EXPERT ADVICE TO THE ENVIRONMENT AND COMMUNICATIONS REFERENCES COMMITTEE INQUIRY INTO THE PROTECTION OF ABORIGINAL ROCK ART OF THE BURRUP PENINSULA

My background: My name is Johan Carl Ivar Kuylenstierna. I am the Policy Director of the Stockholm Environment Institute. I undertook my PhD between 1988-1993 on the sensitivity of ecosystems to acidic deposition, and continued to develop this work and publish articles on global sensitivity to acidic deposition, which includes the Cinderby et al 1998 report and map quoted in the report by Rob Gillette (2008). I was responsible for leading this work. I have been working on aspects of air pollution, including the impact of sulphur and nitrogen emissions on ecosystems, though processes including acidification. I have also worked with experts on the corrosion of materials to acidic deposition. I work at the York Centre of the Stockholm Environment Institute which is an international research institute bridging science and policy in the field of environment and development. I am employed by the University of York in the UK as the York Centre of the Stockholm Environment Institute is housed in the Environment Department at the University.

Relevant references:

D.Phil. *Assessment of Ecosystem Sensitivity to Acidic Deposition: Critical Load Estimates, Detriment and Damage*, University of York 1994

J. Tidblad, K. Hicks, J. Kuylenstierna, B. B. Pradhan, P. Dangol, I. Mylvakanam, S. B. Feresu and C. Lungu (2015). Atmospheric corrosion effects of air pollution on materials and cultural property in Kathmandu, Nepal. Materials and Corrosion. DOI: 10.1002/maco.201408043

Hicks, W. K., Kuylenstierna, J.C.I., Owen, A., Dentener, F., Seip, H.M. and Rodhe, H. 2008. Soil sensitivity to acidification in Asia: Status and Prospects. Ambio, 37(4), 295-303.

Phoenix GK, Hicks WK, Cinderby S, Kuylenstierna JCI, Stock WD, Dentener FJ, Giller KE, Austin AT, Lefroy RDB, Gimeno BS, Ashmore MR and Ineson P (2006). Atmospheric Nitrogen Deposition in World Biodiversity Hotspots: the need for a greater global perspective in assessing N deposition impacts. *Global Change Biology,* **12**, 470–476.

Kuylenstierna, J.C.I., Rodhe, H., Cinderby, S and Hicks, K. (2001). Acidification in developing countries: ecosystem sensitivity and the critical load approach on a global scale. *Ambio* **30**, 20-28.

Cinderby, S., Cambridge, H.M., Hererra, R., Hicks, W.K., Kuylenstierna, J.C.I., Murray, F. and Olbrich, K., Global Assessment of Ecosystem Sensitivity to Acidic Deposition. 20 p. + map. ISBN: 91 88714 58 6, 1998

Kämäri, J., Amann, M., Brodin, Y-W., Chadwick, M.J., Henriksen, A., Hettelingh, J-P., Kuylenstierna, J., Posch, M. and Sverdrup, H. (1992). Use of critical loads for the assessment of future alternatives to acidification. *Ambio* **21**(5): 377-386.

I am addressing Term of Reference (c) of the Inquiry into the protection of Aboriginal rock art on Burrup Peninsula.

Key Points

- The Cinderby et al 1998 report and related papers refer to the sensitivity of ecosystems to acidic deposition
- Using the map of sensitivity of ecosystem to acidic deposition to say anything about the sensitivity of rock art is an inappropriate use of this science
- We used 1:5,000,000 scale global maps from FAO - maps which would not show up the detail of the soil type in an area such as Burrup peninsula, which I understand differs from the main soil type in the region as a whole.
- The maps are not based on information about the parent material of the soil (i.e. the rock types were not included in the assessment)
- What is required is a detailed understanding of the particular weathering processes on the rocks faces on to which the rock art is carved.

Detail
The Gillette (2008) report that has been used as evidence for the Burrup rock art sensitivity to increased acidic deposition caused by the nearby industrial facility includes a passage that references our work (the relevant passage is extracted below). In this it says that the 'the critical load for the Burrup area is at least 200 meq m^{-2} yr^{-1}, and since this is significantly more than the observed deposition fluxes at the sites they are unlikely to cause any deleterious effects to rock or rock art on the Burrup Peninsula.'

This assertion is incorrect.

Firstly, the basis for the critical load assessment is soil type only – and does not use the characteristics of the rocks in the analysis. In most cases the soil type does reflect the parent material, but can be significantly changed by weathering processes over time, or organic matter build up. But the main point is that the map does not directly reflect the rock type and therefore cannot be used to say anything about the rocks where the rock art is carved.

Secondly, the sensitivity referred to in the maps is the sensitivity of ecosystems – i.e. the vegetation or surface waters (lakes and streams) – and not the sensitivity of the rocks to weathering. If anything the inverse is true, as more rapid weathering of minerals in the soil leads to better buffering and less damage to ecosystems – but the process would be more rapid weathering in these areas. Either way this is an inappropriate use of the critical loads – the rocks in a highly buffered region would weather faster.

Thirdly, the scale of the global soil maps we used was 1:5,000,000 which show broad patters but not local detail. For that, more detailed soil maps would be required. But the point is that these are soil maps and not geology maps, and so still misses the point – the method is not based on an assessment of the geology.

Fourthly, weathering processes are complex and specific to the rock types and, in order to say how the surface of the rocks on which the art is carved will be affected by acidic inputs, it will be necessary to develop a specific understanding of the weathering processes of the surface of these rocks.

In conclusion, the use of the Cinderby et al 1998 global sensitivity map and critical loads to say anything of relevance to the rock art in the Burrup Peninsula is just plain wrong – for many reasons and should not be used in evidence to the committee. It cannot be used by industry or governments to justify acid load emissions of 200 meq/m^2/year. Rather a careful analysis of the rock art and its sensitivity to acidic inputs is needed.

Extracted from Burrup Peninsula Air Pollution Study: Report for 2004/2005 and 2007/2008 10th September 2008. Rob Gillett. CSIRO Marine and Atmospheric Research. PMB No1 Aspendale 3195, P117: *The critical load concept can be used to compare with deposition fluxes to determine if adverse effects could result to rock or aboriginal rock art. For a fuller discussion of this see Ayers et al. (2000). The critical load has been defined as "a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified elements of the environment do not occur according to our current knowledge" (Nilsson and Grennfelt, 1988). In a global assessment of ecosystem sensitivity to acidic deposition Cinderby et al. (1998) have determined a critical load or deposition flux of 25 meq m-2 yr-1 for the most sensitive areas of the world. This means that depositions of about 25 meq m-2 yr-1 would only have a detrimental effect on the most sensitive ecosystems. The depositions presented in Table 19a and 19b indicate that some sites are subject to depositions of about 25 meq m-2 yr-1 in 2004/2005 and about 32 meq m-2 yr-1 in. 2007/2008. Given that the overall precision of passive gas measurements in this study was about ± 20% Site 6, for example, would have a deposition flux ranging from about 19.5 meq m-2 yr-1 to 29.2 meq m-2 yr-1, which is only just above that for areas which are very sensitive to acid deposition. The wet plus dry deposition flux at site 8 during 2007/2008 would probably range from about 26 meq m-2 yr-1 to 38 meq m-2 yr-1 given the precision of the passive samplers. In fact the assessment by*

Cinderby et al. (1988) lists 5 sensitivity classes consisting of 25 meq m-2 yr-1, 50 meq m-2 yr-1, 100 meq meq m-2 yr-1, 150 meq meq m-2 yr-1, 200 meq m-2 yr-1 and >200 meq meq m-2 yr-1, and places the Burrup area in the least sensitive class. This means that the critical load for the Burrup area is at least 200 meq m-2 yr-1, and since this is significantly more than the observed deposition fluxes at the sites they are unlikely to cause any deleterious effects to rock or rock art on the Burrup Peninsula. In fact the anthropogenic contribution of the total wet and dry deposition flux estimated at these sites is probably less than the data presented in Tables 19a and 19b. The deposition of ammonia, for example does not vary much from the background sites to the industrial areas suggesting that most of the ammonia deposition results from natural rather than anthropogenic sources. This is also true for some of the other species, but the contributions can not easily be quantified.

Extract from: Burrup Nitrates Pty Ltd

Burrup Peninsula
Technical Ammonium
Nitrate Production Facility
Air Quality Assessment
Update
Report

Reference: 0086269

Section 2.2 page 4.

"ROCK ART GUIDELINES

Rock art has the potential to be impacted through the deposition of acid gases eroding the rock in to which the rock art has been carved. However, no standards currently exist in Australia for the protection of rock art. Deposition of acid gases is measured in milliequivalents per square meter per year (mEq/m2/yr). Milliequivalents is the equivalent deposition flux for all acid gases combined that occurs through both wet and dry deposition.

The CSIRO report concerning the 'Burrup Peninsula Air Pollution Study' (CSIRO, 2008) considered six general sensitivity classes of areas:

- 25 mEq/m2/yr;
- 50 mEq/m2/yr;
- 100 mEq/m2/yr;
- 150 mEq/m2/yr;
- 200 mEq/m2/yr; and
- > 200 mEq/m2/yr.

The CSIRO report used work undertaken by (Cinderby, et al., 1998) which placed the Burrup area in the least sensitive class. The CSIRO report therefore concludes that the critical load for the Burrup area is at least 200 mEq/m2/yr. The value of 200 mEq/m2/yr has therefore been used as the assessment criteria in this report, as indicative of potential harm to the rock art of the Burrup Peninsula."