Deep Time at Clive

Neptune and Company, Inc.

Presentation Outline

- Overview of Deep Time
- “Parking Lot” Issues
- Conceptual Site Model
- Pluvial Lake Occurrence
- Sedimentation
- Uncertainties

Overview of Deep Time

- Simulate the effects of lake formation on the Clive facility from 10,000 years through 2.2 My
- Dispersion and dissolution of waste
- Role of sedimentation and mixing

Parking Lot Issues

- “Deep time - beyond 10,000 years”
- “Long term historical climate characteristics (determine how foreseeable climate change affects performance)”
- “Near certainty of flooding and inundation (site stability)”
- “Flooding has occurred within the last 10,000 years (Gilbert shoreline)”
- “How to deal with uncertainty”

Qualitative: Beyond 10,000 yr

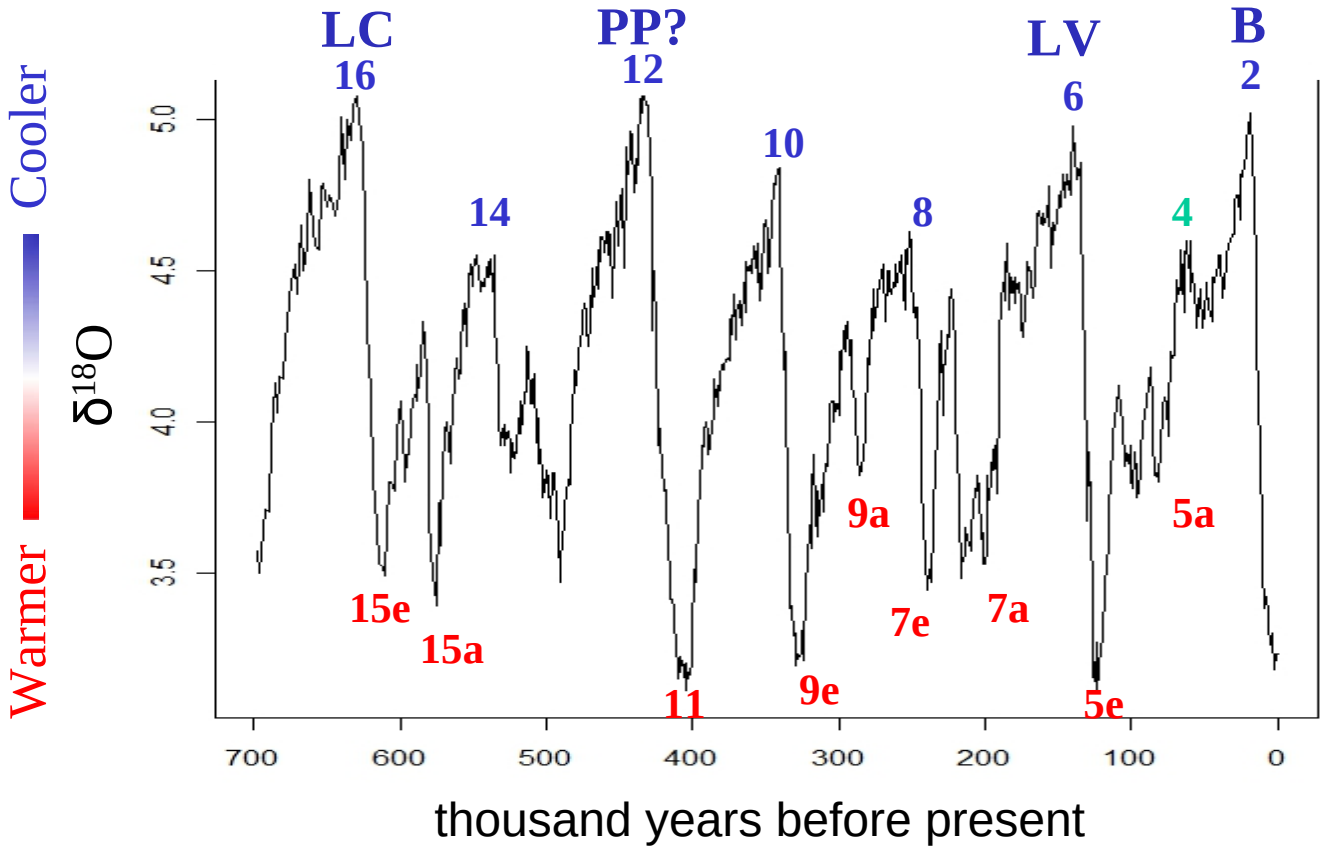
"… For purposes of this performance assessment, the compliance period shall be a minimum of 10,000 years. Additional simulations shall be performed for the period where peak dose occurs and the results shall be analyzed qualitatively."

UAC R313-25-8 2a Technical Analyses

Qualitative: Beyond 10,000 yr

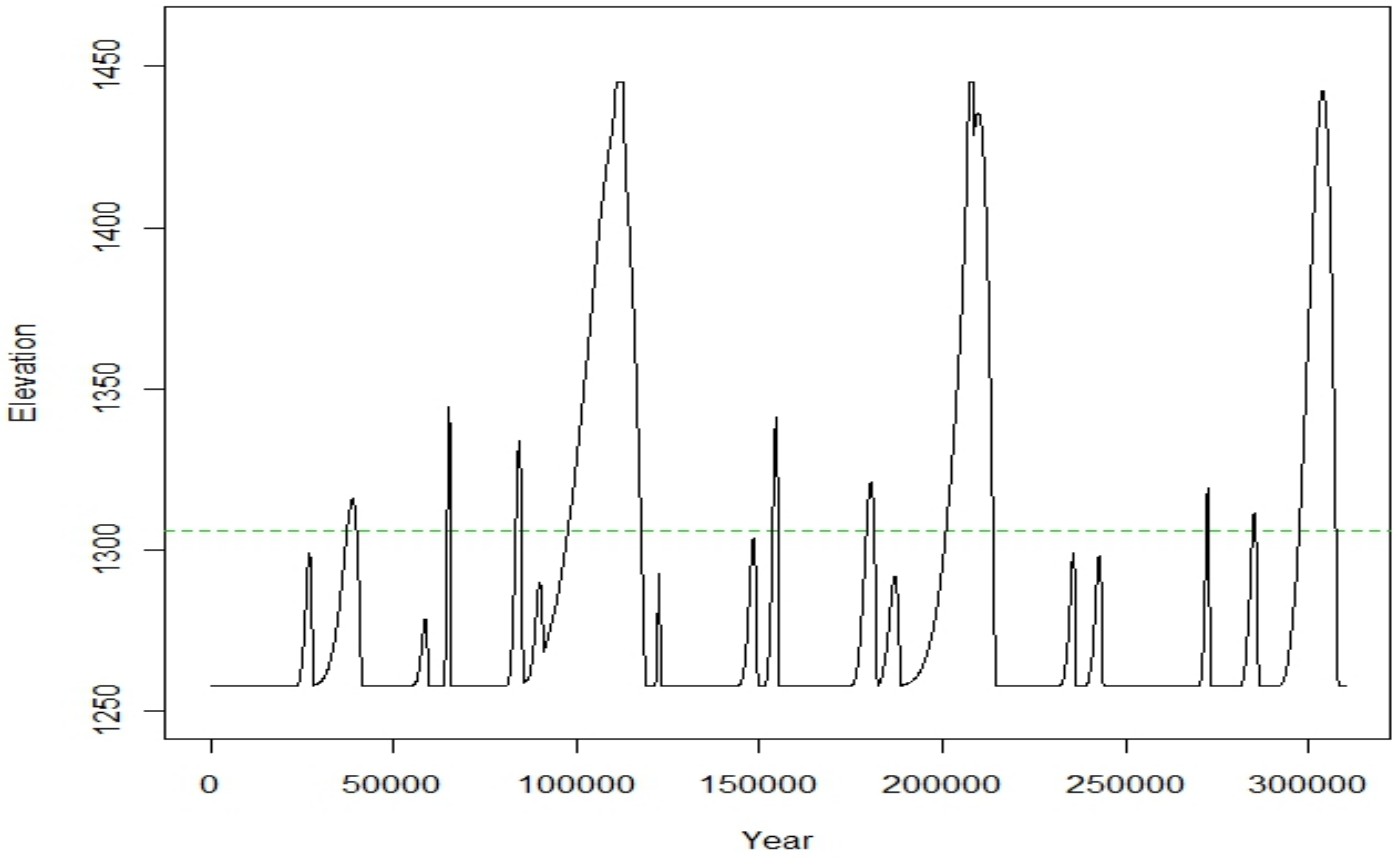
- Simplified deep time model out to 2.2 My
  - Based on information derived from expert elicitation, literature-derived parameters
- Calculating radionuclide concentrations in lake water and sediments
- Qualitatively assess the consequences of the radionuclide concentrations

Long term historical climate



Benthic $\delta^{18}O$ (marine isotope stages) with large lakes that have occurred in the past 700,000 y *[Lisiecki and Raymo, 2005; Oviatt et al., 1999]*

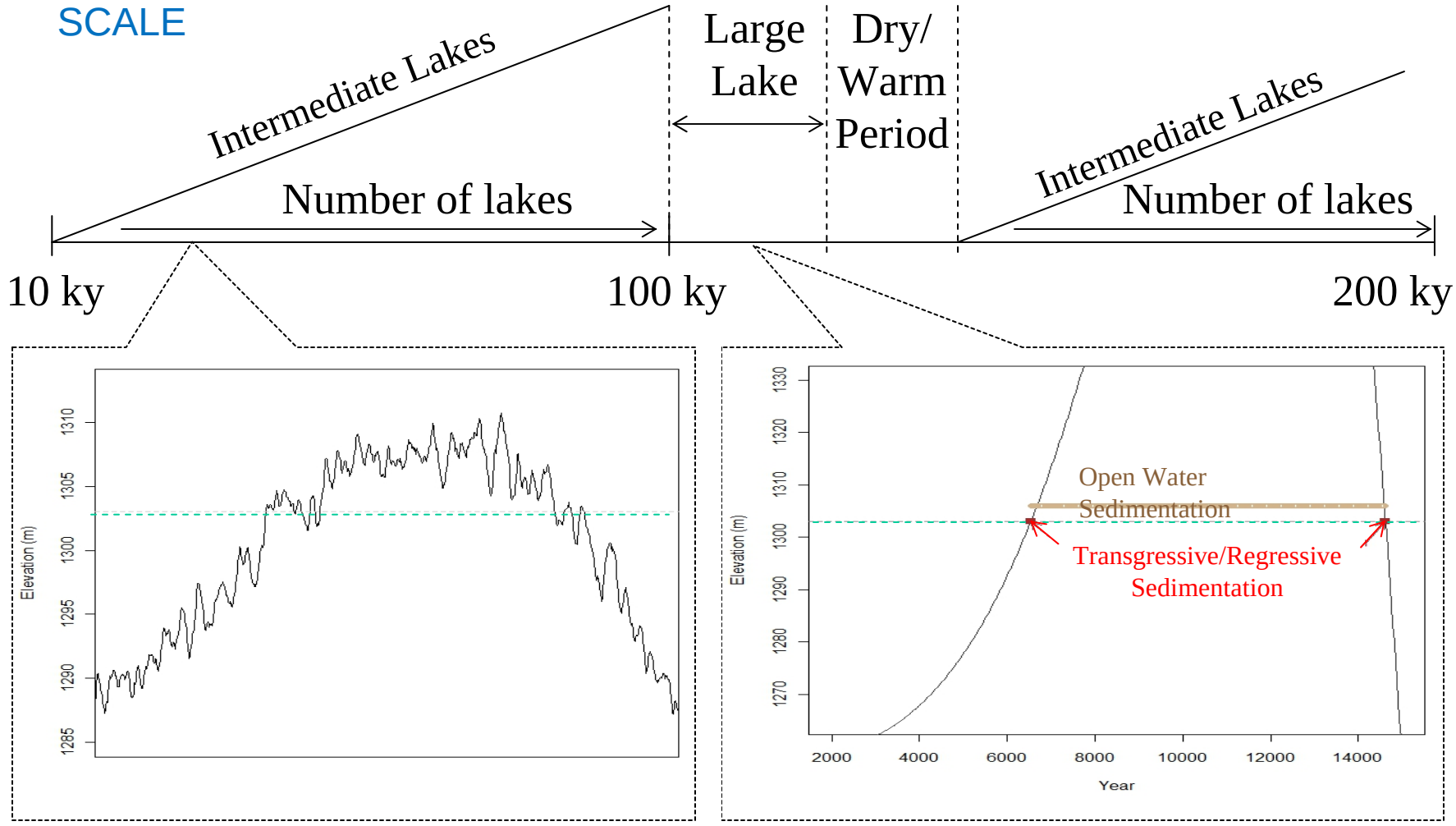
Lake Cycle Process



Clive
Elevation

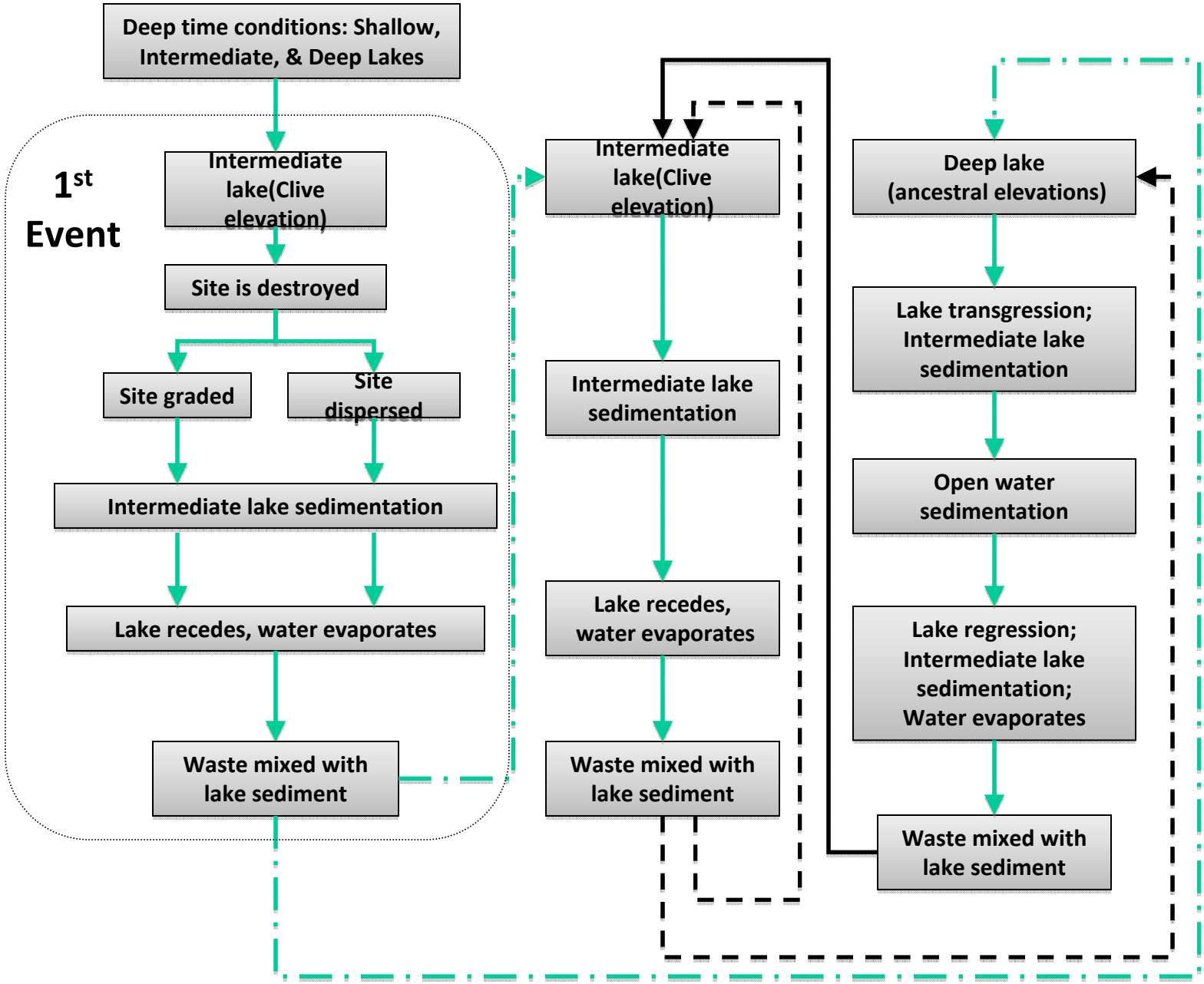
Lake Cycle Process

NOT TO SCALE



Pluvial Lake Occurrence

- Assume intermediate lake destroys the site
- Intermediate lakes occur during interglacial and cooler periods
  - Transgressive/regressive phases of large lakes follow intermediate lake dynamics
- Large lakes form during major glacial periods or every 100 ky (on average)


Deep time conditions: Shallow, Intermediate, & Deep Lakes
1st Event
Intermediate lake(Clive elevation)
Site is destroyed
Site graded
Site dispersed
Intermediate lake sedimentation
Lake recedes, water evaporates
Waste mixed with lake sediment
Intermediate lake(Clive elevation)
Intermediate lake sedimentation
Lake recedes, water evaporates
Waste mixed with lake sediment
Deep lake (ancestral elevations)
Lake transgression; Intermediate lake sedimentation
Open water sedimentation
Lake regression; Intermediate lake sedimentation; Water evaporates
Waste mixed with lake sediment

Flooding and Inundation

- Flooding and inundation will occur at Clive at some point in each 100 ky period for the next 2.2 My
- Intermediate lake formation will destroy the Clive facility through wave action
  - "Grading" of disposal cell around site vicinity
  - Dispersal of disposal cell to surrounding areas (west and south of site)
- Mixing of sediments and disposal cell following site destruction

Sedimentation

Intermediate Lakes

- Derived from Clive pit wall interpretation (Oviatt, 1985), Burmester Core (Oviatt et al, 1999), and Knolls Core (Oviatt, pers. comm.)
- Depth of sedimentation applied to each intermediate lake event

Sedimentation

Large Lakes

- Derived from Clive pit wall interpretation (Oviatt, 1985), Burmester Core (Oviatt et al, 1999), and Knolls Core (Oviatt, pers. comm.)
- Depth of sedimentation applied to each large lake event
- Assume a transgressive, open water, and regressive phase for each large lake event
  - Transgressive and regressive phases of large lakes follow intermediate lake dynamics

Gilbert Shoreline in 10,000 period?

Spits at Clive (A and B) likely pre-Bonneville or transgressive-phase in origin probably buried in Bonneville marl – these are not regressive-phase in age. Three Gilbert spits (C) – uncertain if Gilbert reached Clive.

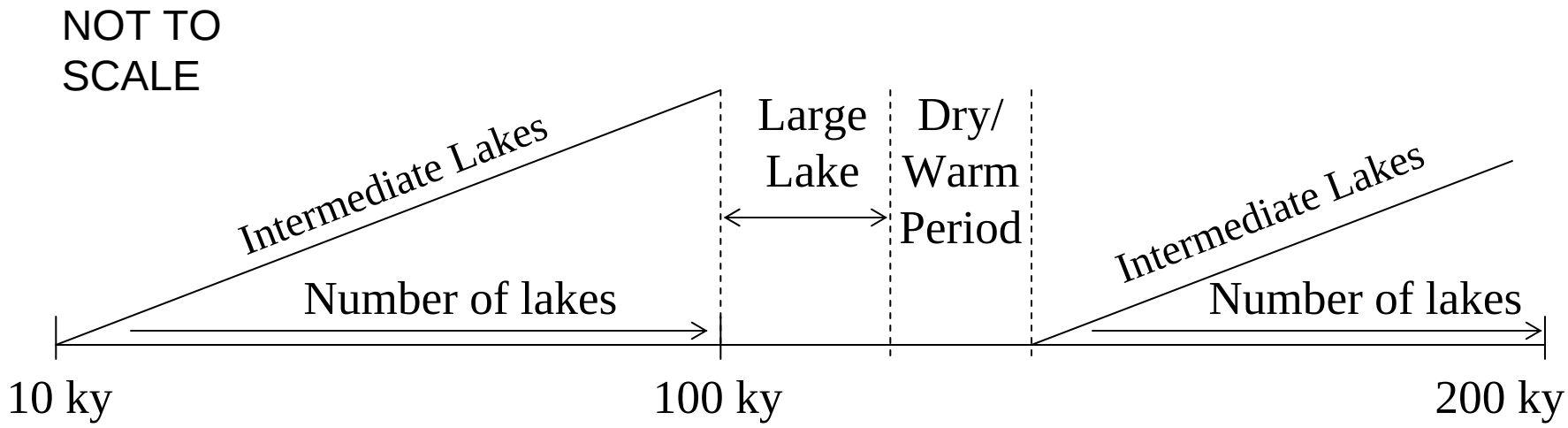
Credit: Jack Oviatt, Kansas State University

Uncertainties

- Quaternary Lacustrine Cycles
  - Total number of large and intermediate lakes (Clive pit wall, Burmester, and Knolls core interpretations accurate?)
  - Sedimentation rates and depth for large *vs*. intermediate lakes
    - Relationship between sedimentation rates, lake duration, and lake elevation
- Mixing depth across lake events
  - Depth of mixing with previous sedimentation?
- Waste dispersion

EXTRA SLIDES

Lake Cycle Process



- Intermediate lakes follow a Poisson process where the number of Lake occurrences increase through time (interglacial periods up to 100 ky)
- Large Lakes form every 100 ky and include a transgressive, open water, and regressive phase
- Dry/Warm period follows regressive phase of a given large lake which is then followed by the next set of lakes