Summary of Recommendations
from the Mercury Measurement Evaluation Team (MMET)

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Mercury Measurement Approaches Evaluated

1. Active. Gold-trap (dual) amalgamation for GEM, with Hg-Isotope option.
   a. Advocate: Dave Krabbenhoft, USGS
   b. Referred to in summary as “USGS” option

2. Active. Gold-trap amalgamation for GEM.
   a. Advocate: Tatsuya Hattori, IDEA Consultants, Inc.
   b. Referred to in summary as “Hattori” option

3. Passive. MerPAS for GEM.
   a. Advocate: Carl Mitchel, University of Toronto
   b. Referred to in summary as “MerPAS” option

4. Active. Direct GOM and PBM – membrane/filter approaches
   a. Advocate: Mae Gustin
   b. Referred to in summary as “Gustin” options

5. Active. Reactive Mercury by difference (dual or switching Tekran)
   a. Advocate: Winston Luke, NOAA; Mark Olson, WSLH
   b. Referred to in summary as “Winston” or “NOAA” option

Glossary

GEM: Gaseous Elemental Mercury

GOM: Gaseous Oxidized Mercury

PBM: Particle-Bound Mercury

RM: Reactive Mercury (GOM + PBM)

Executive Summary

The Mercury Measurement Evaluation Team (MMET) was tasked with reviewing the fit-for-purpose of five measurement approaches for Gaseous Elemental Mercury (GEM) and Reactive Mercury (RM) in ambient atmospheres. A pre-selection process limited the measurement approaches to those of relatively low-cost with an overarching purpose of inclusion in a new atmospheric mercury monitoring network. The compatibility of the approaches for operating under a NADP construct was an important evaluation criterion. The MMET was not tasked with network design, though the measurement approaches were evaluated with respect to suitability to scale and other network operational characteristics. While general costs were considered in the just completed evaluation, more detailed costing under several network scenarios would be a critical part of the network design phase of this effort.

Advocates for the five approaches presented an overview and performance data for the methods in a half-day workshop and subsequently provided the MMET with written documentation and references on the respective measurement approaches, as well as responses to a detailed questionnaire from the MMET. This questionnaire asked for information on key performance and implementation characteristics of the approaches – pool(s) of mercury captured, temporal resolution, “simplicity”, mercury isotope capable, deployment and analytical costs, field requirements, analytical requirements/procedures, performance metrics (precision, bias, dynamic range, signal/noise, species selectivity) and deployment history and community acceptance. The full survey is included as an appendix to this document.

Each MMET member reviewed the information submitted by the advocates and additional material as available, and prepared a summary report with recommendations on suitability to task for each of the measurement approaches. Those reports comprise the core of this synthesis document. A short “executive” summary of recommendations is provided below. Note, we include in the summary a role for the “gold-standard” GEM measurement approach (Tekran 2537 or equivalent). Though not “low-cost”, there are certain network design scenarios, where the Tekran would be the best option and even cost competitive.

Our recommendations for mercury measurement approach are structured by overarching network design goals. These being:

(1) Species of mercury targeted
(2) Temporal resolution required
(3) Network scale
(4) Mercury stable isotope capable

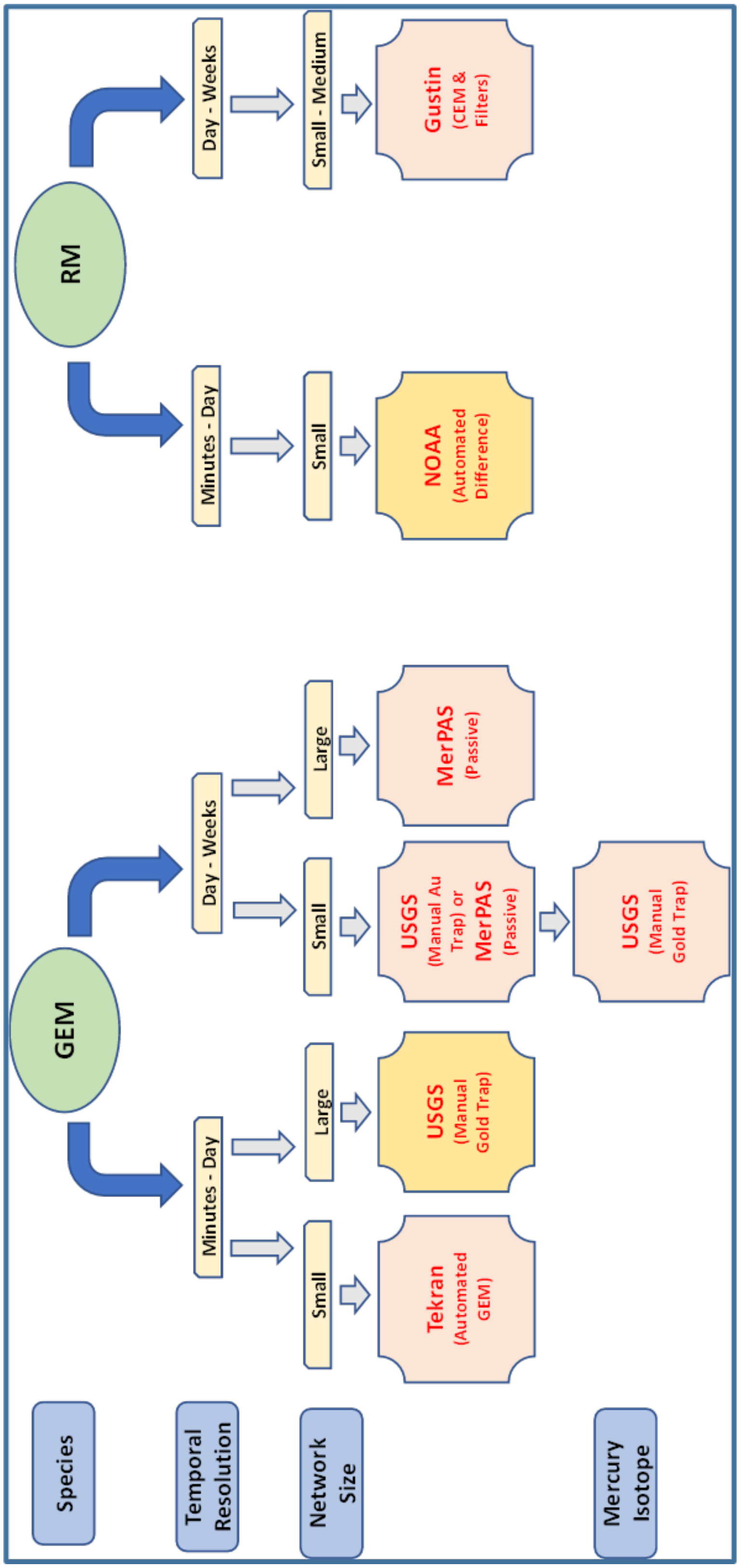

Figure 1. Decision Tree

Though the community of mercury researchers continues to debate the merits of GEM versus RM for long-term monitoring of atmospheric concentrations and (modeled) deposition, it is reasonably certain that GEM will be a major component of such monitoring networks. RM monitoring will likely also be a component at selected ("super") sites and may join GEM as a more routinely monitored species after further study.

The MMET recommendations are graphically presented in the Decision Tree shown in Figure 1. Two of the advocated approaches, along with a basic Tekran are recommended for **GEM measurement**; the specific choice dependent upon the temporal resolution required and network scale. For fine temporal resolution it would be difficult to improve upon an automated basic Tekran (2537 or equivalent). This approach has proven to be robust under a tremendous range of environmental conditions, worldwide, for over 40 years. Though the capital costs are not "low-cost", the long-term operational costs are competitive, and one can envision a network scenario where Tekrans provide the core GEM data. We do not have a strong recommendation for "lower-cost" large-scale implementation of **fine time resolution** monitoring (not sure that such a network design would even be desired). However, the USGS manual, active gold trapping approach would certainly be capable, but logistics and QA issues would be challenging to implement at large scale.

For **extended-term trend monitoring**, a longer temporal sampling resolution would actually be desirable and the MMET recommends two measurement approaches. The MerPAS passive sampler is the option of choice for larger networks (>30 sites) with advantages of simplicity of deployment and use, well-defined species capture, good performance (dynamic range, precision) and provenance. For smaller networks, the USGS manual, active gold trapping approach, along with the MerPAS are recommended. Though the up-front cost of the USGS approach is greater than with the MerPAS, the continuing operational costs will be lower. As it is unlikely that mercury stable isotope characterization will be performed routinely at scale, the decision-tree places the isotope analysis under the small network configuration and recommends the USGS manual active gold trapping approach (with sampling for at least a week). This approach is currently the best validated isotope option, however, if further work documents that the MerPAS can also provide robust isotope data, then the MerPAS may become the approach of choice. Both the MerPAS and especially the USGS approaches would benefit from head-to-head evaluation (for both concentration and isotope work) under a much broader range of environmental conditions than currently deployed. The approach presented by Hattori for collection and measurement of GEM provides no specific advantage, and some drawbacks, over the similar USGS approach and thus one can effectively remove this option from consideration.

For **reactive mercury** (RM) species measurement the options are limited, and we can at this time only recommend the cation exchange membrane/filter approaches advocated by Professor Mae Gustin for broader use/exploration at scale. These approaches are suitable for monitoring over time scales of days-weeks and could effectively be implemented/integrated into NADP networks. The automated difference approach advocated by NOAA researchers is just too challenging to routinely implement (and may not be robust outside of sites/periods with relatively high RM). The high cost is also a very substantial barrier. Though the NOAA approach does offer the unique ability to provide RM data on fine timescales (minutes to hours).

Note: an assessment of wet-deposition methods for mercury and network support/design was beyond the scope of this workshop.