

Green Lake Water and Phosphorus Sources

FOGL Meeting May 26, 2025

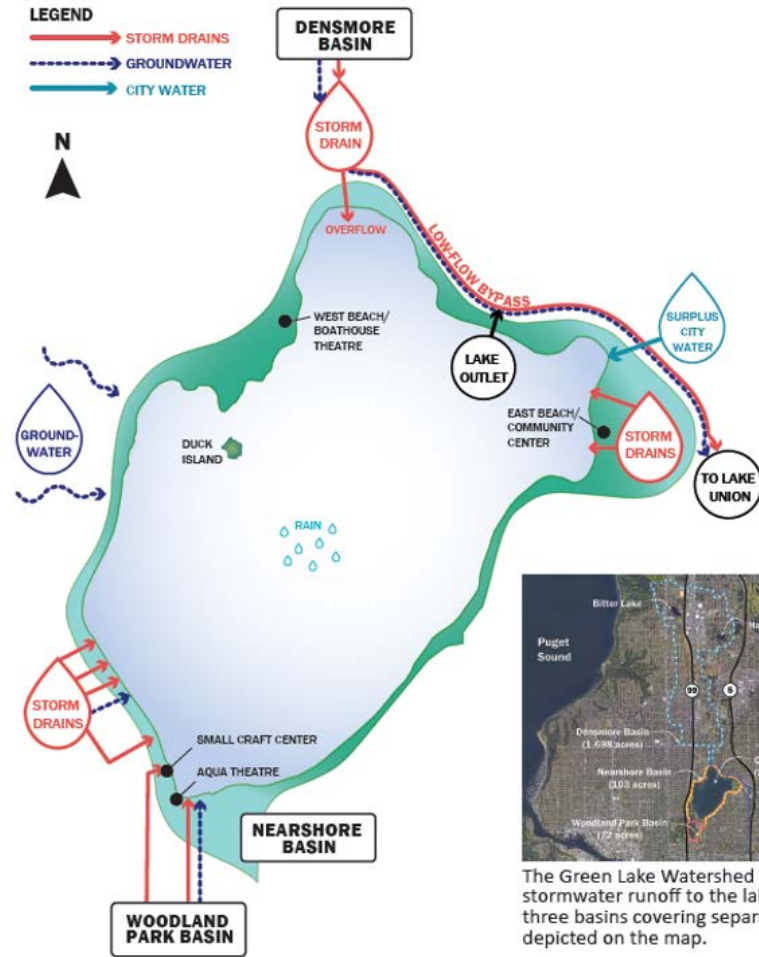


Water Inputs/Outputs

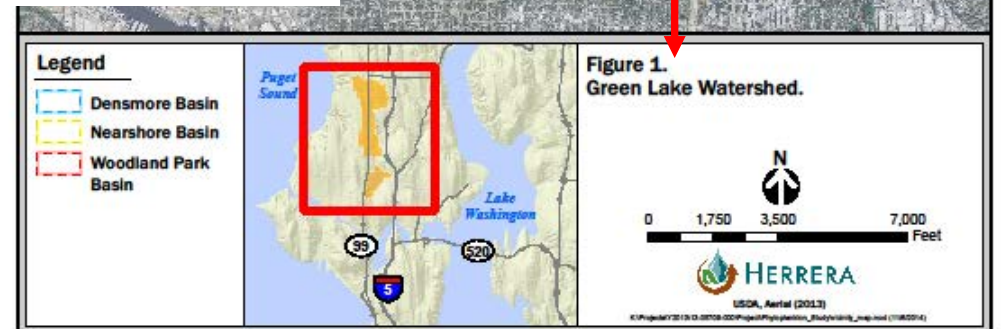
Input	Acres
Storm-Densmore	1,698-acre urban
Storm-Woodland	103-acre playfields
Storm-Nearshore	72-acre park
Base-Woodland	103-acre playfield
Base-Phinney	Small west drain
Groundwater	Unknown springs
City Water	Reservoir drain
Direct Precipitation	259-acre lake

Output	Acres
Outlet	259-acre lake
Evaporation	259-acre lake
Groundwater	Unknown seepage

SOURCES OF WATER AND PHOSPHORUS

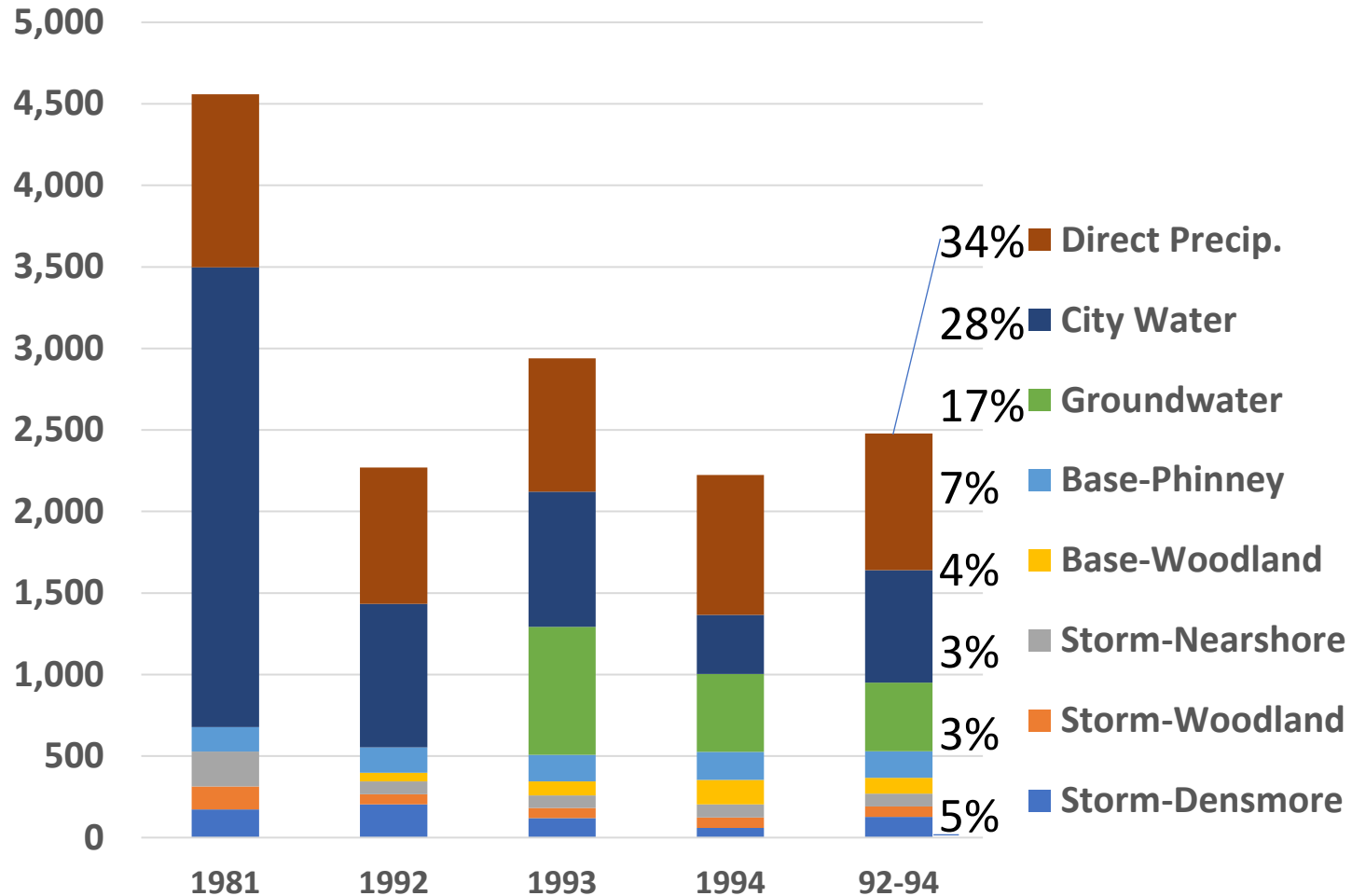


The Green Lake Watershed drains stormwater runoff to the lake from three basins covering separate areas depicted on the map.



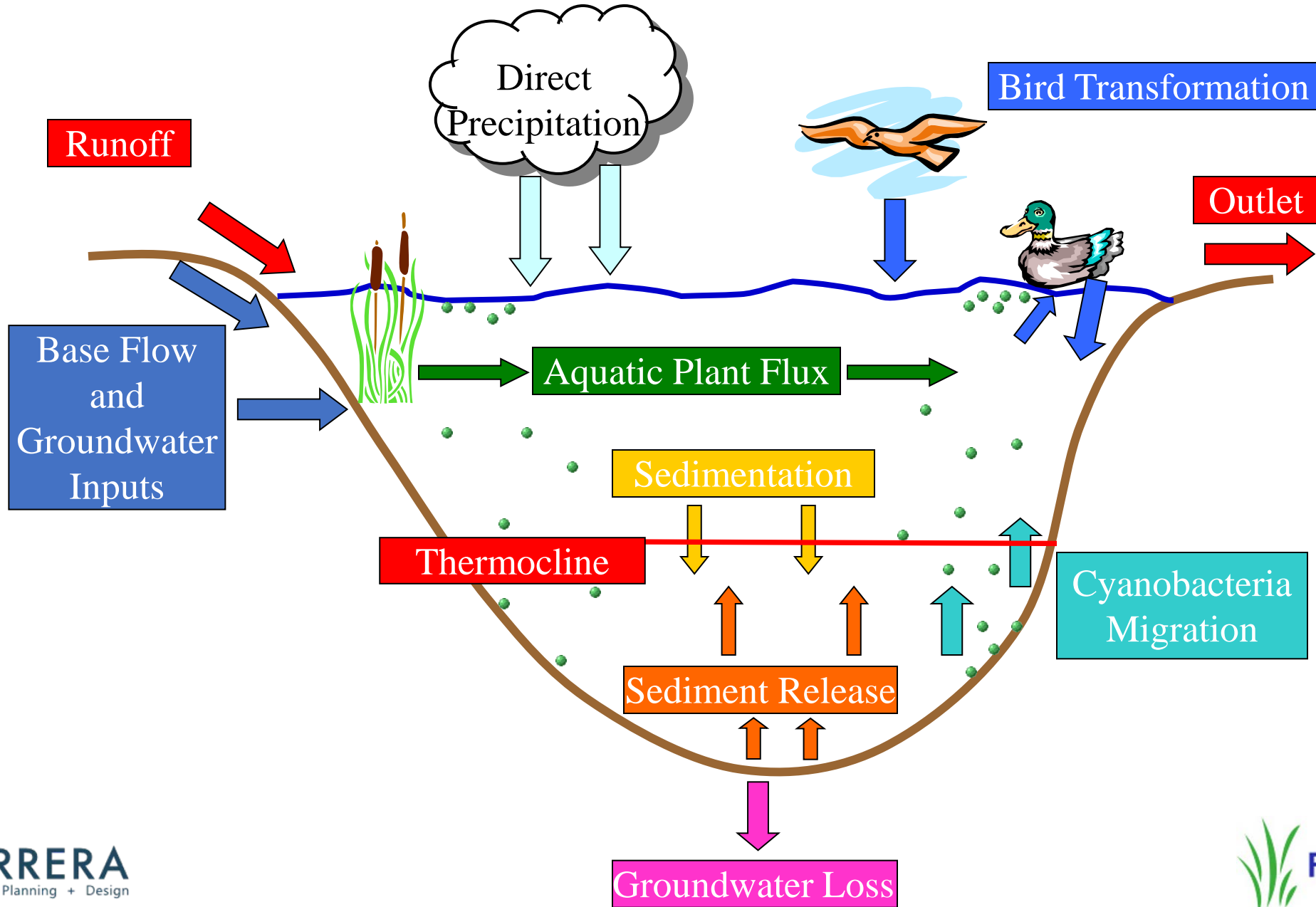
Water Inflows

Green Lake Water Inflows (1,000 m³/yr)



- Precipitation was largest source at 34% in 92-95
- City water decreased from 62% in 1981 to 28% in 92-94 to <2% in 2014
- Ground/base flow inputs only Phinney at 3% in 1981 to 27% in 92-95
- Stormwater small at 11% in 1981 and 12% in 92-95
- Densmore decreased from 9 to 3% in 92 to 94 from raising of diversion weir
- Estimate 10% of Densmore runoff jumped weir into the lake

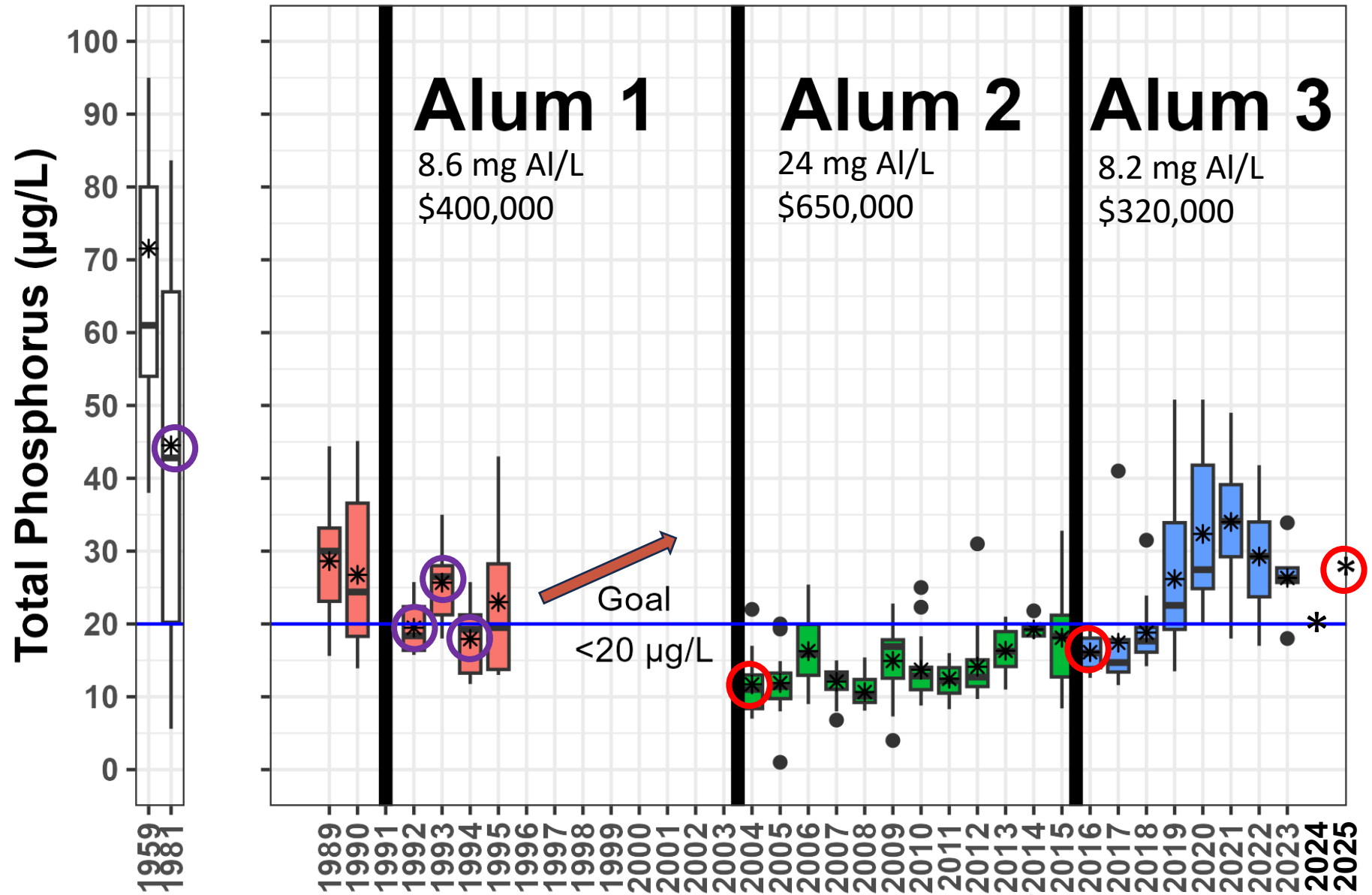
Lake Phosphorus Cycle



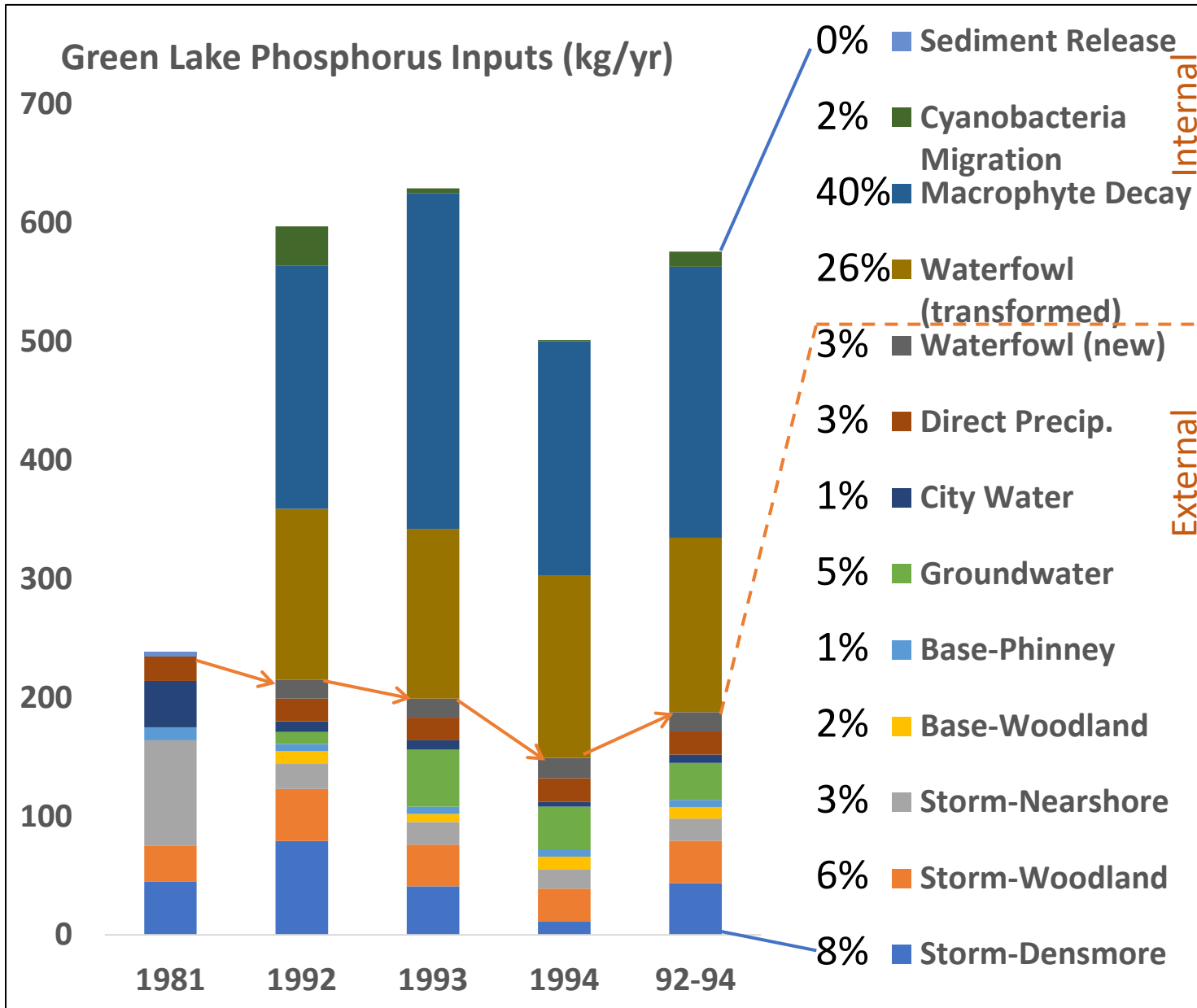
Lake Total Phosphorus

TP Goal <20 µg/L as summer mean
(= 82 kg in lake)

Alum added to reduce sediment release to meet goal in 1992, 2004, and 2016, and intended to last for ~10 years



Phosphorus Inputs



- Internal inputs only 1% in 1981 did not account for cyanobacteria, macrophytes, or waterfowl
- High internal inputs in 92-94 from macrophytes (40%) and waterfowl (26%) but no sediment release assumed due to alum treatment
- Stormwater inputs at 17% in 92-94, with decreasing Densmore amounts
- Base/ground water inputs at 8% in 92-94, with <5% precipitation and city water
- Phosphorus outputs in 92-94 at 92% sedimentation and 4% each for lake outlet and groundwater seepage

Phosphorus Input Changes Since 1992-1995

1992-1995 to 2004

- High alum dose (24 mg/L) in spring to inactivate 10,000 kg mobile sediment phosphorus
- Lake summer mean TP decrease from 21 to 11 mg/L
- Macrophyte cover decrease from 85% to 10%
- Assume small decrease in waterfowl (transformed); large decrease in Woodland/Densmore stormwater

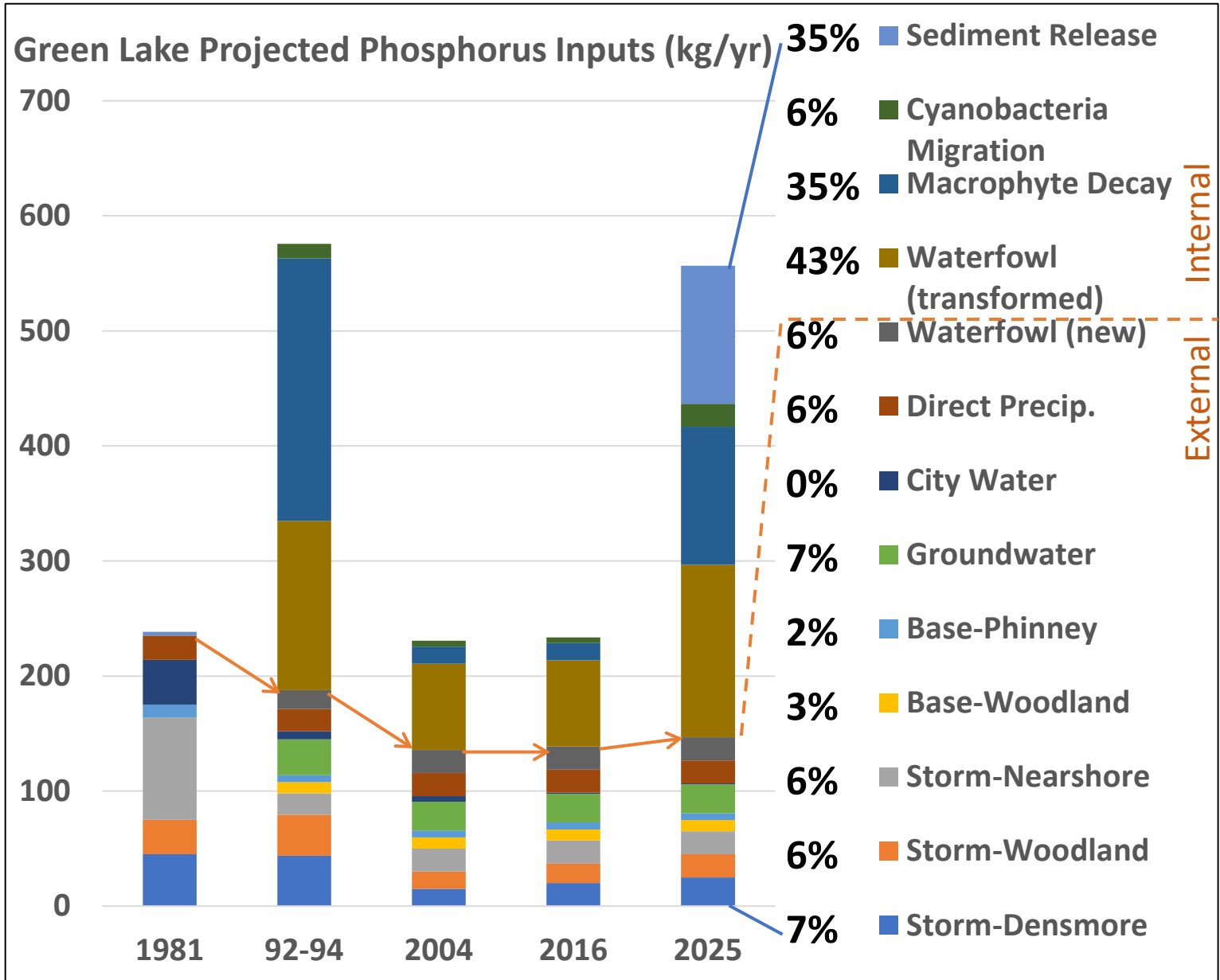
2004 to 2016

- Moderate alum dose (8.2 mg/L) in spring to inactivate 5,000 kg reactive sediment phosphorus
- Lake summer mean TP increase from 11 to 16 mg/L
- Macrophyte cover increase from 10% to ~26% (to 48% in 2022 from Egeria invasion)
- Assume no change in waterfowl; small increases in stormwater

2016 to 2025

- No alum treatment for 9 years with sediment P accumulation increasing sediment P release
- Lake summer mean TP increase from 16 to 28 mg/L
- Milfoil treated in June decreasing macrophyte cover from ~65% to ~45%
- Assume small increase in waterfowl (transformed); small increases in stormwater

Projected Phosphorus Inputs



- >50% reduced P inputs following 2004 and 2016 alum treatments from 92-94 due to less macrophytes, waterfowl, stormwater, and P in lake
- >Doubling P inputs by 2025 in 9 years since 2016 treatment due to more sediment release, macrophytes, and waterfowl
- Currently, ~ 550 kg/yr total P input includes ~130 kg/yr (25%) external P input and 420 kg/yr (75%) internal P input

External Source Control Matters

- Stormwater P inputs in winter settle to bottom, become biologically available in summer through microbial decay and chemical (redox/pH) processes for sediment release, macrophyte uptake/decay, and waterfowl grazing/defecation
- Major portion of current 75% internal P input originated from historical stormwater P inputs
- Reducing stormwater P inputs will improve water quality and extend effectiveness of alum treatments costing about \$50,000/year





Questions?

Rob Zisette

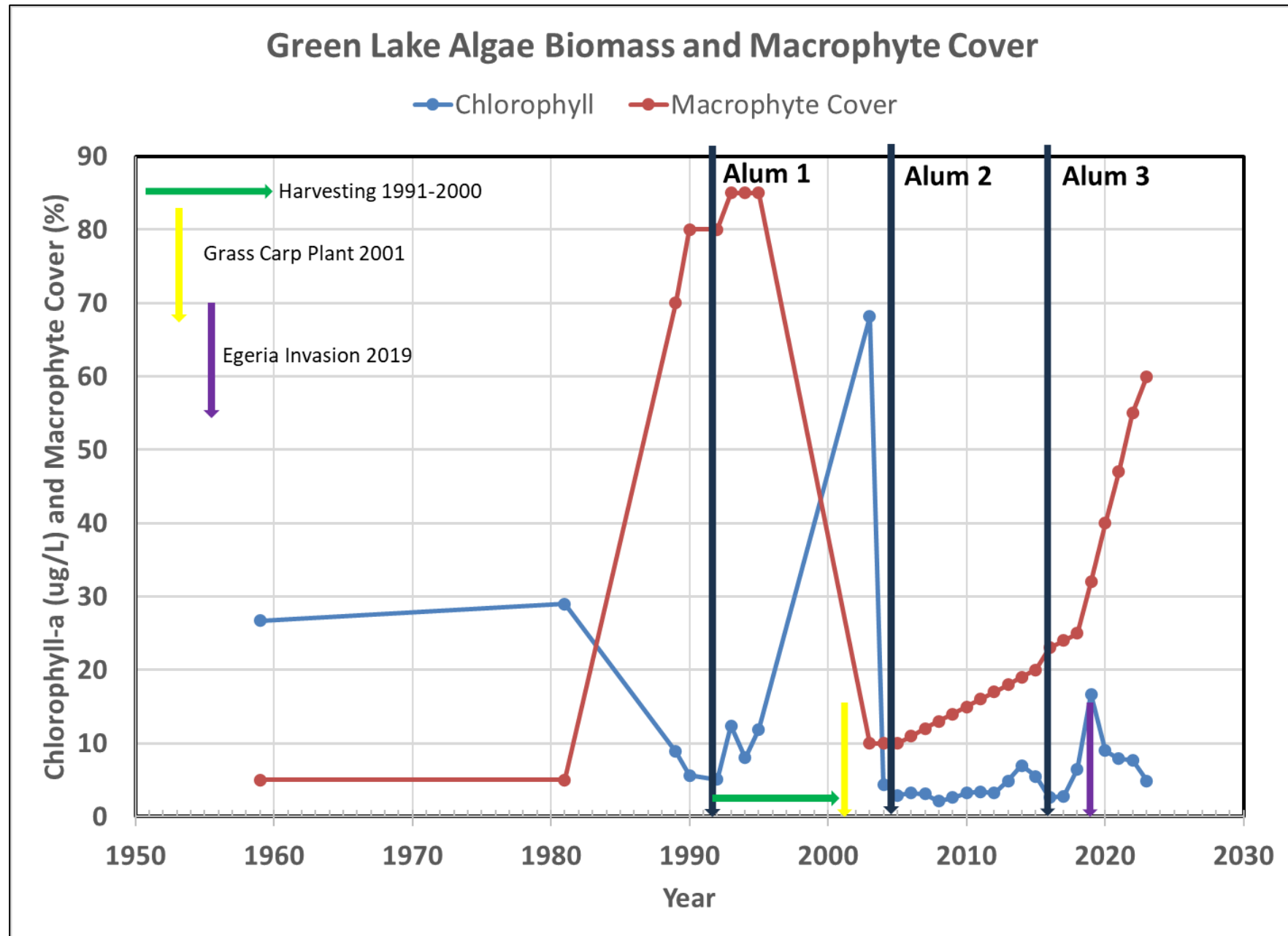
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Working to keep Green Lake swimmable



Alternative Stable States in Green Lake

- Pre-treat: Milfoil expansion and algae decline 1981-1991
- Alum 1: Milfoil crash and algae bloom 2001-2003
- Alum 2: Slow Milfoil expansion and low algae 2004-2018
- Alum 3: Egeria expansion and algae decline 2019-2023



Alternative Stable State: ----- Algae ----- |-----Plant-----|-----Algae-----|-----Plant-----