Response of Net Settling Rate (Knet) to Reductions in External Load

Published Empirical Phosphorus Models
Pre- & Post-Restoration Case Studies

Calibration of Lake Okeechobee Water Quality Model

Preliminary Results for Dynamic P Balance Model *
Model Structure & Parameter Estimates
Calibration Plots
Forecasts
TMDL Sensitivity to Depth

* This shows that a two-box model can be calibrated to simulate historical concentration & Knet time series. The apparent quadratic dependence of recycling rate on depth (found by examining residuals plots) indicates sensitivity to water management. This type of model should probably be run with a monthly time step, although a yearly one is used here. Results yield a steady-state Knet & TMDL similar to those derived from the one-box quasi-steady-state model discussed at previous LOTAC meetings. Results are not definitive. There are five degrees of freedom (calibrated parameters) in the model and alternative sets of parameters may fit the data equally as well. One of the parameters (burial rate) is constrained to match the average sedimentation rate (1 mm/yr) assumed in the LOWQM.
Predictions of Empirical Phosphorus Retention Models

Type of Variation

A Vollenweider (1976) across-lakes
B Canfield & Bachman (1981), Natural Lakes across-lakes
C Canfield & Bachman (1981), Reservoirs across-lakes
D Walker (1985), Corps of Engineer Reservoirs across-lakes
E Ahl (1989) temporal

Ahl's relationship is derived from pre- & post-restoration data from individual lakes.
The other models are derived from collections of lakes & reservoirs.

Symbols show observed values for Lake Okeechobee in various time intervals
TMDL for Lake Okeechobee derived from state-model discussed at July LOTAC meeting.
Model: $\text{Knet} = S - 4$

For Lake Okeechobee, mud zone sedimentation rate = 0.85 g/m²-yr
predicted settling rate = -3.15 m/yr
observed settling rate (from steady state model) = 0.89 m/yr

Observed & Predicted Yearly-Mean Lake Total P Concentrations
Lake Okeechobee Water Quality Model Calibration

Data from file 'lowqm.cal.val.xls', June 2000
Lake Okeechobee Dynamic P Balance Model

Parameter Estimates Calibrated to 1983-1999 Data:

- $K_g$: gross settling rate (m/yr) = 12
- $K_s$: recycle rate (1/yr) = 0.02
- $a$: depth exponent = 2
- $K_b$: burial rate (1/yr) = 0.02 *
- $S_o$: initial ('73) storage (mt) = 3000

* burial rate computed from:
  - sediment depth (cm) = 5
  - bulk density (g/cm$^3$) = 0.15
  - sed. rate (mm/y) = 1

TMDL Calculation:
- $Z$: mean depth (m) = 2.7
- $K_{net}$: steady-state $K_{net}$ (m/yr) = 0.97
- TMDL: 40 ppb TMDL (mtons/y) = 135
- $C_i$: lake inflow conc (ppb) = 41
Forecasts  

TMDL = 135 mtons/yr starting in 2010
Simulations are run using the above historical depth time series, constraining the maximum monthly depths to values ranging from 2.0 to 3.8 m. The table shows the corresponding average depth for the entire simulation period, Knet, TMDL, and inflow concentration resulting in an average lake concentration of 40 ppb.
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<th>Max Monthly Depth</th>
<th>73-99 Monthly Mean Depth</th>
<th>Steady-State Depth Knet</th>
<th>TMDL Conc</th>
<th>Inflow Concentration</th>
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