Nutrient Criteria in Lakes and Reservoirs: Maryland's Approach

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Maryland's Impoundments—Background

- No natural lakes
- State authority over "Significant, publicly owned lakes"
- Many small, recreational
- Fewer large, water-supply reservoirs

Water Quality Standards: Components

- Designated Uses
- Criteria to protect the Designated Use
- Managerial endpoints applicable to the criteria

Designated Uses of Lakes and Reservoirs in Maryland (existing)

- **Use I, I-P**: Water Contact Recreation, Protection of Aquatic Life, (and Public Water Supply)

- **Use III, III-P**: Natural Trout Waters (and Public Water Supply)

- **Use IV, IV-P**: Recreational Trout Waters (and Public Water Supply)

Maryland Lake Nutrient Criteria—Generalized Approach

- Effect-based approach
- Relation to trophic state and managerial goal
- Relation to Maryland's water quality standards as in Code of Maryland Regulations
- All nutrient criteria are currently under revision. Lake criteria completion target date: Late 2005

Current Status of Maryland Lake Nutrient Criteria

- Numeric:
  - Dissolved Oxygen

- Narrative (*i.e.*, general):
  - Waters of the State shall not be polluted by any materials in sufficient quantities to interfere with the Designated Use

Dissolved Oxygen Criteria

- Code of Maryland Regulations (COMAR):
  - 5 mg/L at all times (all uses)
  - Minimum daily average of 6 mg/L in Use III, III-P
- Applies to all State waterways, with exceptions for natural conditions

Dissolved Oxygen Criteria—Problem

- Standard does not acknowledge ***stratification*** issue
  - Impoundments may naturally stratify during warm season
  - Bottom waters may naturally become hypoxic
  - Managers must interpret DO standard
- Interim interpretation developed by Maryland (1999)

Interim Interpretation of DO Standard

- As applicable to stratified impoundments:
  - 5 mg/L in surface layer during periods of stratification and during complete mixis
  - 5 mg/L throughout water column during periods of complete mixis
  - Saturation-based standard in hypolimnion during periods of stratification
    - Temperature, pressure, elevation
    - Desired trophic state

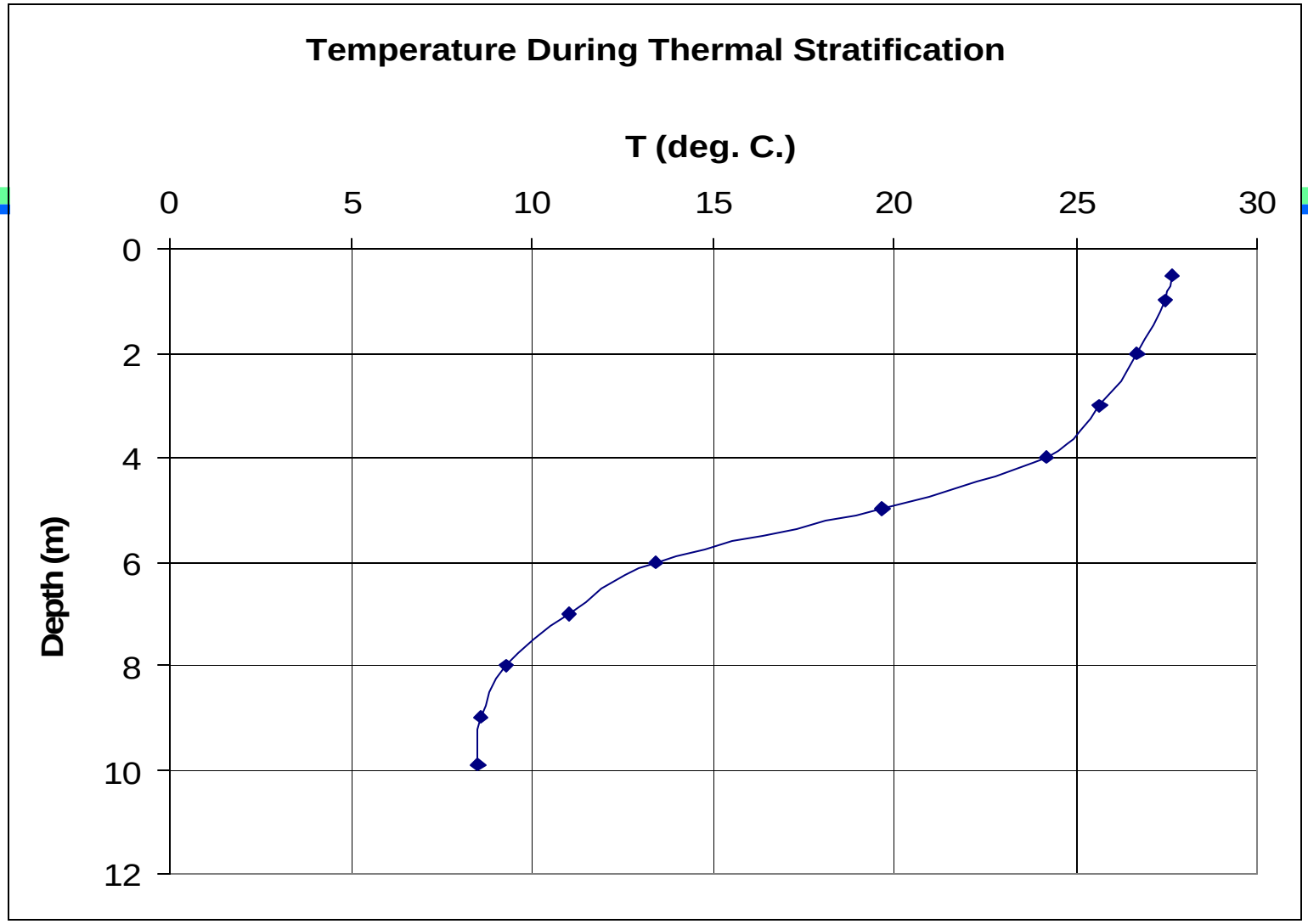
Minimum Hypolimnetic DO Saturation based on Desired Trophic State

TROPHIC STATE	EXPECTED % SATURATION (DO)
Oligotrophic	> 80%
Mesotrophic	10% to 80%
Eutrophic	< 10%

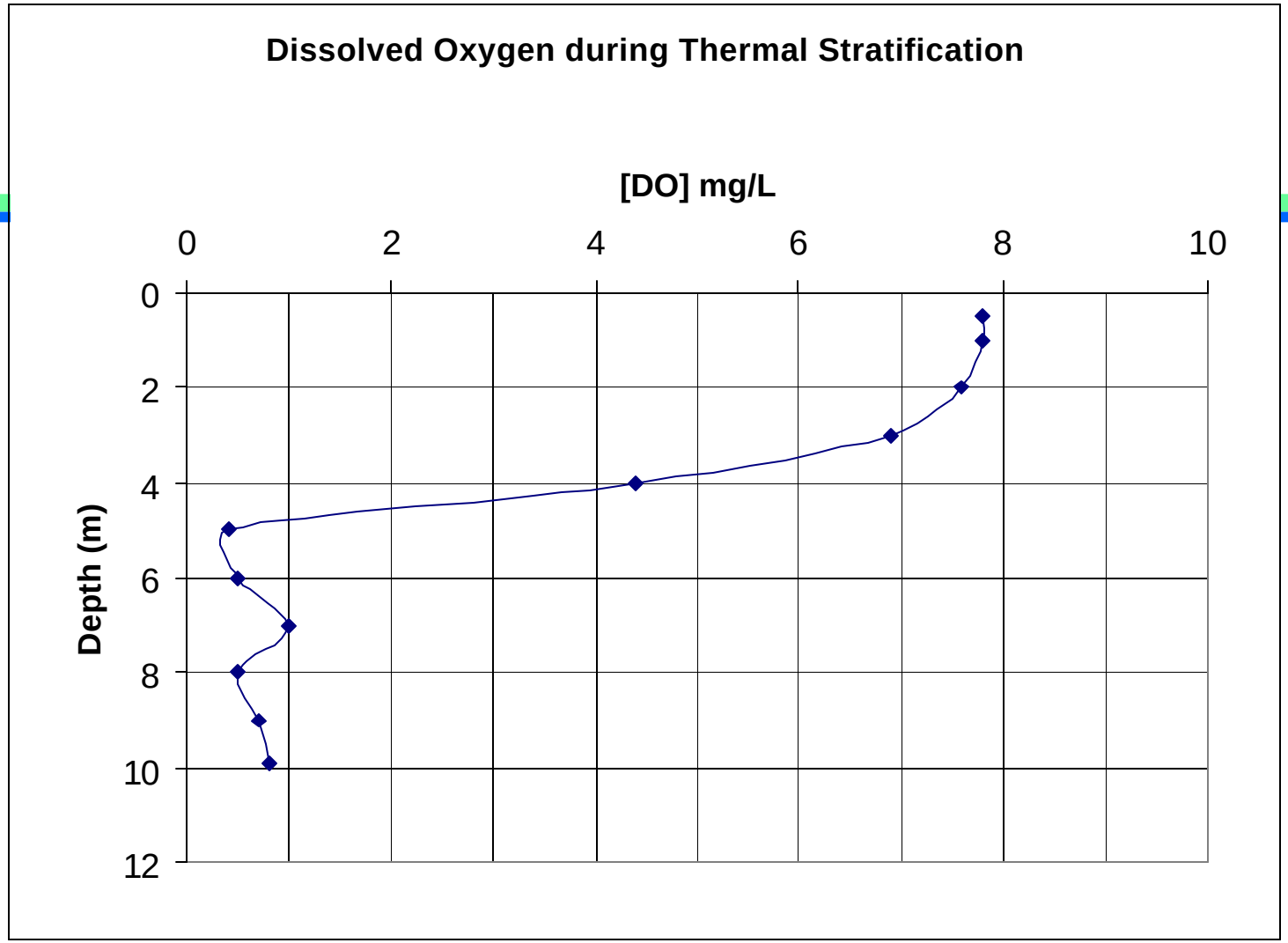
***Source*: Chapra, 1997**

Example Application of Interim DO Standard: Greenbrier Lake

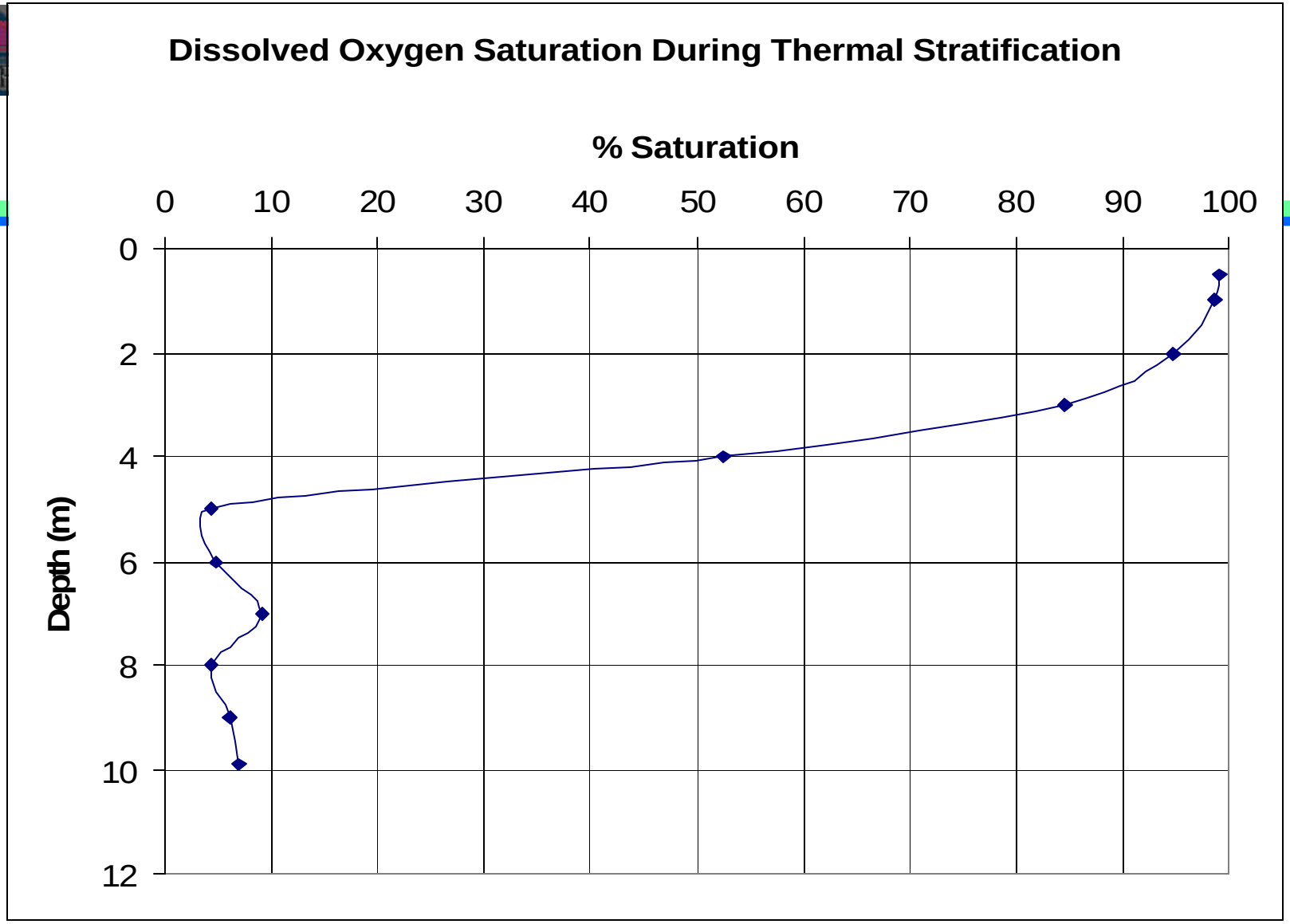
- Managed as Mesotrophic
- Surface DO: > 5.0 mg/L at all times
- Hypolimnetic DO: > 10% saturation concentration during period of thermal stratification



Temperature in Greenbrier Lake, Aug. 7, 2001



Dissolved Oxygen in Greenbrier Lake, Aug. 7, 2001



Dissolved Oxygen Saturation in Greenbrier Lake, Aug. 7, 2001

Chlorophyll *a*

- Surrogate for narrative criteria
- Quantified threshold to be used in conjunction with professional judgement
- Threshold to trigger managerial investigation

Selection of Chlorophyll *a* Endpoint

- What [chl *a*] indicates impairment of use? Considerations:
  - Literature
  - Goals of water quality managers
    - Baltimore-area Reservoir Watershed Management Agreement
  - Association with Trophic State Indices

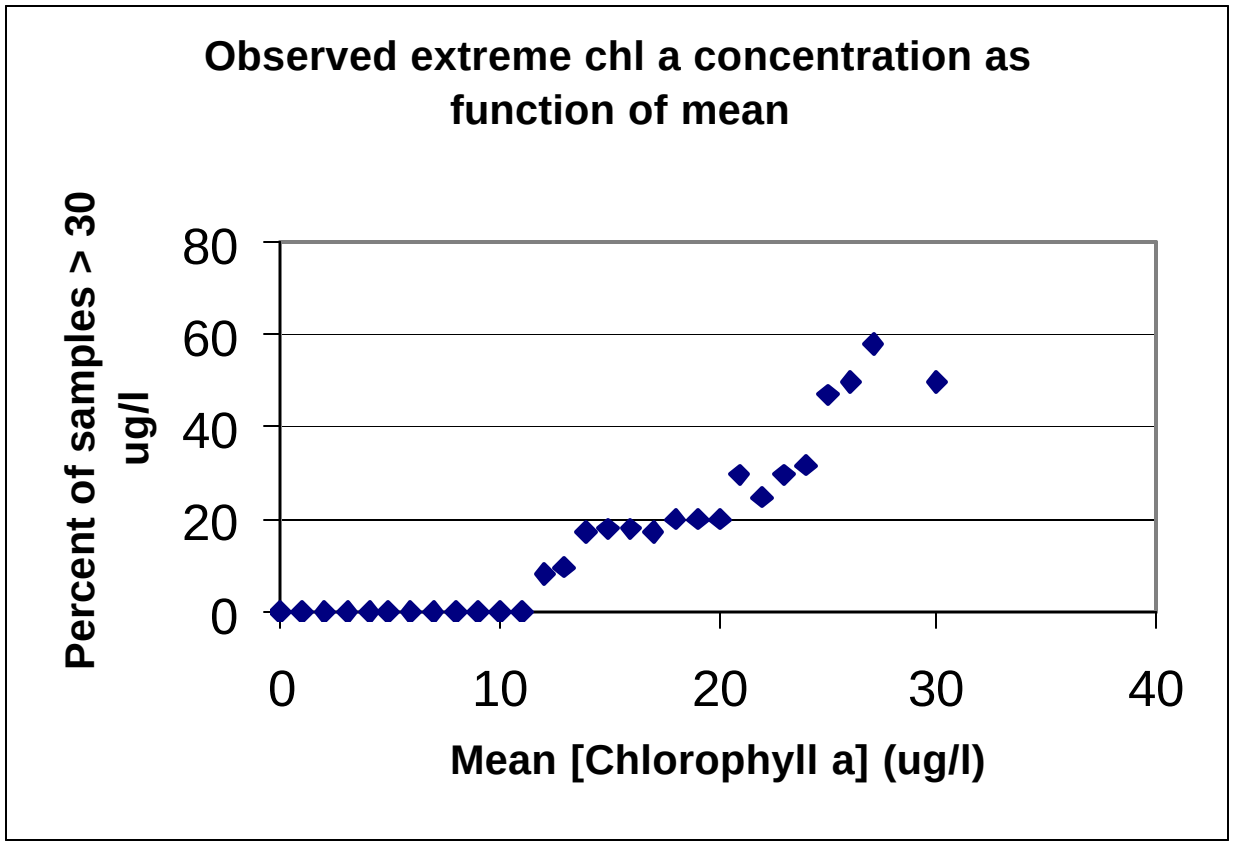
Selection of Chlorophyll *a* Endpoint

- Two general categories:
  - Management to prevent eutrophication: Threshold of 10 ug/L (Carlson's TSI of 53)
  - Management to prevent *excessive* eutrophication: Threshold of 20 ug/L (Carlson's TSI of 60)

Selection of Chlorophyll *a* Endpoint

- What metric best indicates impairment of use?
  - Instantaneous values
  - Growing-season mean
  - Peak values
  - Frequency of algal blooms
  - Correlations among these metrics

Correlation of instantaneous and growing season mean Chlorophyll *a* concentrations



Source: adapted from Walker 1985.

Chlorophyll *a* Endpoints for Maryland Lakes and Reservoirs

- Mean: < 10 µg/l (growing season or other appropriate period of interest)
- Individual values: < 30 µg/l
- Either condition serves as 'trigger' for managerial inquiry during TMDL analysis and development
  - Interpretation of water quality data
  - Analysis of model output/management scenarios
- **Issue**: Data Sufficiency

Maryland's Current Impoundment Management Endpoints

- Dissolved Oxygen:
  - 5 mg/L in surface and throughout WC during mixis; minimum daily avg 6 mg/L (Use III-P)
  - Hypolimnetic [DO] not less than 10% saturation
- Chlorophyll *a*: < 10 µg/L avg. or 30 µg/L instantaneous

Future Approach to Nutrient Criteria in Lakes and Reservoirs

Chlorophyll *a*

- Current approach to be retained
  - 10 ug/L represent cutoff between mesotrophic and eutrophic conditions
  - 20 ug/L in lakes managed in lower range of eutrophy

Dissolved Oxygen

- Retain surface standard

- Develop method that realistically addresses hypolimnetic DO

Hypolimnetic DO—The Challenge

- Saturation-based relationship may not apply to impoundments
  - Morphometric differences
  - Larger watershed:waterbody ratio than natural lakes
- Impoundments may thus “naturally” have greater organic loading and therefore greater hypolimnetic oxygen demand

Hypolimnetic DO—Solutions?

- Saturation-based relationship may suggest limit of expected or attainable hypolimnetic DO in simulated “natural” conditions

- Excursions below saturation threshold may be due to natural conditions

- How to quantify this?

Hypolimnetic DO—Solutions?

- ***Can*** expected hypolimnetic DO be quantified in an impoundment?
  - Morphometry and hydraulics differ from natural systems
  - Natural variability in climatic conditions (*i.e.*, from year to year) may preclude meaningful comparison
- ***Should*** managers try to do so?

Conclusion

- Area of future work: Hypolimnetic DO in impoundments.
- Questions?
- Thanks!