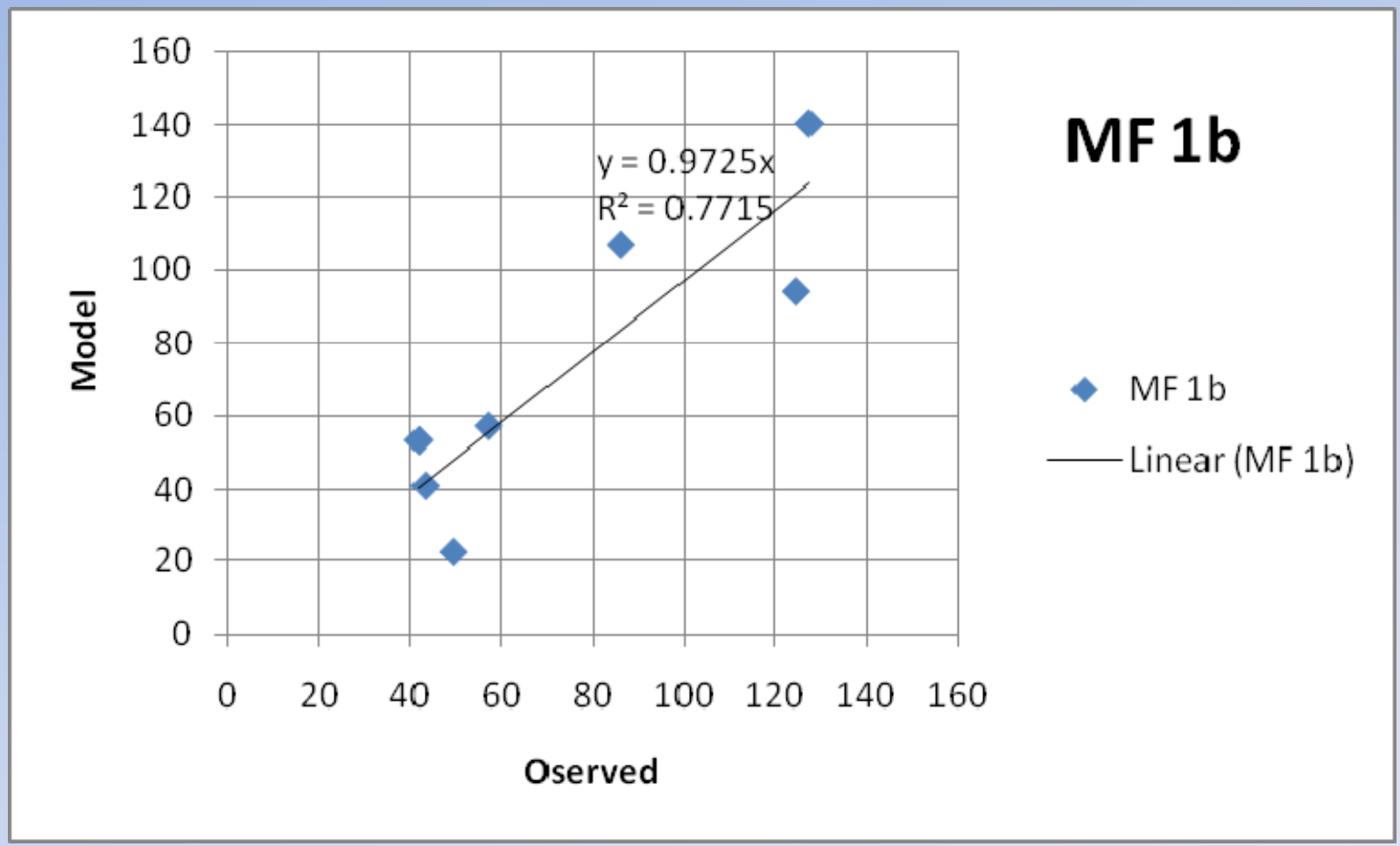

SFWMM 1a
y = 0.9565x
R² = 0.5169
Model
Observed
0
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200
SFWMM 1a
Linear (SFWMM 1a)


SFWMM
1.b
y = 1.0031x
R² = 0.6749
Model
Observed
0
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200
SFWMM
Linear (SFWMM)


SRSM 1a
y = 1.0556x
R² = 0.6076
Model
Observed
0
20
40
60
80
100
120
140
160
180
SRSM 1a
Linear (SRSM 1a)


SRSM 1b
y = 0.9871x
R² = 0.565
Model
Observed
0
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200
SRSM 1b
Linear (SRSM 1b)


MF 1a
y = 0.9311x
R² = 0.6388
Model
Observed
0
20
40
60
80
100
120
MF 1a
Linear (MF 1a)


MF 1b
y = 0.9725x
R² = 0.7715
Model
Oserved
0
20
40
60
80
100
120
140
160
MF 1b
Linear (MF 1b)