An aerial photograph of Lake Tahoe, showing the deep blue water of the lake and the surrounding mountain ranges under a clear blue sky with some light clouds. The text is overlaid on the upper portion of the image.

Overview of the Lake Tahoe Atmospheric Deposition Study (LTADS)

Leon Dolislager

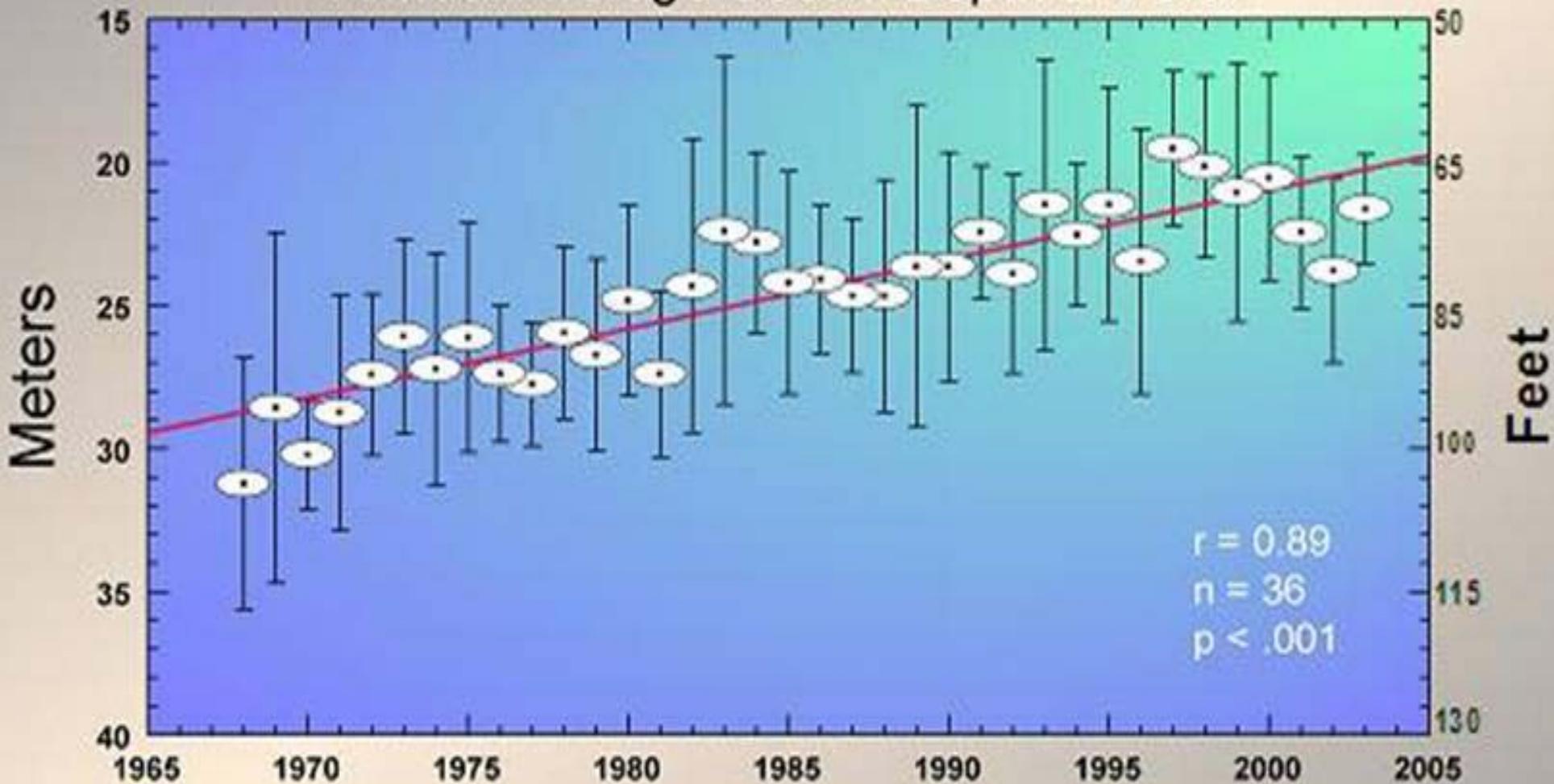
Atmospheric Processes Research Section

Air Resources Board

December 14, 2005

LAKE TAHOE

Annual Average Secchi Depth \pm 1 s.d.

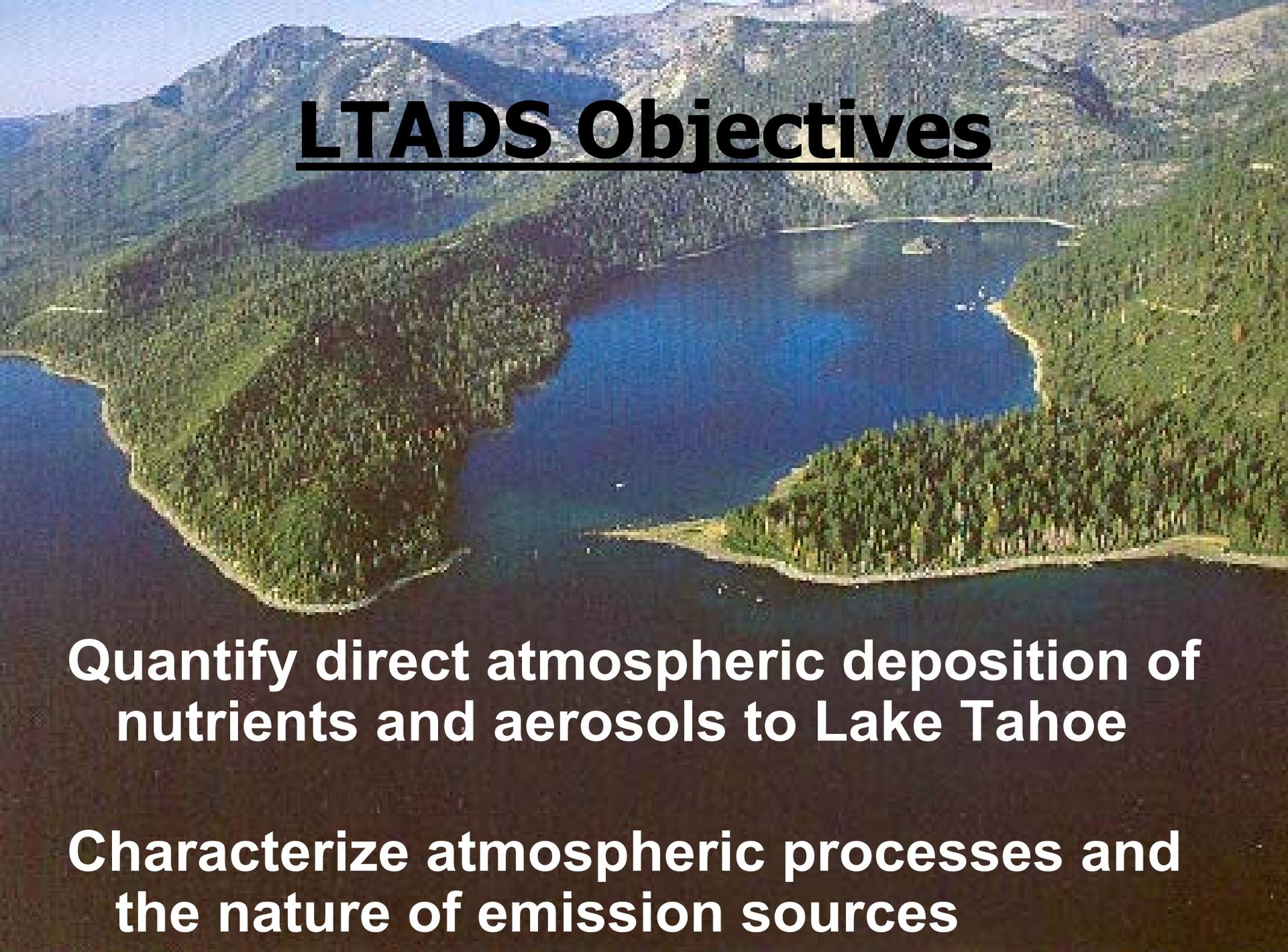


TAHOE RESEARCH GROUP
UC DAVIS

Presentation Outline

- **Study Design**
- **Activities**
- **Results**



An aerial photograph of Lake Tahoe, showing the deep blue water of the lake surrounded by dense green forests and rugged mountains in the background. The sky is clear and blue.

LTADS Objectives

Quantify direct atmospheric deposition of nutrients and aerosols to Lake Tahoe

Characterize atmospheric processes and the nature of emission sources

★

LTADS Monitoring Network

- ★ AQ - gas & PM
- ★ AQ - PM ★
- ★ AQ - single gas
- ★ Deposition
- ★ On-Lake
- ★ Meteorology aloft



1. **Big Hill**
2. Echo Summit
3. Tahoe Airport
4. **SLT-Sandy Way**
5. SLT-SOLA
6. DL Bliss SP
7. Ward Creek
8. Tahoe City
9. **Lake Forest**
10. Incline Vlg - AQ
11. Incline - Met
12. **Thunderbird Ldg**
13. Cave Rock SP
14. Stateline - Harvey
15. **Buoys/Piers**
16. Grass Valley

Primary Instruments

winds aloft

RWP/RASS also provides
temperature aloft

Mini-Sodar



TSP

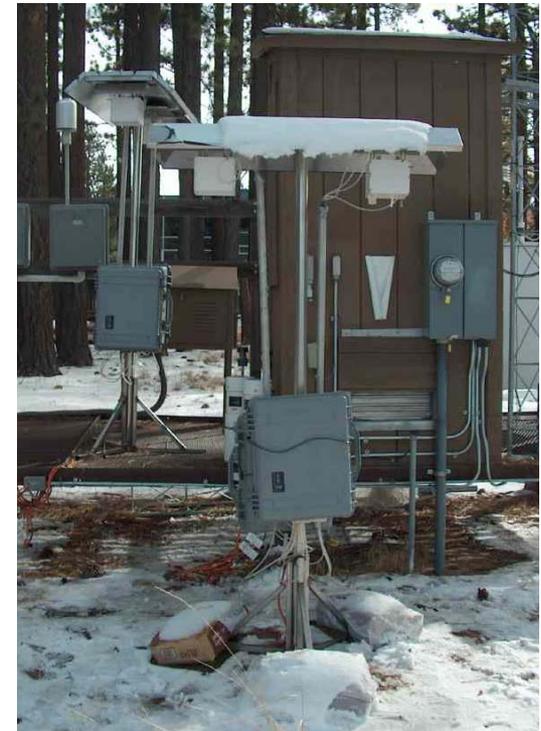
and PM species
on buoys & piers

Mini-Volume Sampler



TSP, PM10, & PM2.5,
& PM species, and
NH₃ & HNO₃
at land sites

Two-Week Sampler



Special Measurements

- UCD Carroll – aircraft & boat
- UCR Fitz – wood smoke & MV fleet
- DRI Kuhns – residential wood smoke & road dust
- UCB Cohen – reactive nitrogen & transport
- UCSD Michalski – isotopic fingerprints
- DRI/UCD Kohl/Cliff&Green – XRF/s-XRF & ICP-MS
- DRI Dana – heat and momentum flux
- TRG Schladow & JPL Hoek – met on buoy & piers
- ARB Tony/Jim/Ash – Optical Particle Counters
- ARB Leon – surrogate surface comparison

LTADS Complexities

- **AQ Measurements**
 - Siting
 - Atmospheric conditions
 - Clean air
- **Meteorology**
- **Emissions**

LTADS Activities

Characterizing Emission Sources

- **Source profiles**
 - Smoke (residential, neighborhood, prescribed burns)
 - Road dust
 - Fleet composition
- **Source Activity**
 - Wood burning survey
 - Driving patterns

To model, more investigation needed of Tahoe-specific emission factors

LTADS Activities

Characterizing Atmospheric Processes

- Air flow
- Vertical temperature profiles
- Precipitation

To model, more investigation needed:

- Atmospheric processes aloft
- Microscale processes @ lake/air interface
- Meteorological model that replicates seasonal patterns and is constrained by pollutant patterns

LTADS Results

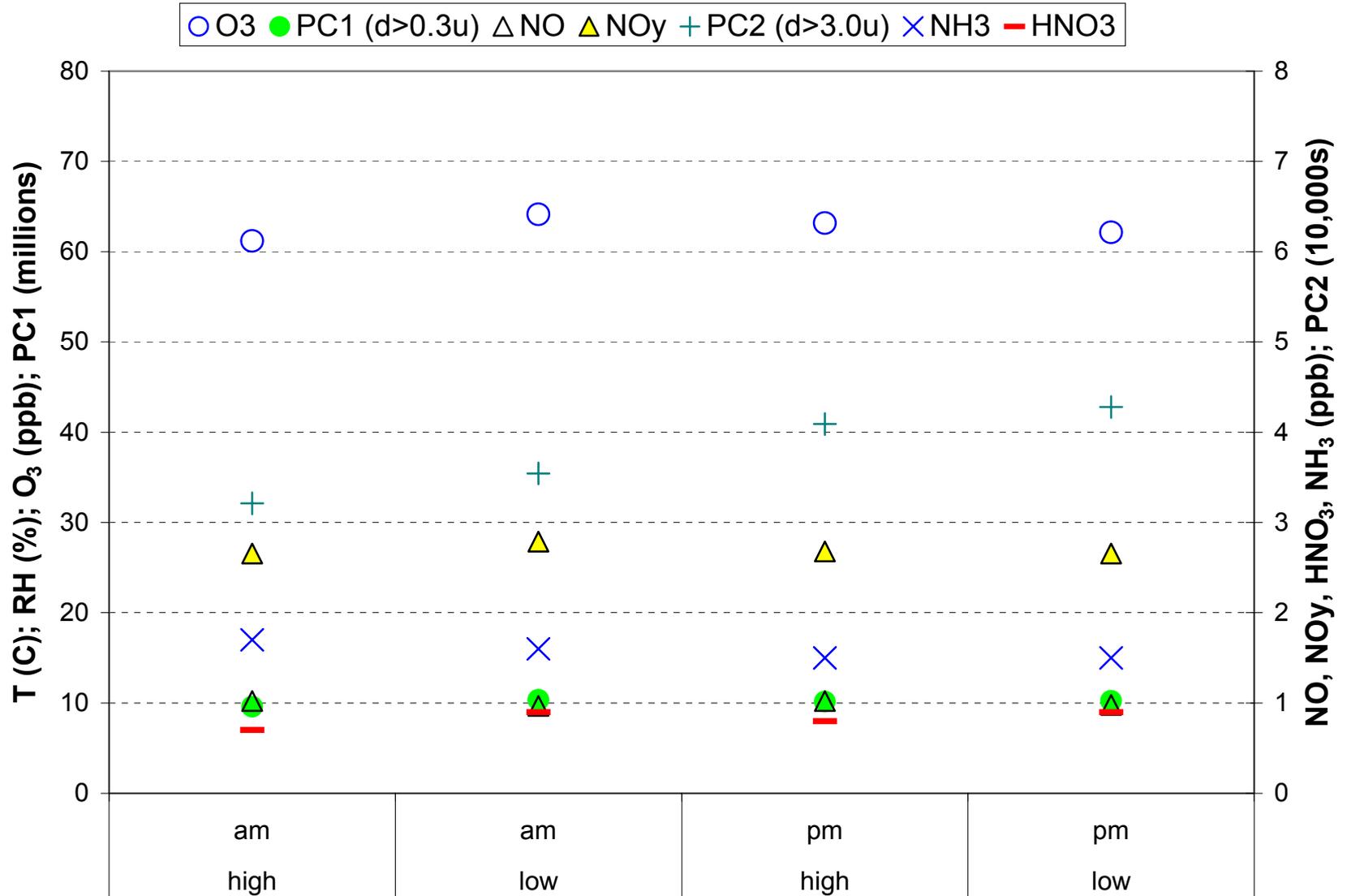
Hierarchy of Air Quality during LTADS

Atmospheric Deposition Estimates

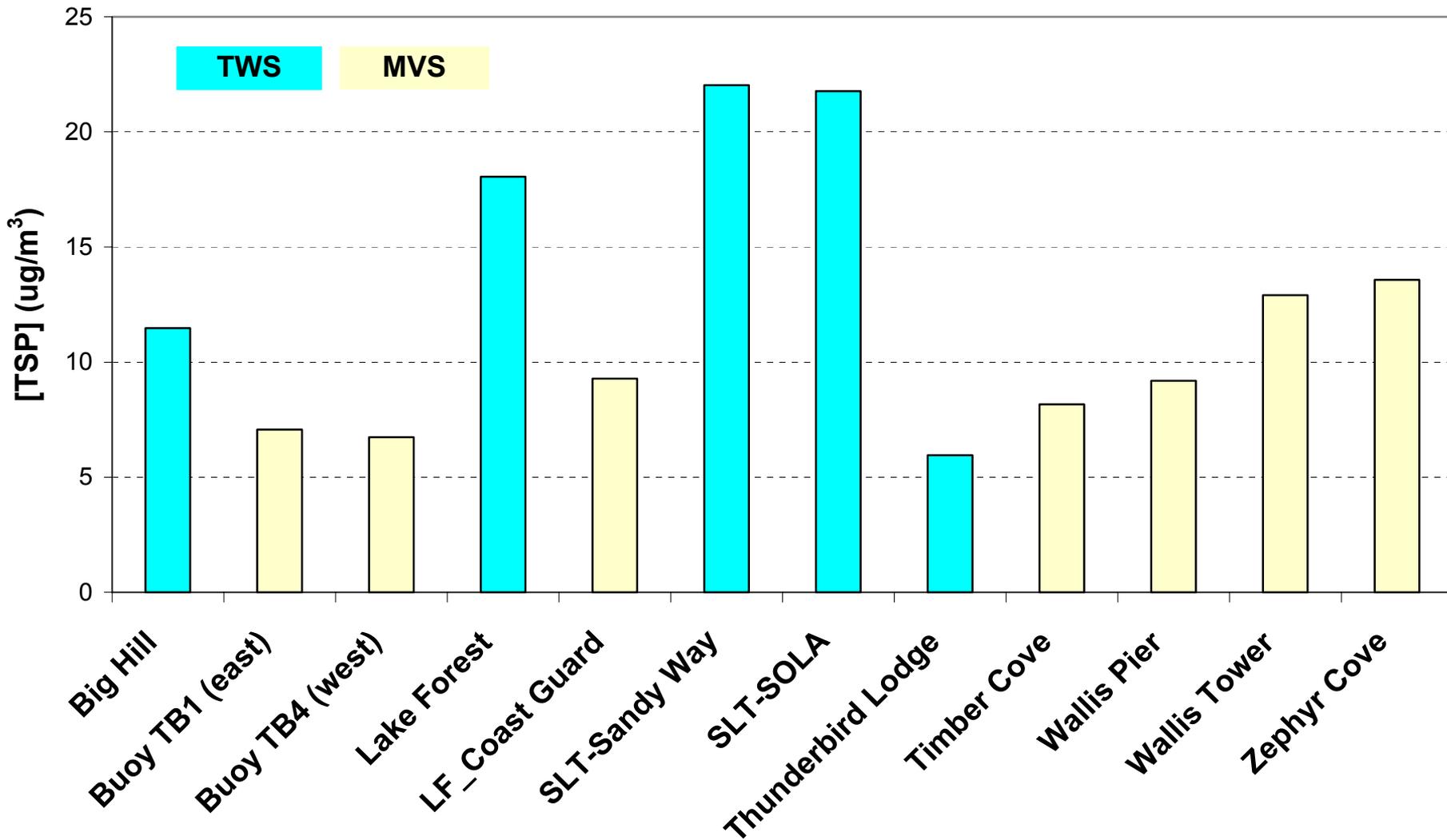
- Nitrogen
- Phosphorus
- Particulate Matter

LTADS Results - AQ during Aircraft Orbits

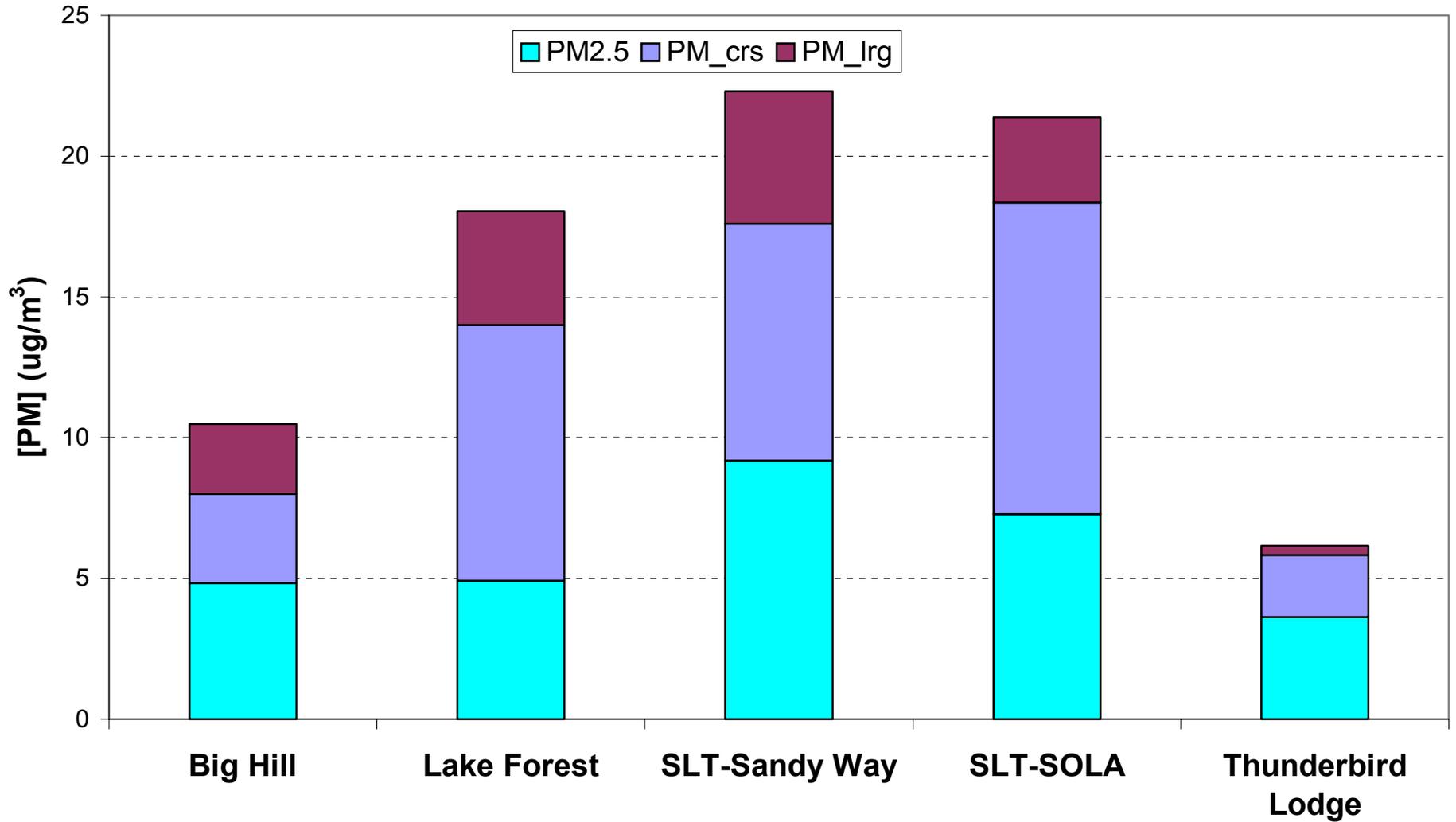
Mean Values during orbits at 7800' & 6800' over Lake Tahoe - Sept. 2003



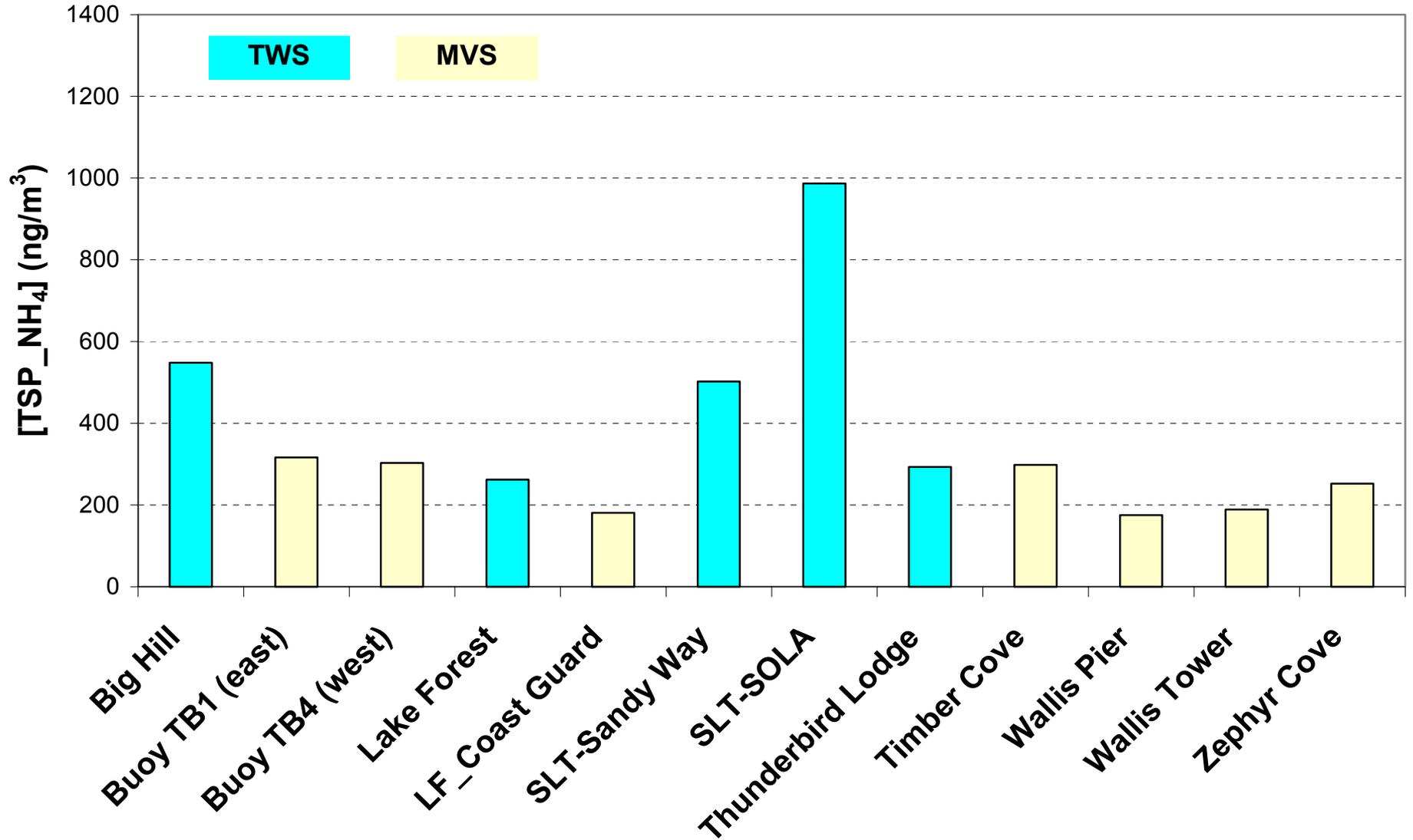
Annual Mean Total Suspended Particulate Matter during LTADS



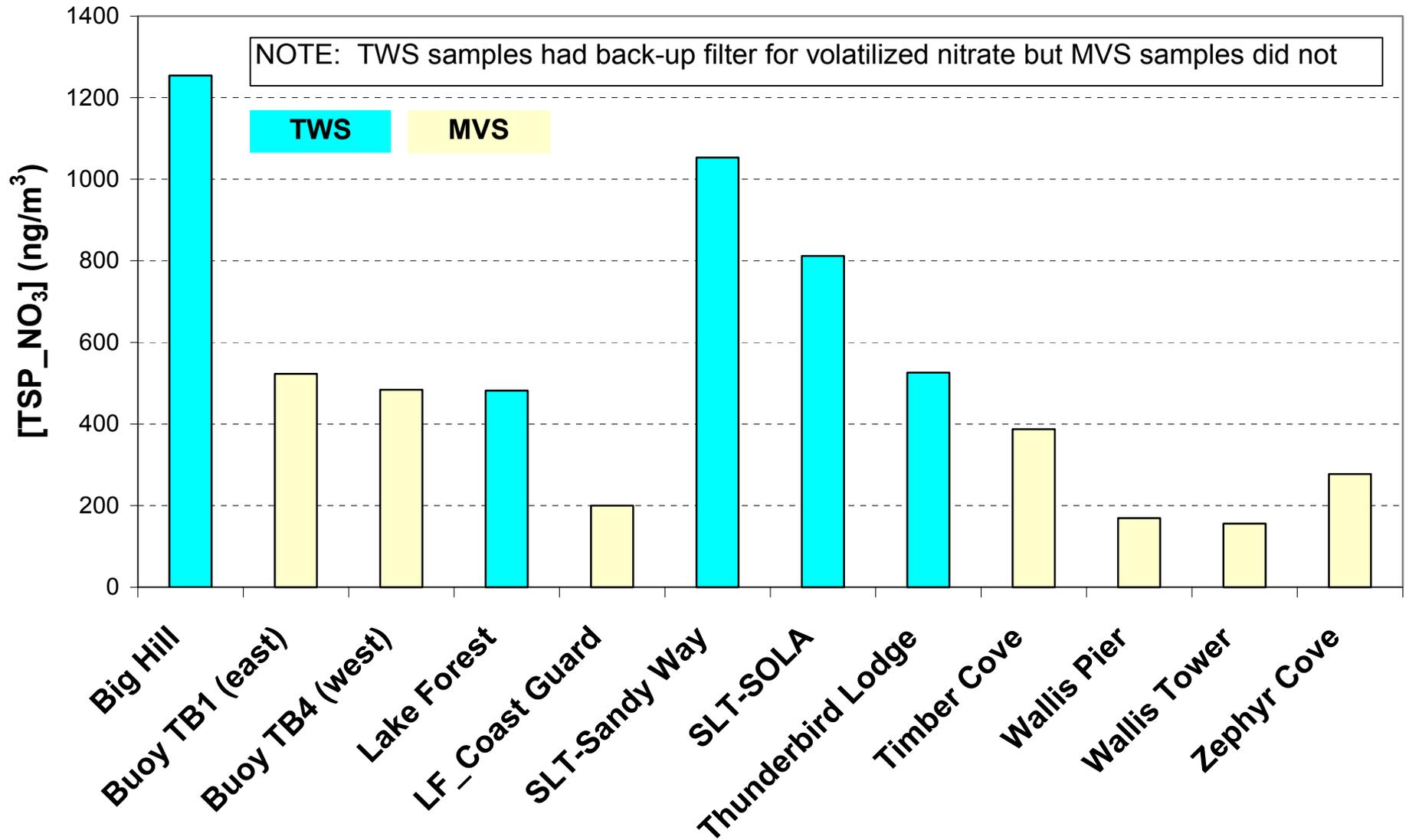
Annual Mean Particulate Matter by Size during LTADS



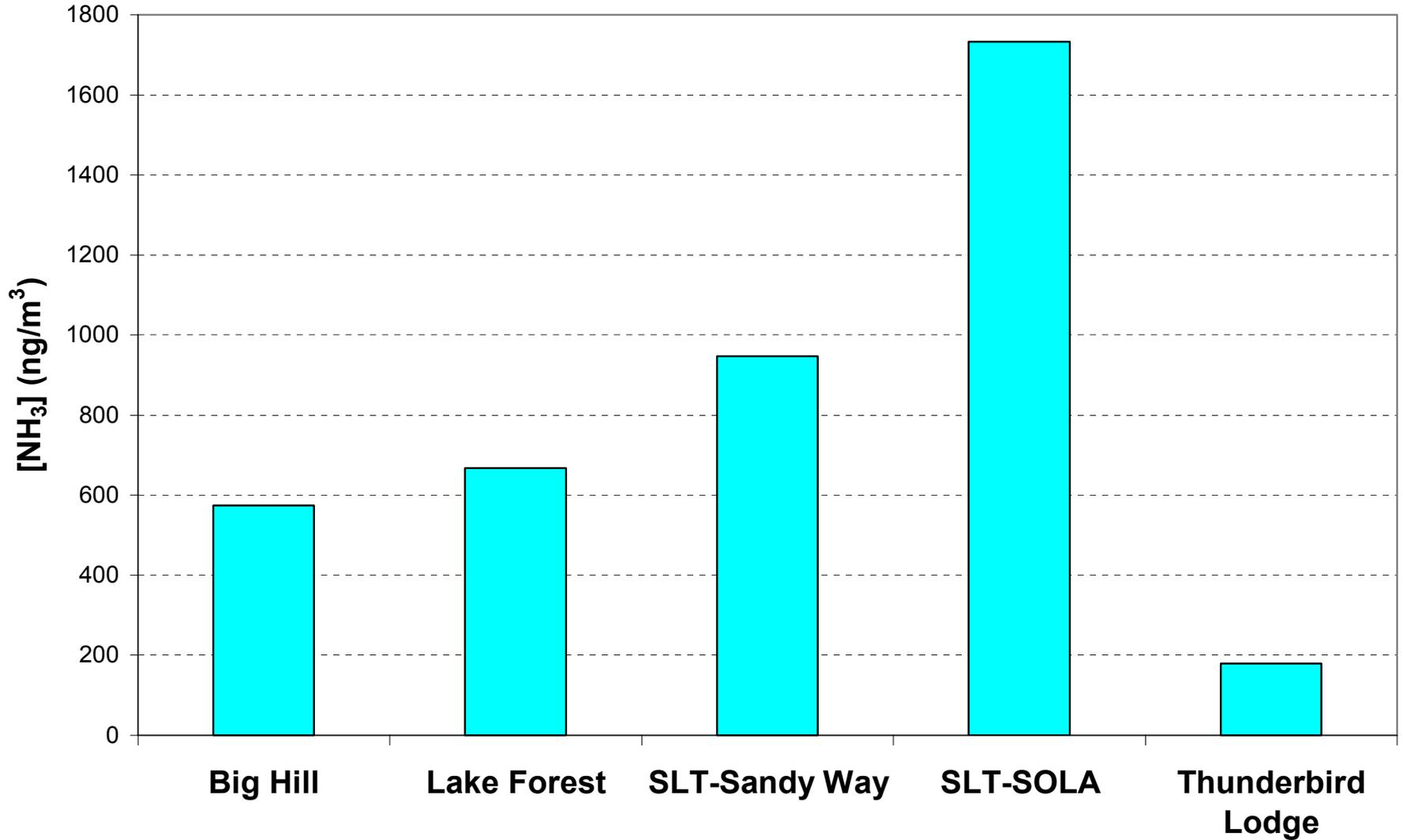
Annual Mean Ammonium Ion during LTADS



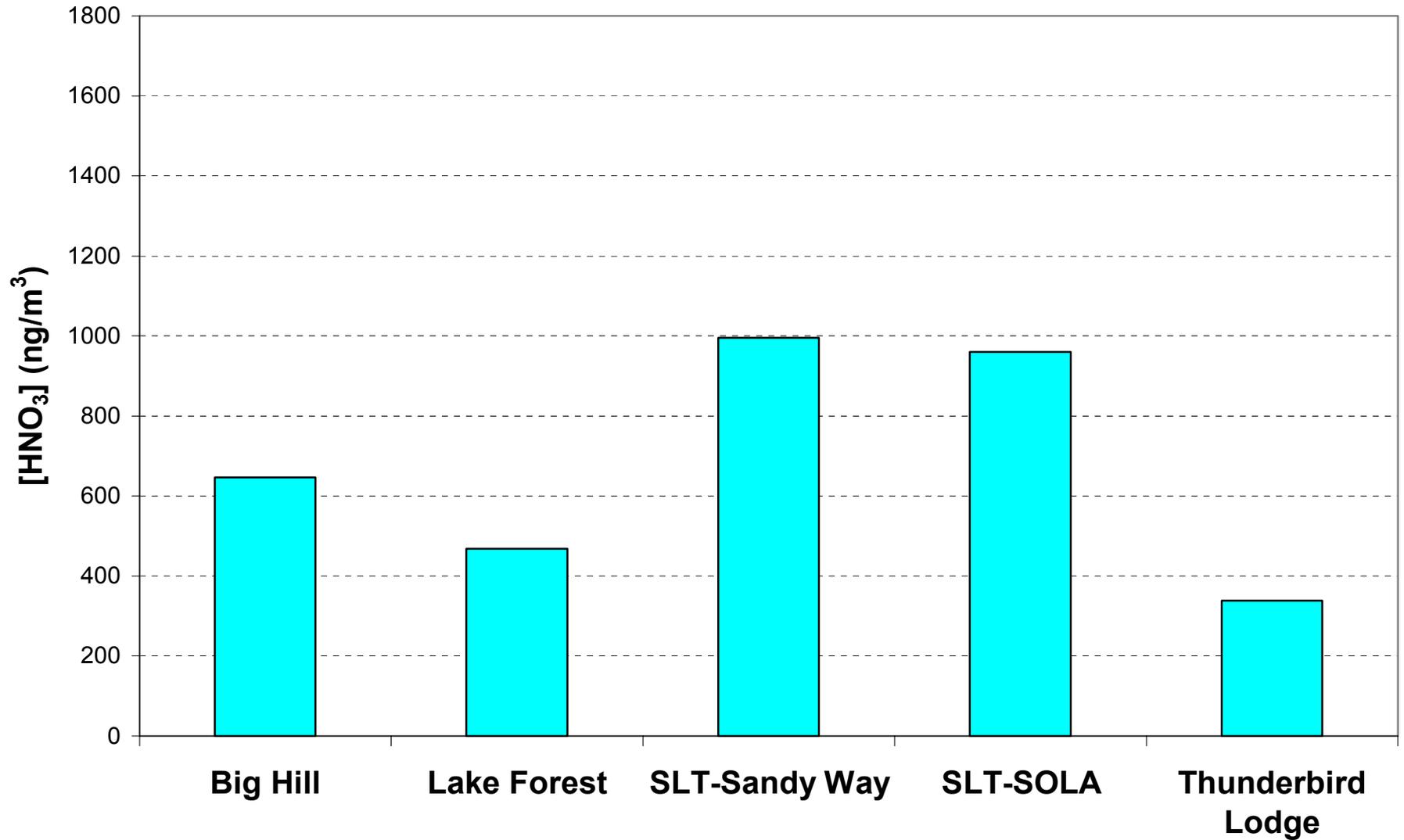
Annual Mean Nitrate Ion during LTADS



Annual Mean Ammonia during LTADS



Annual Mean Nitric Acid during LTADS



Estimate of Total Atmospheric Deposition Directly to Lake Tahoe

(Metric Tons/Year)

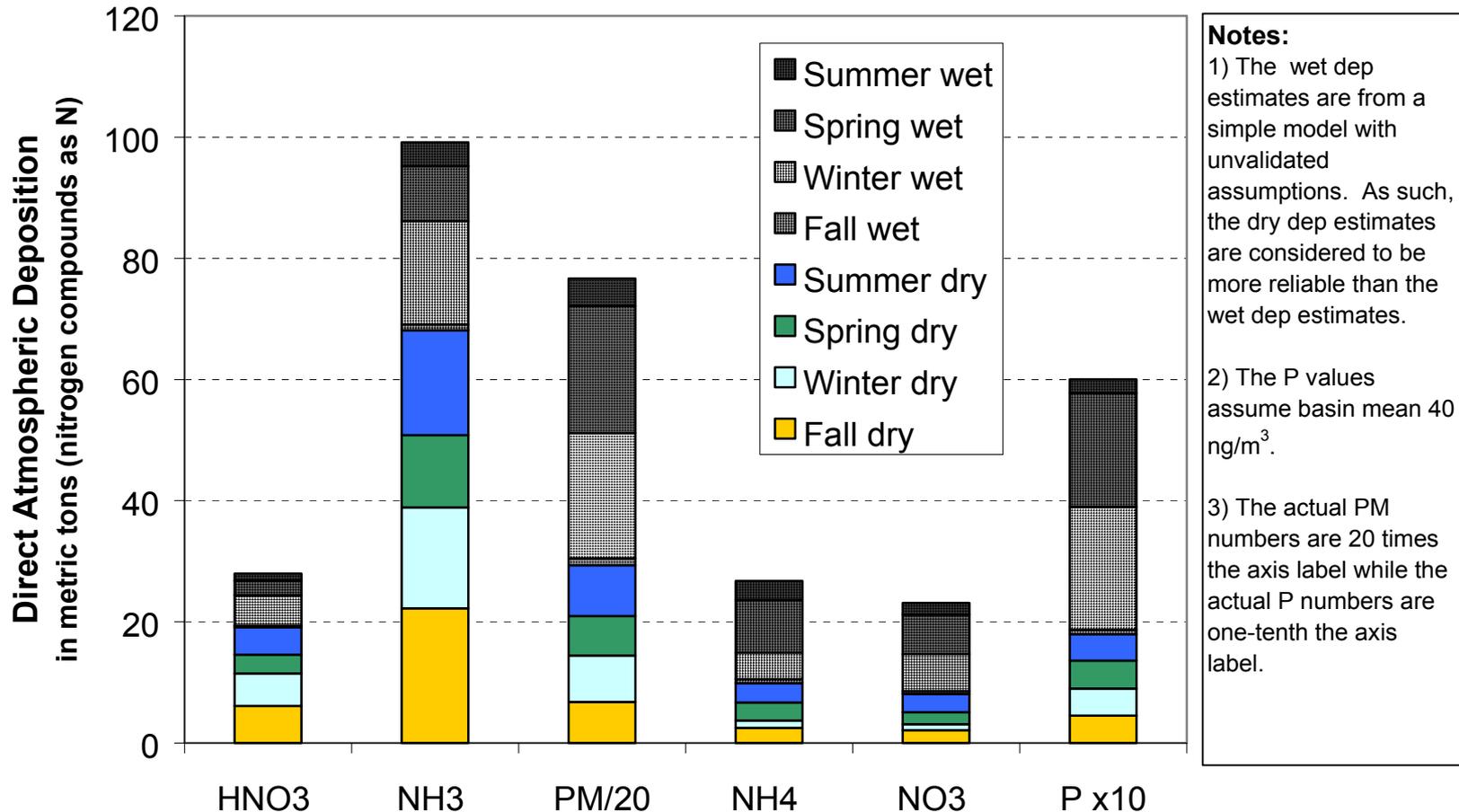
Pollutant	Dry	Wet	Total
TSP_NH ₄	9.8	16.8	26.6
TSP_NO ₃	8.0	15.0	23.0
NH ₃	68.2	31.0	99.2
HNO ₃	19.1	8.9	28.0
Total N	105.2	71.8	177.0
P	1.2 (1.8)*	2.1 (4.2)*	3.3 (6.0)*
TSP	718 (587) ⁺	946	1664 (1533) ⁺

* # within () indicates update associated with new P measurement correction factors and on-lake depletion factor

** # within () indicates update associated with new P measurement correction factors

+ # within () indicates update associated with on-lake depletion factor

Estimate of Total Atmospheric Deposition Directly to Lake Tahoe (Metric Tons)

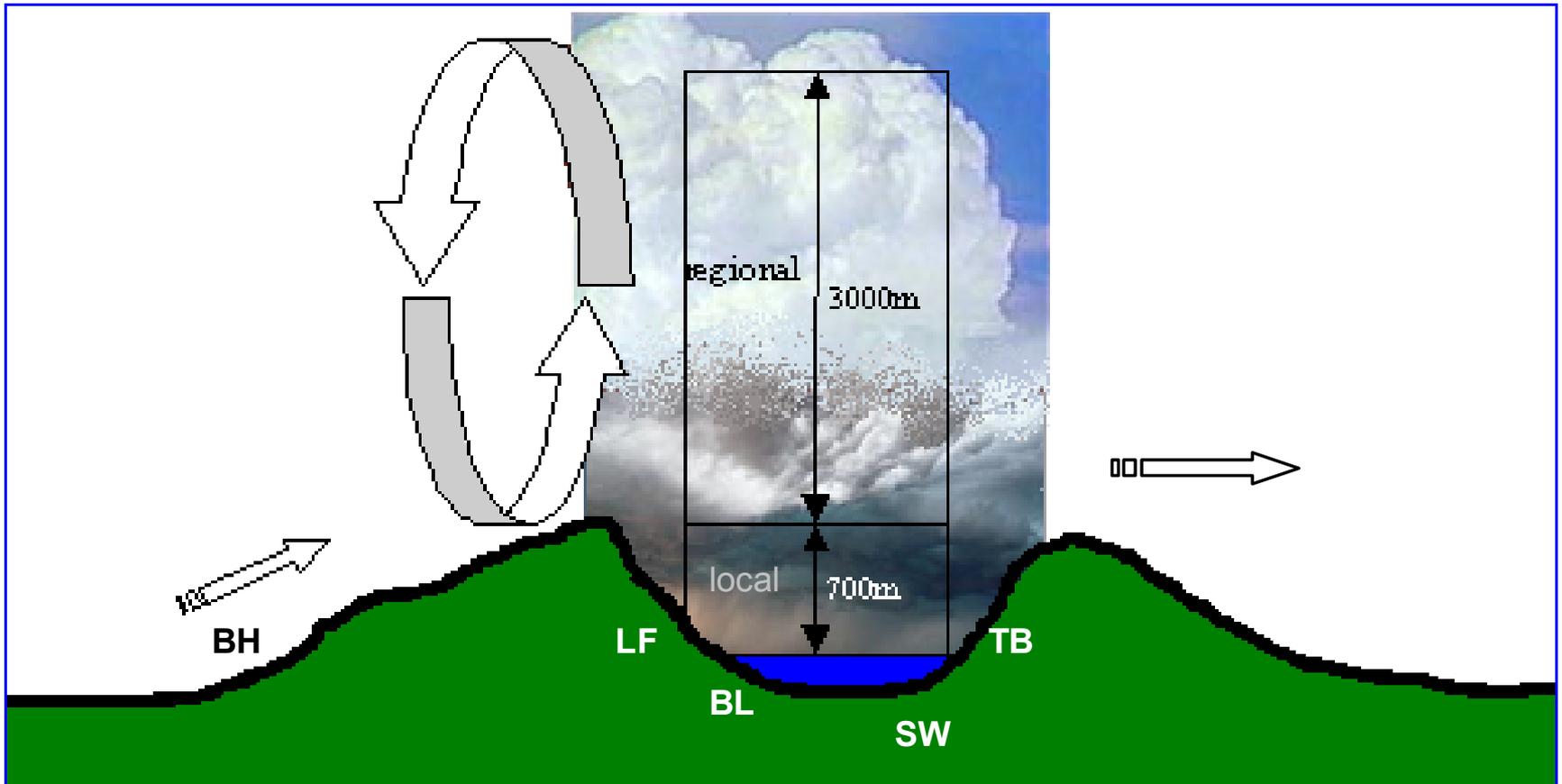


Notes:

- 1) The wet dep estimates are from a simple model with unvalidated assumptions. As such, the dry dep estimates are considered to be more reliable than the wet dep estimates.
- 2) The P values assume basin mean 40 ng/m³.
- 3) The actual PM numbers are 20 times the axis label while the actual P numbers are one-tenth the axis label.

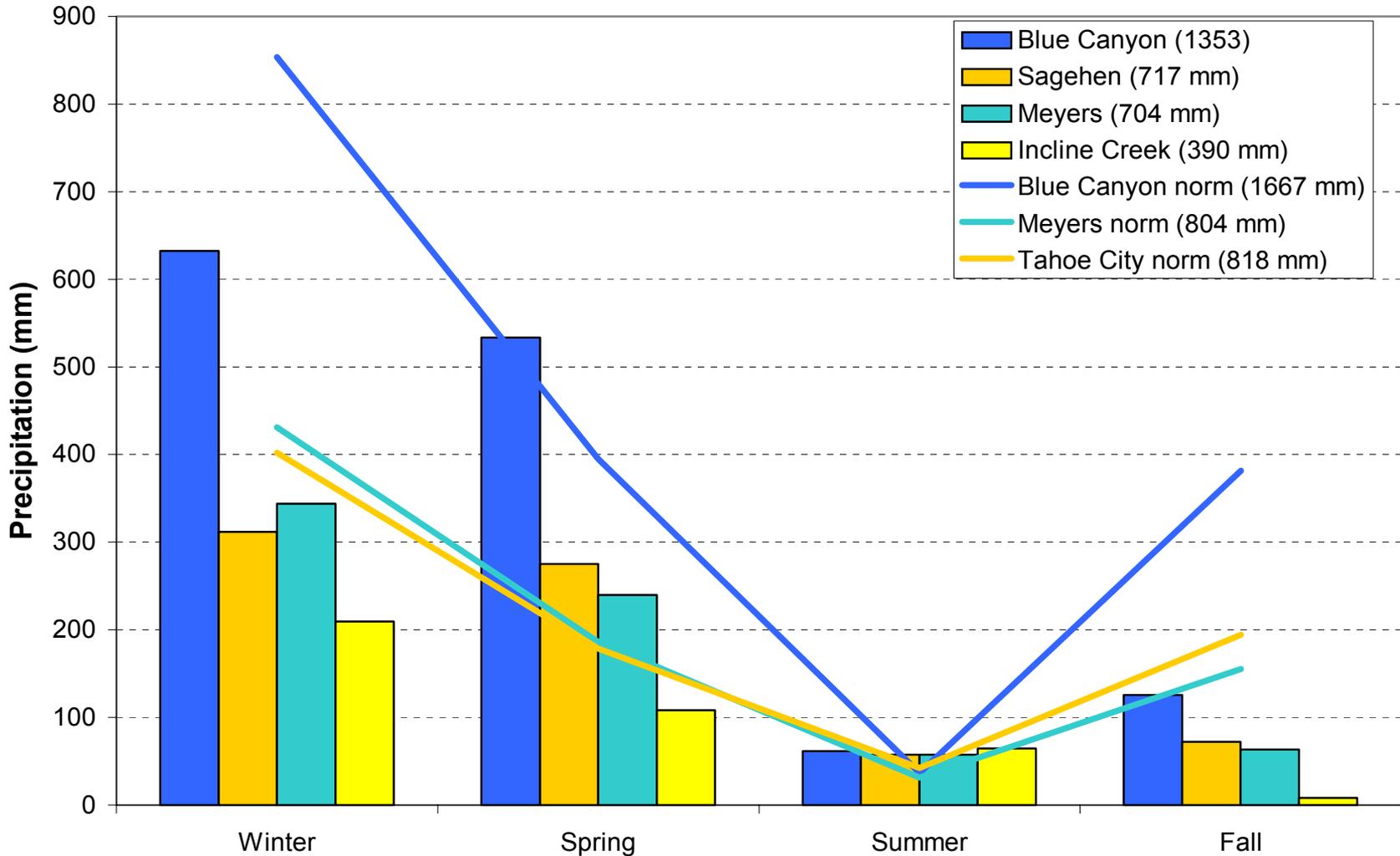
Note adjustment to PM and P values. Actual PM dep is 20 times greater and actual P dep is 10 times less than indicated on Y-axis.

Meteorological Processes



LTADS Precipitation

2003 Precipitation versus Seasonal Normal



LTADS Results

Emission Source Indications

- Default MV assumptions inappropriate
- PM – in-basin road dust
- Reactive N – in-basin
- NH_3 is primary contributor to total N

Extensive database for Tahoe can help address outstanding issues

Additional data analysis needed

Additional research needed



Acknowledgements

- TRG (Richards, Hackley, Schladow, Reuter)
- Lahontan (Landy & students)
- TRPA (Quashnick & Americorps volunteers)
- DRI (Kohl, Dana)
- UCD (Cahill, Cliff, Bucknell)
- UCR (Venkatram, Davis)
- NDEP (trailer)
- ARB MLD (Popejoy, Goodenow, Poore, & staff)
- ARB PTSD (Hsu & Fitzgibbon)
- ARB RD (Taylor & management)

ARB's LTADS Survivors

