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Legacy Phosphorus in Soils and Sediments: Implications for Restoration of Shallow Lakes

K. Ramesh Reddy
Wetland Biogeochemistry Laboratory
Soil and Water Science Department
University of Florida

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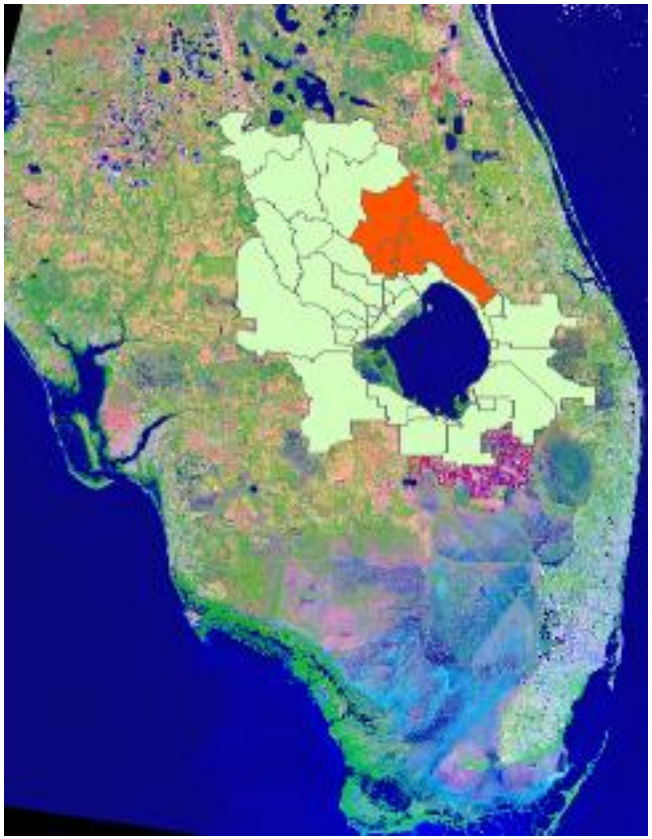
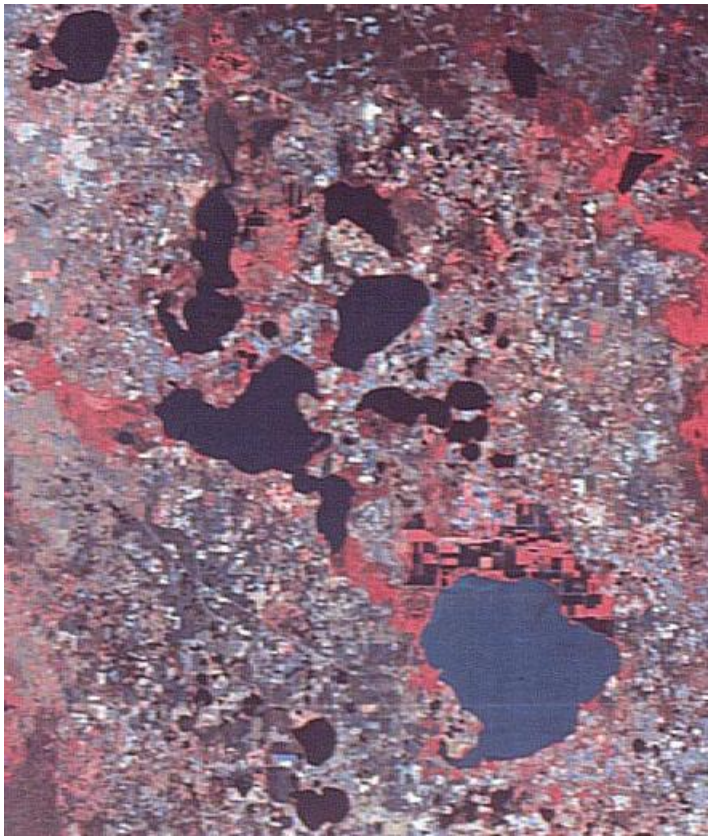
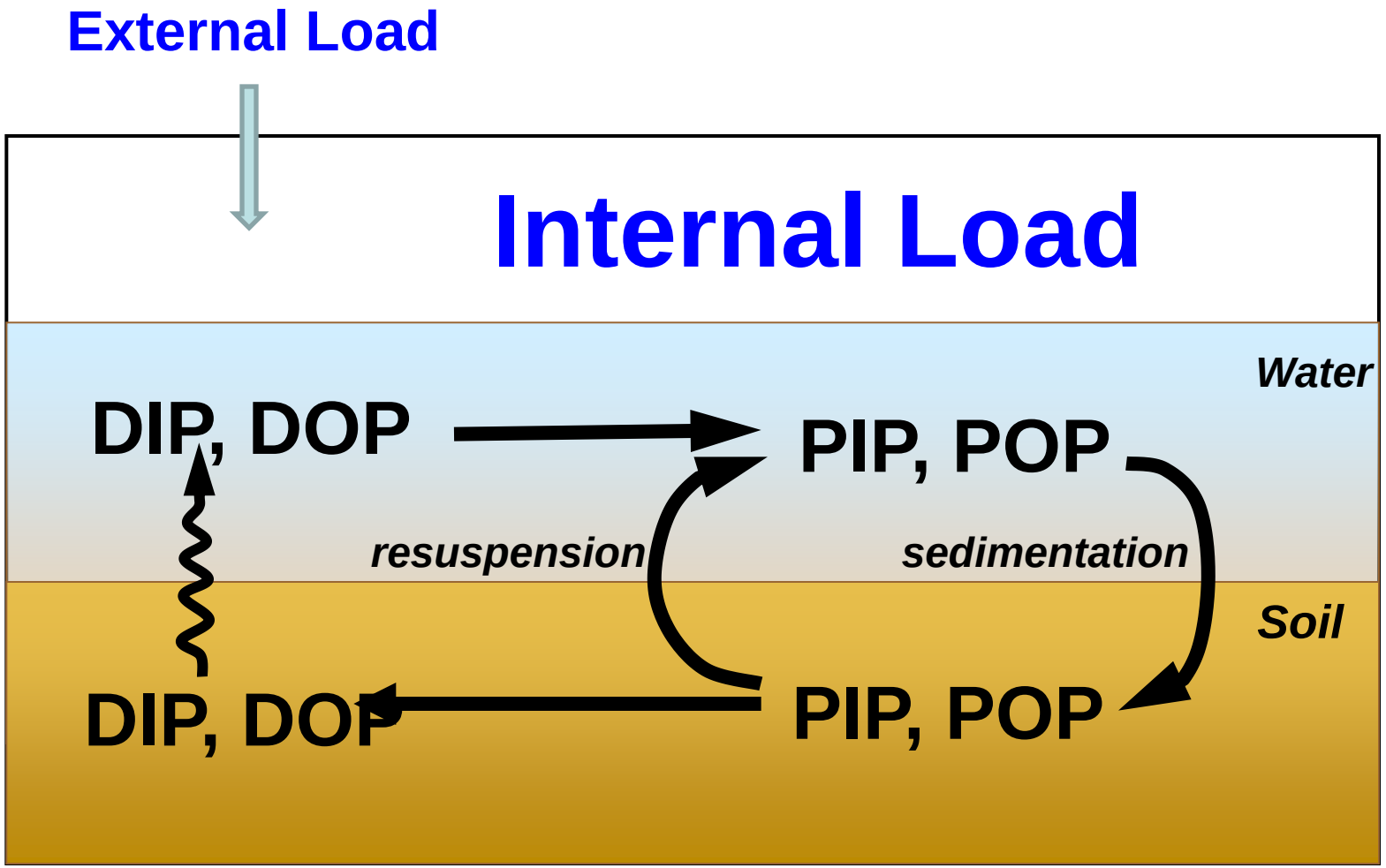
Lake Apopka Restoration Summit

Lake Okeechobee

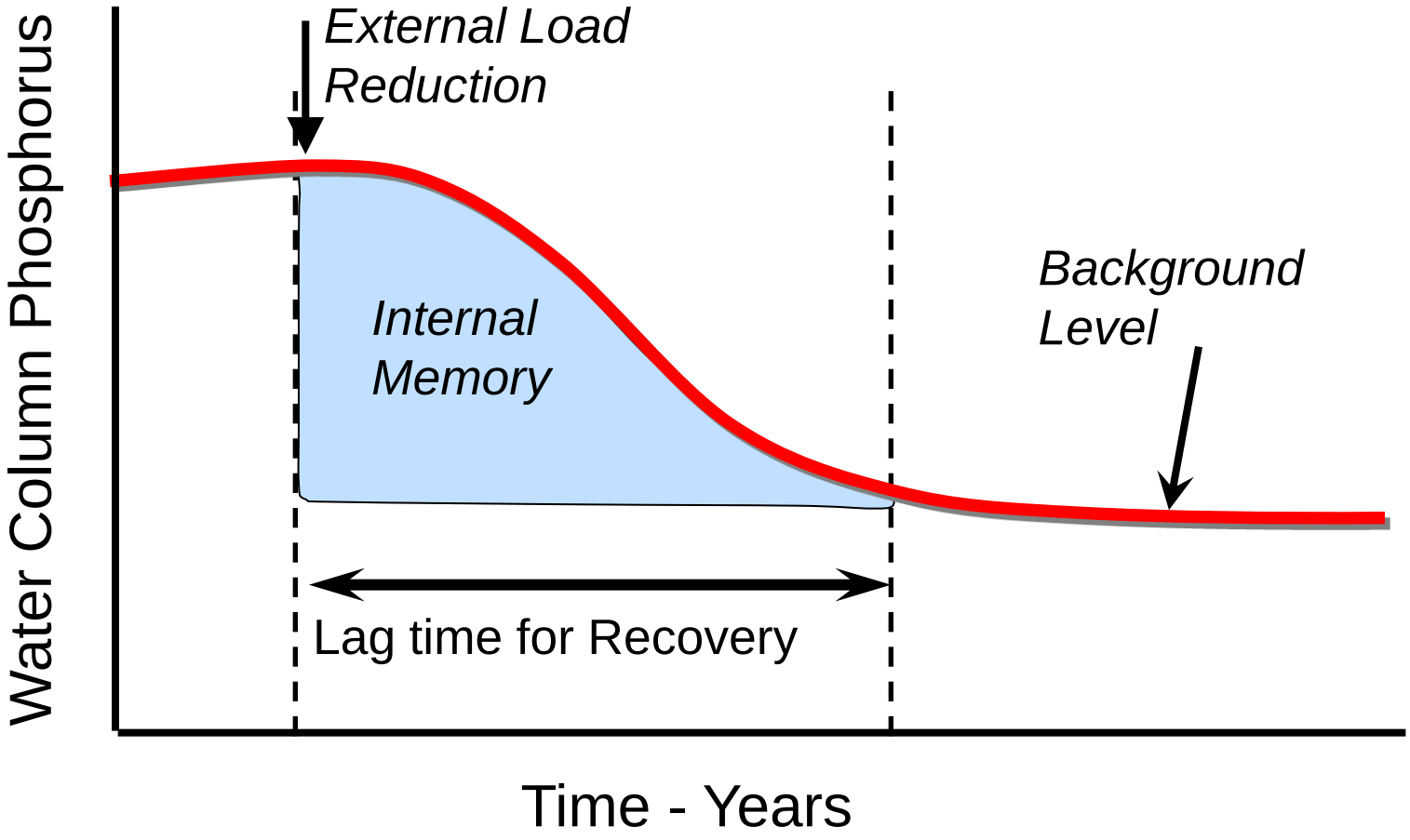


Lake Apopka

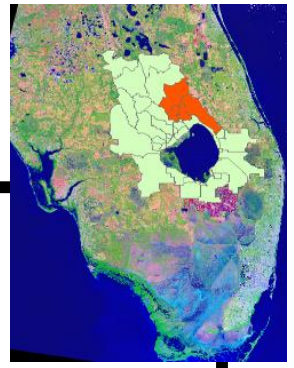



External Load
Internal Load
Water
DIP, DOP
PIP, POP
resuspension
sedimentation
Soil
DIP, DOP
PIP, POP

Legacy Phosphorus

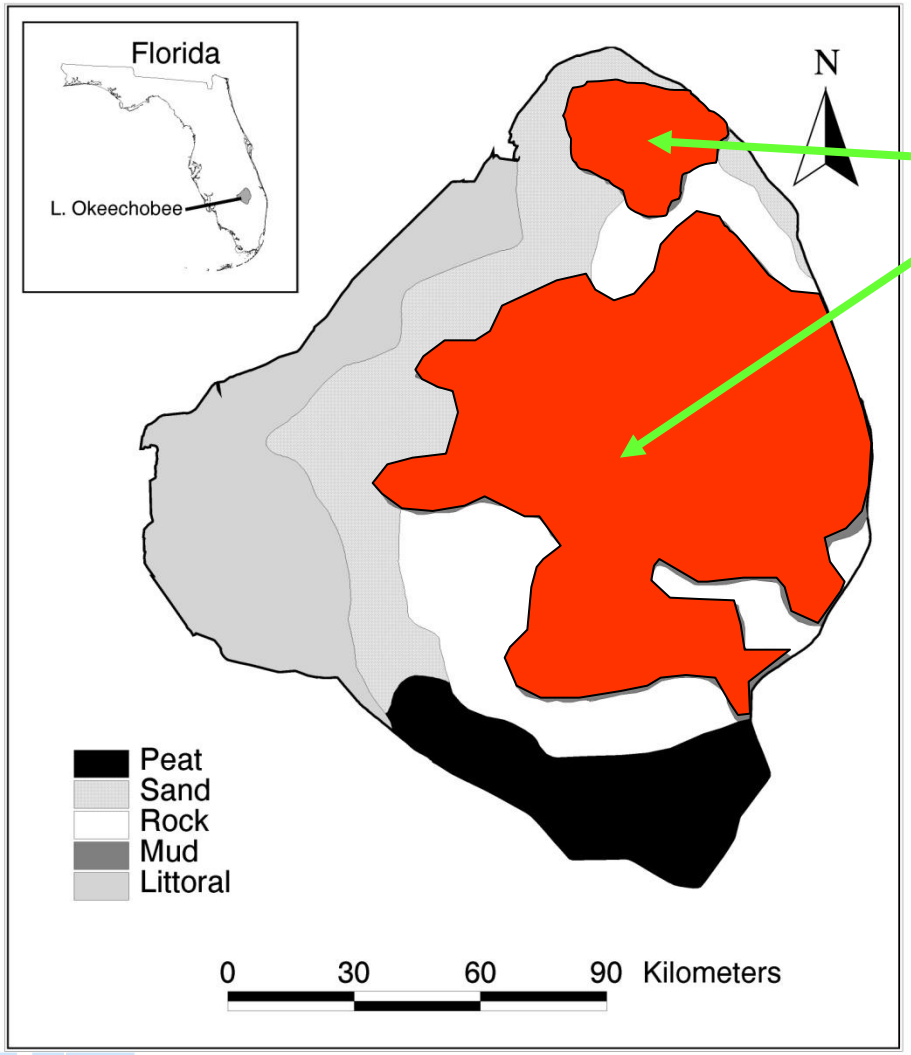


Phosphorus Loads to Lake Okeechobee



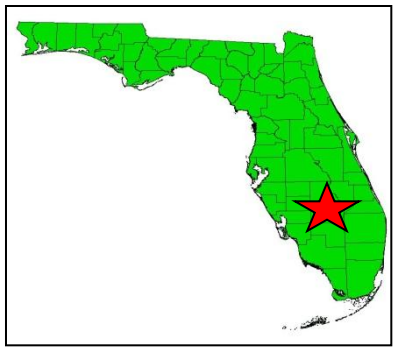
Source: SFWMD, 2010

Lake Okeechobee



Mud sediment

- 40% lake bottom
- 1035 mg kg^{-1} P (0-10cm)
- 28,600 mt P (0-10cm)
- Contribute 200 mt P yr^{-1}
- Internal Loads = External



Phosphorus Forms

Surface Soils & Sediments: 0-10 cm

% of Total P

Reactive Phosphorus

- Inorganic P extracted with acid/alkali
- Organic P extracted with alkali

→ **65%**

Non-reactive Phosphorus

- Total P – Reactive P

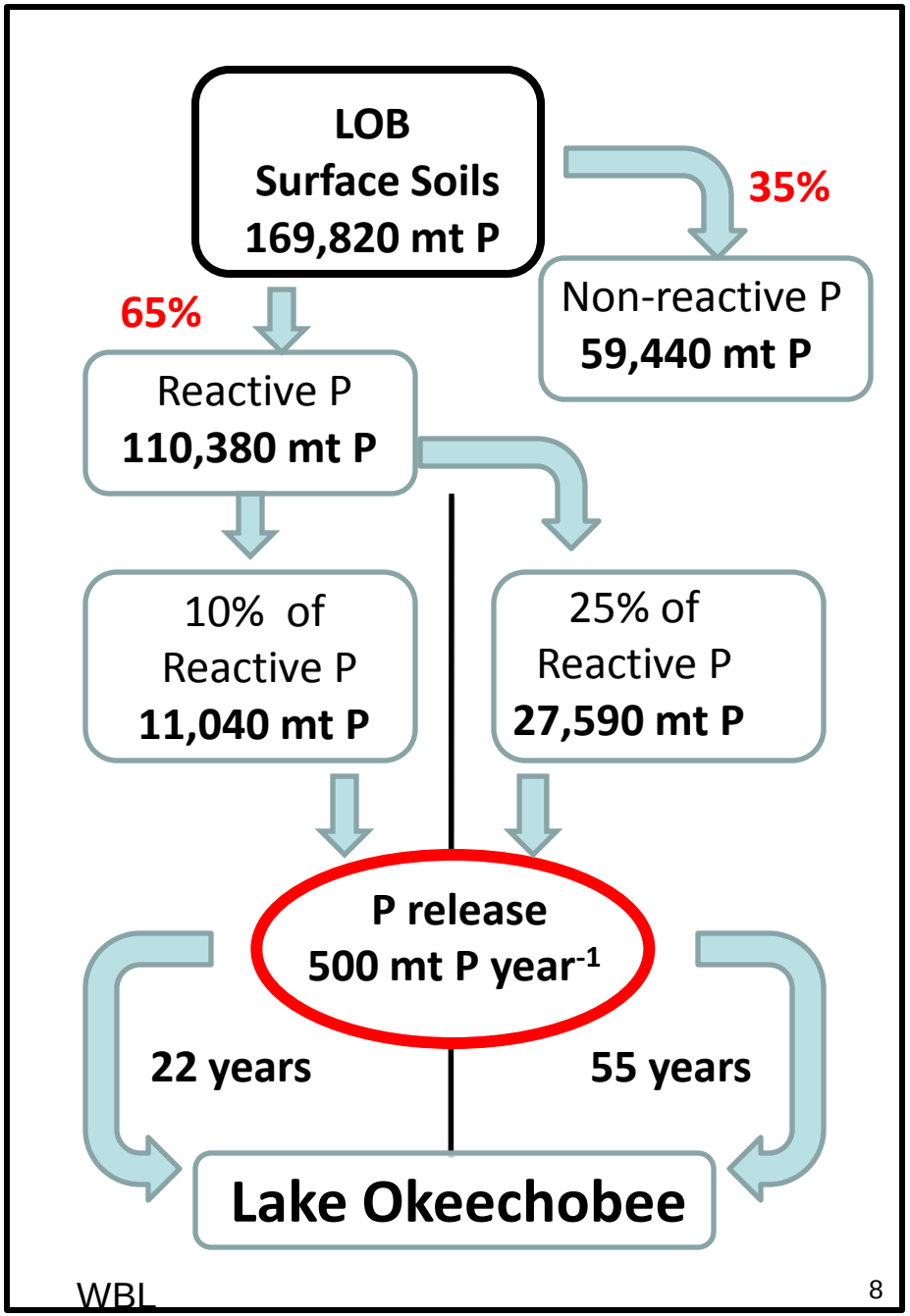
→ **35%**

Reddy et al., 2011

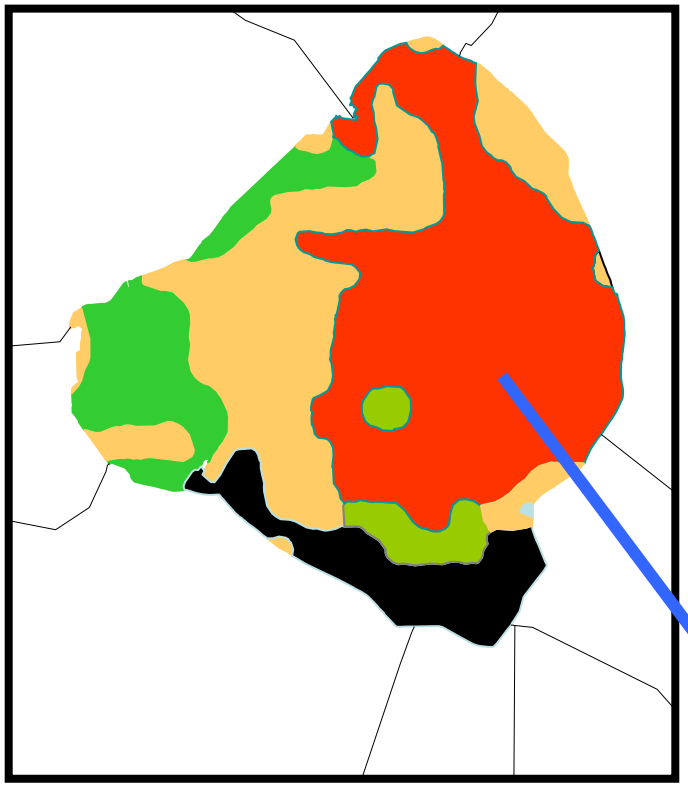
Legacy Phosphorus

Okeechobee Basin

Reddy et al., 2011



Lake Okeechobee



Peat
Littoral
Sand
Mud
Rock

Reddy et al., 2011

External Load - 500 mt P year^{-1}

Lake Okeechobee

12 years

31 years

Internal Load
112 mt P year^{-1}

10% of Reactive P
1,390 mt P

25% of Reactive P
3,475 mt P

Reactive P
13,900 mt P

Non-reactive P
7,490 mt P

65%

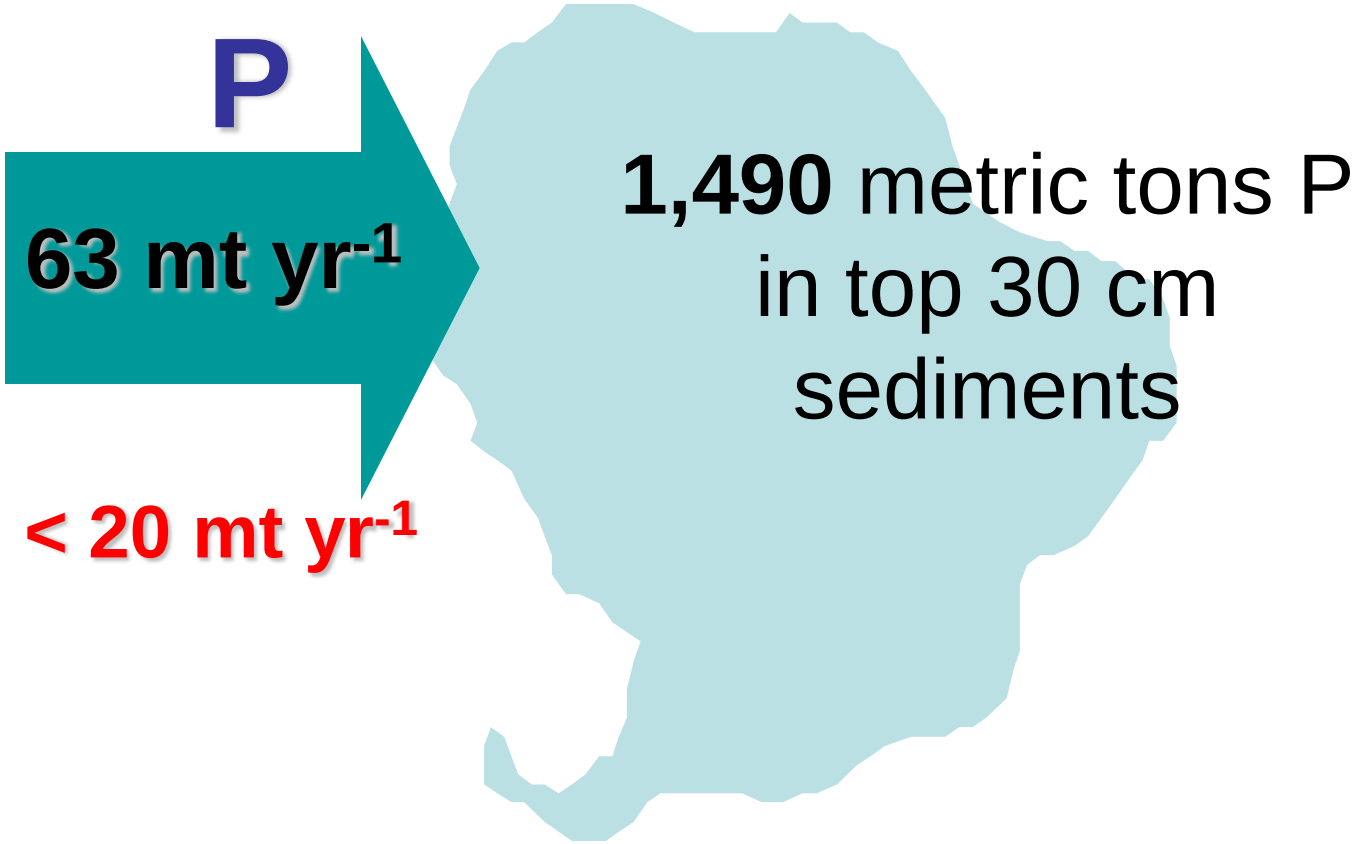
35%

MUD zone sediments
Lake Okeechobee
21,390 mt P

Lake Apopka

1989-96; 1997-2009

SJRWMD



Phosphorus Forms

Surface Sediments: 0-10 cm

% of Total P

Reactive Phosphorus

- Inorganic P extracted with acid/alkali
- Organic P extracted with alkali

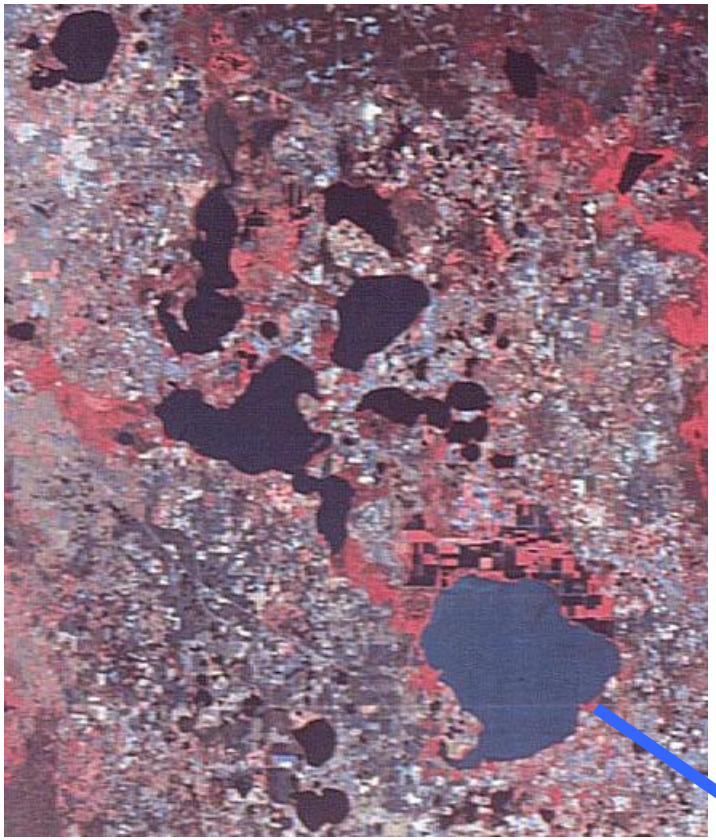
→ **83%**

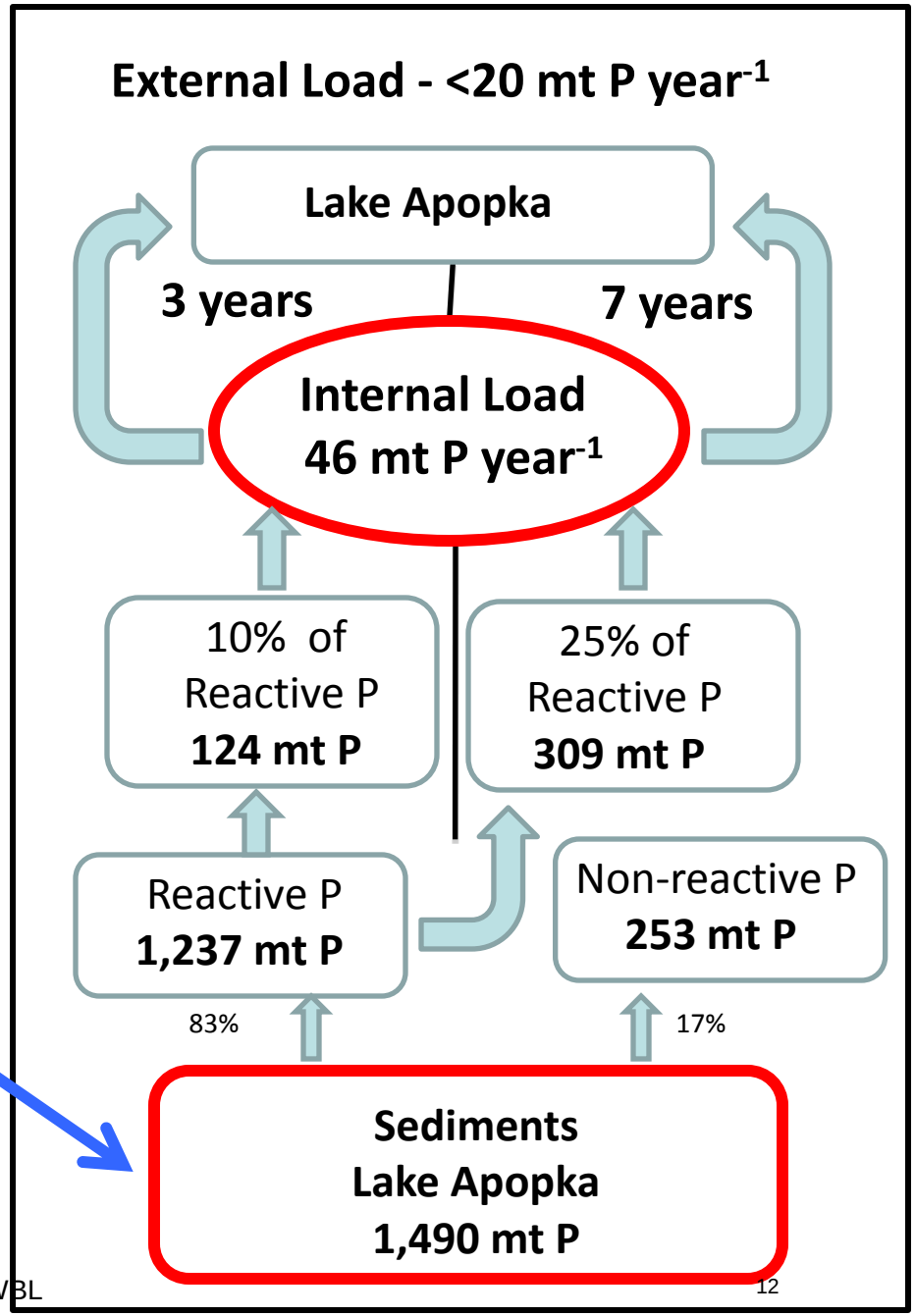
Non-reactive Phosphorus

- Total P – Reactive P

→ **17%**

Lake Apopka




External Load - <20 mt P year-1
Lake Apopka
3 years
7 years
Internal Load
46 mt P year-1
10% of
Reactive P
124 mt P
25% of
Reactive P
309 mt P
Reactive P
1,237 mt P
Non-reactive P
253 mt P
83%
17%
Sediments
Lake Apopka
1,490 mt P

Restoration Implications

- Legacy P in the drainage basin can increase the lag time for recovery… can extend for several decades
- In-situ immobilization of soil phosphorus is needed to reduce P loads
- Dredging sediments is not a viable option
- Stormwater treatment areas are effective in reducing P loads, but they must managed for long-term sustainability
- Phosphorus reactivity and stability needs further investigation