TDEP Committee Meeting, April 24, 2017, Louisville, Kentucky

1. **Welcome and Introductions**
   - See Attendance List for list of attendees, their organization and email addresses.

2. **TDEP 2015 Map Update** (Gary Lear)
   - TDEP 2017v1 uses 2016 measurement data and CMAQv5.0.2. Model results included in this version were for years 2002-2012.
   - Additional CMAQ runs not yet available
   - The new version will be similar to 2016v2, but with the following changes:
     - Sea salt sulfate
     - Slightly different parameterization for IDW
     - Removal of SEARCH sites
   - Scripts are now available on GitHub
     - https://github.com/Measurement-Model-Fusion/Total-Deposition
     - There is a project in that repo called Concert2Python

3. **World Meteorological Organization (WMO)/Global Atmosphere Watch (GAW) Workshop Update** (Amanda Cole)
   - Workshop held from February 28th through March 2nd, 2017 in Geneva, Switzerland
   - The scientific advisory group (SAG) for total atmospheric deposition was responsible for an earlier undertaking of global assessment of precipitation chemistry and deposition; this effort was led by Bob Vet
   - During this effort the measurement data were overlaid with model results. CASTNET and CAPMoN data were also mapped out. Results were not the best, but this early work set the stage for a measurement-model fusion effort.
     To date, Sweden and US had been the only ones attempting this type of effort
   - Workshop objectives were to:
     - Review the state-of-the-science and establish a GAW project on measurement-model fusion for global total atmospheric deposition.
     - Explore the feasibility and methodology for producing global maps of atmospheric concentrations of gas and aerosol species as well as wet, dry and total deposition;
     - Meet the needs of policy-makers, science programs and client communities including human health, ecosystem health, biogeochemical cycling, biodiversity, agriculture, and climate change.
   - Participants were experts in human health; ecosystem health; international programs such as WHO (health), INMS (nitrogen), GESAMP (phosphorus); measurement-model fusion, data assimilation and objective analysis; global and regional modelling and evaluation; data management, analysis and distribution; satellite observations and

applications to human health and deposition; ground based gas, aerosol and deposition measurements; wet and dry deposition; WMO; WMO/GAW SAG groups and expert teams

- The workshop structure consisted of:
    - ➢ Keynote speakers who covered topics on international biodiversity, critical loads, nitrogen and human health;
    - ➢ Science presentations panel discussions on:
        - ✓ Current MMF-TAD projects and activities worldwide;
        - ✓ Surface and satellite measurements;
        - ✓ Regional and global modelling, evaluation and comparability
    - Breakout and plenary sessions
- Major Outcomes:
    - ➢ Unanimous agreement to establish a formal WMO/GAW MMF-GTAD Project with focus on S, N, O3
    - ➢ A 3-phase project:
        - ✓ Phase 1 short term: MMF of existing 2010 ensemble global model results with existing data sets
        - ✓ Phase 2 medium term: stitch together MMF-TAD existing and new regional/global maps to produce global maps and a journal article
        - ✓ Phase 3 long term: ongoing operational re-analysis using data assimilation
    - ➢ Buy-in of all major modelling groups, WMO SAG, measurement groups, policy and science drivers
    - ➢ WMO/GAW Workshop report to be posted on: http://www.wmo.int/pages.prog/arep/gaw/WorkshoponMeasurementModelFusion.html
    - ➢ "Roadmap to the Future" report
- Alignment with NADP/TDEP includes:
    - ➢ Global model comparisons/ensembles: variability of models
    - ➢ Stitching of regional products: US-Canada Air Quality Agreement
    - ➢ Potential use of TDEP scripts/routines for new regions (Europe or Asia?)
    - ➢ Global dataset compilations
    - ➢ Measurement breakout recommendations:
        - ✓ Increased acceptance of passive sampler data and potential development of DQO's; organic nitrogen
    - ➢ Focus on model development of dry deposition schemes, land use
    - ➢ New methods for satellite data assimilation

4. White Paper – Progress and Discussion on Total Deposition Research Science Needs (John Walker)

- White paper objectives are to:

  - Provide road map for TDEP with respect to reactive nitrogen
  - Describe research priorities and highlight benefits to science
  - Describe relevance of priorities to agencies such as EPA, USGS, NPS, NOAA, USFS, USDA, as well as national monitoring networks
  - Share with other groups to motivate and prioritize research; facilitate collaboration and leverage existing funding; and to request/justify funding
- Audience for white paper is air quality scientists and ecologists; NADP and TDEP data users; federal and state air quality managers; program managers for EPA STAR, USDA NRI, ARS, NRCS; NSF; Intramural EPA and NPS
- Stakeholders would be USDA Agricultural Air quality task force and others
- Status of white paper:
  - Draft of sections 1 through 3 near completion
  - Science need template on "Low Cost Flux Methods" has been distributed
- Updated schedule for the paper is:
  - May 12, 2017 – first draft of one science need from each topic lead
  - June 1, 2017 – Additional science needs from leads with multiple topics
  - June 30, 2017 – Walker and Beachley to provide feedback to topic captains
  - August 18, 2017 – Revisions on science needs from TC's
  - October 16, 2017 – W&B return full draft document to co-authors for review before Fall NADP meeting
  - November 13, 2017 – Final comments from co-authors
  - December 11, 2017 – submit for internal agency review and begin preparation of material for journal submission
- Path Forward – Section 4 of White Paper
  - Key Question: How do we increase coordination across agencies to address the science needs that have been identified?
  - Approach:
    1. Relate the research needs identified in Section 3.0 to programmatic interests common to different agencies:
       - An example topic would be "Understanding linkages between agricultural NH3 emissions and Nr deposition"
       - Agencies involved in this topic and their specific area interest would be:
         USDA: emissions and near-field deposition
         EPA: emissions, deposition, and air quality
         NPS: deposition and visibility
         NOAA: atmospheric composition and remote sensing
         USFS: deposition, land use change
         USGS: air and water linkages
         NSF: LTER
    2. Identify specific opportunities for interagency coordination

  - Routine Monitoring: Air and Water (WAIM); Air and Ecosystems (AMoN at NEON and Ameriflux sites
  - Field Studies: Atmospheric chemistry and ecological (deposition) communities, e.g. coordination with large field campaigns such as SOAS, CALNEX, FRAPPE
  - Model development and evaluation: measurement model fusion efforts , e.g. remote sensing data for deposition
3. Propose activities to increase coordination
  - Programmatic integration of existing research: common cross-agency science objectives should be reflected in intramural research plans, e.g. near-source deposition in USDA ARS 5-year project plan was outcome of EPA/USDA workgroup. This effort will provide data to support EPA/ORD modeling activities
  - Creation of new opportunities for collaborative research. This could be done by pushing for deposition science to be reflected in USDA, NSF, EPA grant programs
  - Increase communication by promoting interaction between different communities through organization of scientific meetings

- How can TDEP promote/increase interagency coordination?
  - ➢ Form small work group including representatives from EPA, NOAA, NPS, USDA, USGS, and USFS
  - ➢ Group would focus on programmatic integration, new opportunities, increased communication, etc.
  - ➢ Would not duplicate efforts of the larger TDEP group
- Discussion highlights on whether to from a small group to increase interagency coordination:
  - ➢ CLAD has been successful working in smaller subgroups, but scientists have always been involved. A smaller group focusing on administrative aspects only can lose the science focus going forward. CLAD has been successful working in smaller subgroups, but scientists have always been involved. This risk should be considered.
  - ➢ Invite administrators to the TDEP committee meetings as the energy of this group would get the point across much better than a smaller group working in isolation.
  - ➢ Several people were ambivalent about the idea of forming a smaller group. John Walker clarified that the smaller group would not be separate from TDEP but would be there to get input from group and take our priorities to outside of the group.
  - ➢ Another idea was to have a point of contact in the different agencies than forming a smaller group within TDEP, but some members thought a separate smaller

group was necessary in order for this to not die out.

- There is definitely a need to communicate up and why we need what we need and the white paper is good start and journal articles will come out of the white paper, but we still need to think about the best ways to move our needs up the chain.
- There are tremendous resources going into atmospheric deposition and water quality monitoring. Can these activities be linked? The Water Quality & Atmospheric Deposition Integration (WADeIN) group is currently crafting a vision on how to improve coordination, activities, etc. and are looking for boots on the ground people.
- Others are worried about scope creep and that white paper should be limited to state of the science and research needs and why these are important and to have the TC's engage policy makers and other agencies cos we may lose the reader if paper is too long. Piggy-backing on this John wondered if we should include the common themes across agencies at end of paper and what other agencies are doing?
- Others thought that were already too many science summary white papers out there and that we should focus on the policy end.
- It is important that we point out that TDEP is not doing the same research as other groups but that everyone is doing apiece of it and that we need to dovetail it all together. What TDEP is doing is unique but show how our work fits in with other groups.
- Also important to engage with policy people as we go forward and not just dump research onto policy makers all at once. Work with them step by step.
- Important to engage the NADP as far as help with coordination of agencies as NADP is brilliant at this.
- It was concluded that Section 4 of white paper will be written up first and to maybe table the small group idea and see where we get as we continue writing.

5 **AMoN Site Characterization Study** (John Walker and Melissa Puchalski)

- Objectives of this study are to:
  - Develop a methodology for using 2-week average AMoN concentrations in a bi-directional NH3 flux model;
  - Provide NADP with a model for calculating and reporting net and component NH3 fluxes at AMoN sites; and
  - Inform the use of AMoN measurements in TDEP maps
- Two-layer bi-directional flux model:
  - Resistances: Aerodynamic, boundary layer, in-canopy, stomatal, and cuticular

  - Compensation Points: canopy, stomatal, ground; these compensation points will be parameterized in order to characterize the biogeochemistry that drives these points
  - Fluxes: net canopy-scale, stomatal, cuticular, foliage, and ground
- Regional chemical Transport Model:
  - This model uses EPIC for agricultural systems which is part of CMAQ
  - Field-scale model inputs include measured soil and vegetation chemistry, ambient NH3 concentrations, and meteorology
  - Study will focus on compensation points of the foliage and ground layers
  - NH4 content of leaves, litter, soil, and the pH of the solutions will be measured to calculate emissions potentials
  - Need relevant biogeochemical data for North American ecosystems as currently data sets are derived primarily from European experiments
- Study Design:
  - Develop biogeochemical datasets to improve parameterizations of NH3 compensation points
  - Assess model sensitivity to surface parameterizations
  - Assess impact of measured versus modeled meteorological inputs
  - Develop methodology for applying diurnal profile to 2-week AMoN concentration
- Site Selection: three pilot sites were selected based on land use, vegetation type, soil type, and atmospheric NH3 concentrations
  - Chiricahua National Monument (CHA467, AZ): rangeland
    - ✓ Soil types: 58% thin soil/rock outcrop, complex; 18% Pima-Grabe flood plain, 11% Santo Tomas (gravelly loam)
    - ✓ Vegetation types: 60% sagebrush/grass, 26% oak, 8% juniper
  - Bondville (BVL130, IL): agricultural
    - ✓ Soil types: 62% silty clay loam, 38% silt loam
    - ✓ Vegetation types: 92% eastern cool temperature row crops
  - Duke Forest (DUK0008, NC) hardwood forest
    - ✓ Soil types: 48% Iredell gravelly loam, 33% Enon loam
    - ✓ Vegetation types: 76% bottomland mixed hardwood,17% pine, and 7% grass
- Field Measurements:
  - Meteorological Measurements: 3D wind components, solar radiation, 2 and 9 m temperature, wetness, wind speed and direction
  - Soil properties: moisture and temperature
  - Soil chemistry: NH4 and NO3 concentrations, and pH
  - Vegetation properties: LAI
  - Vegetation chemistry: bulk leaf and litter will be measured for moisture and total nitrogen, ammonium, and pH
- Recent Progress: Emission potential of vegetation

    - Model parameterization based on N deposition input
    - Some measurements have been made at the SANDS, Coweeta, NC site
    - Emission potential of understory vegetation much lower than upper story vegetation. When model is run with site specific chemistry we get much higher deposition rates than what is in the literature
    - 2-layer model was modified to include the lower measured stomatal emission potential and by replacing soil emission potential with litter emission potential
    - Lowering leaf emission potential reduces stomatal emissions, thereby increasing net deposition rates
- Timeline:
    - Field data collection: Spring 2017 through Spring 2018
    - Methodology development for application of diurnal profile to 2-week AMoN concentration: completed by late 2017
    - Assessment of model sensitivity to surface parameterizations: completed by early 2019
    - Assessment of impact of measured versus modeled meteorological inputs: completed by early 2019
    - Draft modeling methodology for TDEP review: Spring 2019

6. Status Update and Re-Proposal: AMNET Mercury Dry Deposition

- Not much progress since last meeting, but the work is done and hoping to make it available for use, evaluation, and improvements. Paper has been published since last NADP meeting
- Model results for the AMNeT Mississippi (MS12) site show that there are really high values for GEM; most of the deposition is driven by GEM
- When modeled for a single land cover type, e.g. deciduous broadleaf forest, deposition is again driven by GEM
- Multiyear mean land cover area-weighted deposition for all sites in this study show that typically dry and wet Hg deposition is comparable. There are sites where this does not hold up though, e.g. Hawaii site
- Brief History and Status:
    - TDEP Approved Motion: supports contribution to generate and deliver to NADP average weekly Vd for GOM, GEM, and PBM at AMNeT sites;
    - Peer Review Publications: Zhang, et.al. 2016. “The Estimated Six-Year Mercury Dry Deposition Across North America”. There are also seven related previous publications.
    - White Paper (Updated) Zhang and Gay. “Brief Description of the Proposed Method Estimating Weekly Dry Deposition of Speciated Mercury at NADP AMNeT Sites”.
    - Independent Model Review: TDEP Ad Hoc Committee – conducted an

  - independent review of Zhang, et.al., Hg dry deposition model by three expert Hg air modelers
  - Uncertainty Document for Measurements and Model (Draft): summarizes previous estimates of measurement uncertainty and impacts of new findings for GOM and PBM. Summarizes causes and uncertainty for the model
  - Data Output Plan (draft read me file): Weekly flux of GEM, GOM and GEM; 50% measurement data threshold for week seasonal and annual sums.
  - End-Users to Target for Fall meeting participation and Feedback (Draft.
- GEM Uncertainty
  - GEM measurement accuracy is 10% and uncertainty is 15%
  - GEM Bi-directions model:
    - ✓ S and N model results for dry deposition has uncertainty of 2; for Hg it will not be any better
    - ✓ High annual GEM ddry deposition fluxes supported and constrained by NADP litterfall measurements, suggesting model may be an underestimate
    - ✓ Summertime (July-August) net GEM evasion in broadleaf deciduous forest supported by limited canopy studies
    - ✓ Experimental data on GEM emission potential from leaf and needle stomata over all four seasons is needed to validate the model and reduce the uncertainly
- GOM and PBM Measurement Uncertainty
  - GOM and PBM often near the MDL with the shutdown and/or control of point sources. Uncertainty at the MDL is 100%
  - GOM may be biased low when water vapor concentrations are high. A factor of 2-5 has been suggested for the SE USA
  - A high bias for PBM in dry air has been presented
  - The potential bias for GOM and PBM are expected to be transitory
  - Even 3x bias in the GOM and PBM measurements will not significantly impact the annual dry deposition flux since flux dominated by GEM at most sites
- GOM and PBM model Uncertainty
  - PBM includes an estimated course fraction that is not measured by AMNeT. Spatial and temporal measurements of the size distribution of PBM would help reduce the model uncertainty
  - Similarly, GOM model uncertainty would be reduced with new seasonally representative GOM flux measurements over difference land use categories
- Proposed Action Plan
  - Develop content for a Hg Dry Deposition webpage under the TDEP banner, similar to TDEP Total Deposition Maps webpage
  - Webpages will not be accessible until approved
  - Embedded links in both AMNeT and MDN to new webpage

- Proposed Content for Hg Dry Deposition Webpage
    - Gay and Zhang White Paper
    - Readme file for Data/Model – detailed documentation regarding AMNeT data, deposition model and methods as well as missing data criteria
    - Readme file for measurement and model uncertainty analysis
    - External review summary presentation
    - References or links to Zhang et.al. and other relevant papers
    - Data
- Data Details:
    - Observations: Generate weekly average AMNeT GEM, GOM and PBM2.5 values from Tues day to Tuesday for each site to match MDN
    - Model Estimates: Generate weekly average AMNeT GEM, GOM and PBM2.5 values from Tuesday to Tuesday for each site to match MDN
    - Calculated Flux: Weekly GEM, GOM, and PBM flux for each site. A weekly 50% data completeness criteria will be applied. A mean annual flux for all three fractions for each site will be calculated
    - Period Covered: Will start with 2009 AMNeT data and extend to the foreseeable future
- Comments:
    - Surprised that there has not been more engagement for getting this all together as there was an abundance of submissions on Hg for the Rochester Meeting
    - Eric thinks that there a substantial amount elemental emissions that are not being considered. There are huge area sources from the oceans and fires, SE Asia. So we have to have bigger sinks. A lot of these emissions may be going into the ground. Also, constrained by litterfall.
    - Need more measurements done with better technology
    - Need to do a similar study like John Walker is doing, but at AMNeT sites. Need to do weekly collection of leaves over the whole summer, over and under canopy.
    - Models have improved but not many people pushing them.
    - There is huge effort in China to measure fluxes but these values will not translate to the US as China has so much particulate matter than us.
    - The end goal is to have total Hg fluxes and focusing right now on dry deposition

7. **Evaluating Some Uncertainties in TDEP Total Deposition Estimates** (Gary Lear)
    - This presentation will focus on:
        - Characterizing and optimizing interpolation error, and
        - Additional error from using non-matching CAMQ runs
    - Optimizing parameters for IDW interpolation
        - Compared effect of IDW parameters on aggregate error in air concentrations
            - ✓ Minimum number of points used in interpolation is 8

    - ✓ Maximum distance of points used in interpolations is 400 km
    - ✓ Inverse power function of 3
  - Estimated using jackknife approach of comparing values of removed point with the value calculated from remaining sites
  - Results are in median absolute relative percent difference (MARPD)
  - Bob Larson and Gary Lear described some of the differences in parameterization used by the PO and TDEP
- Results for HNO3:
  - Not a lot of difference between the maximum distances and the P power increase
  - Some sites provide better results but there really is not a big difference
  - Stranded sites have greater errors. Coweeta different than anything else around it for a variety of reasons yet we still use it for interpolation.
  - Some northeastern sites also showed similar tendencies. If you take out the values from such sites and estimate these values, you get high errors.
- Results for pNH4:
  - The power makes very little difference; 300 km distance or greater is an issue. 300 km distance yields the best results.
  - There are differences between the outliers. The power of 2 yields higher error for majority of the sites.
  - Power is when you do the distance weighting and put it to a different power. A nearby site has more influence than distant ones.
  - Distribution was very similar to HNO3
- Results for SO2:
  - Much higher error than expected because of local influences of power plants. HNO3 not influenced as much by point sources.
  - Distance of 300 km works best
- Results for pSO4:
  - Generally lower errors
  - Western sites have more errors because there are less sites with more complex terrain with a lot of elevation difference between sites
- Error due to non-matching CMAQ runs from 2002-2012:
  - Use CMAQ matching year for measurement data when available
  - Use nearest year when matching CMAQ year not available (e.g. 2012 CMAQ for 2015 measurement year)
  - Estimated additional error from using non-matching CMAQ runs
    - ✓ Compared estimate from concordant years with estimate using discordant years having 1 to 5 year lag
    - ✓ Repeated with 2010 CMAQ+(2011-2015 measurement years)
- Additional error by CMAQ lag:
  - Only compared N and S; dry and total

- Additional error was very low for N
- The greatest additional error occurred for dry S because of significant SO2 emission reductions during the study years
- Increasing bias and spread as we get further out from the year
- Very little change in the median value
- Additional error for N was very low; greatest bias in the SW implying that there is a greater change in emissions than thought so. I t could also be changes in meteorology
- Big spread in error for S due to lag year. It is a much different picture in where we are seeing these changes. There is more change in the Midwest and east due ti emission reductions. Using an old model year does not account for these changes. So TDEP has minimized the differences but this can also go the other way if emissions increase.

- Conclusions:
  - On average, TDEP estimates are relatively insensitive to IDW parameters for all variables.
    - ✓ Recommend using power=2, max distance=400km, Mo maximum number of points
  - On average, using discordant CMAQ model years adds relatively low error unless emissions are dramatically changing
- We now have 2013 and 2014 versions of CMAQ. Version v5.2 is to be released in June 2017 CMAQ. No money to go back and regenerate all runs.
- Some discussion ensued on how to reconcile bias between different model runs used in TDEP. A specific approach will be proposed once CMAQ 5.1 runs are released.

8. **Effect of Missing data on Annual Flux or Exploration of Biases in Annual Nitrogen Wet Deposition Estimates and If We Can Do Better** (Bret Schichtel)

- Nitrogen wet deposition values for Rocky Mountain National Park (RMNP) show a big increase in 2013. However, 43% of precipitation data were missing in 2013. Every year there are about 30% or more missing data which is not unusual.
- How are missing data handled in annual deposition flux estimates?
  - Missing ion concentrations are replaced with precipitation weighted annual average of available data;
  - Assumes ion concentrations and precipitation rate are independent and no seasonality in concentrations or missing data;
- Are these assumptions reasonable?
- Ion concentrations versus precipitation rate:
  - There is a strong non-linear dependence of ion concentrations and precipitation,
  - Log regression produces the best fit when plotting analyte concentrations versus precipitation
- Seasonal ion concentration versus precipitation rate:

- Across the network and decades there is some seasonality
- Spring concentrations are approximately 50% higher than winter concentrations
- Spring precipitation rates are approximately 25% higher than winter
- Some sites, such as the Loch Vale site (CO89), are highly seasonal

- Can invalid data be used?
    - A comparison of valid and invalid concentrations to annual averages was conducted for all NADP sites from 2000-2016
    - Contaminated samples and many bulk samples were clearly biased
    - Extended and undefined samples had similar statistics as valid samples
- Inclusion of extended and undefined samples in annual averages
    - The addition of the extended and undefined samples to the annual averages did not, on average, change the annual means, but can significantly change a given site-year's wet deposition rate
- Should some valid data be invalid?
    - NADP uses the rain gauge (RG) precipitation rate, when available, to calculate annual averages
    - The RG and precipitation from sample volume often differ significantly
    - The precipitation from sample volume is usually less than the amount collected in the RG as would be expected due to:
        - ✓ Delayed lid openings
        - ✓ Snow overflow
        - ✓ Wind turbulence
- Are ion concentrations dependent on the fraction of the precipitation sample collected?
    - There is an apparent increase in ion concentrations as the fraction of precipitation loss from the sampler (while sampling) increases.
    - The ion concentration dependence is explained by changes in the precipitation rate, except when less than 25-50% of the precipitation sample is collected.
    - Low sample volumes (with respect to RG volume) primarily occur in winter, most likely during snow events, when ion concentrations tend to be lower. This suggests that concentrations from low sample volumes are biased high.
- Exploration and evaluation of different data filling methods
    - Current method fills in missing ion concentrations using the annual precipitation weighted mean. This method does not account for ion concentration dependence on precipitation rates and seasonality.
    - Alternative methods were explored:
        - ✓ Using a log regression fit to ion concentrations for each site and each species:
            - Accounts for spatial variation but not seasonal
            - Lesser amount of data at newer sites creates regression stability issues

  - ✓ Using a log regression fit to scaled ion concentrations across all sites for each species and each season:
    - Ion concentrations are scaled by the average at each site and year
    - Assumes concentration to precipitation rate relationship is not spatially dependent
    - The derived seasonal relationships account for the average ion concentration seasonality across the U.S. as well as changes in concentration to precipitation relationship.
- Comparison of data filling methods
  - ➢ Each measured value was modeled using the data filling method which were then compared to the measured value. Statistics (mean, standard deviation) were aggregated for each site, then aggregated across sites.
  - ➢ Log ion-precipitation fits produced less bias averages over a year than using the annual average
- Items Presented for Discussion:
  - ➢ Should some “extended” and “undefined” samples by flagged as valid?
  - ➢ Should data with low precipitation collection efficiency (<25%) be invalidated?
  - ➢ Should new data filling methods be explored?
  - ➢ How to improve sample collection in challenging environments since the best method of all is to collect valid complete samples?
- Comments:
  - ➢ There were questions about the rate of missing data. Some data are missing due to power failures after extreme events.
  - ➢ There was concern over maybe including currently invalid extended samples as far as the distributions of these concentrations. A bulk sample should be compared with a normal sample.
  - ➢ There is a difference between a bulk sample and an extended sample which means the sample only went 6 hours or more beyond the expected collection time. Maybe wintertime extended samples could be included as these samples are pretty well preserved
  - ➢ Explore the definition of an “undefined” sample and maybe change it.
  - ➢ Bulk data do have biases but maybe these biases will be less than extra or intrapolating
  - ➢ Focusing on the bias of each sample may be better than focusing on what is valid or invalid
  - ➢ If we adopt Bret’s method going forward what do we do with past data? All critical loads are calculated with the current method.

9. Election of new TDEP Co-chair

- Chris Rogers nominated John Walker as incoming co-chair to replace Kristi Morris.
- John Walker was approved by the group as new co-chair

10. Meeting Adjourned