TO: Nityanand Jayaraman
FROM: Mark Chernaik
SUBJECT: Critical assessment of documents purporting to support a site-specific target level of 25 mg/kg for the remediation of mercury-contaminated soils at the HUL factory site in Kodaikanal
DATE: March 5, 2010

The memo critically assesses four documents:

- The October 2007 Detailed Project Report "Soil Remediation at HUL Factory site, Kodaikanal, Tamil Nadu, India" by Environmental Resource Management Pty Ltd.

- The September 2006 Report "Former HLL Mercury Thermometer Factory, Kodaikanal, Tamil Nadu, India: Site-Specific Target Levels" by Environmental Resource Management Pty Ltd.

- The February 2007 Report "Protocol for Remediation of Mercury Contaminated Site at HLL Thermometer Factory, Kodaikanal" by NEERI.

- The May 2002 Report "Environmental Site Assessment and Risk Assessment for Mercury HLL Thermometer Factory Site Kodaikanal, Tamilnadu, India" by URS Dames & Moore.

These documents have been held out as the basis for the proposed remediation of mercury contaminated soil at the HUL Factory site. Specifically, these documents have been offered as support of a cleanup plan in which soil containing greater than 25 mg/kg of mercury would be excavated, washed, vacuum retorted, and backfilled to the contaminated site, but soil containing less than 25 mg/kg of mercury would be left in place untreated. This memo concludes that the four documents provide grossly inadequate support for a Site-Specific Target Level of 25 mg/kg and that a much lower Site-Specific Target Level may be necessary to protect critical ecological resources and public health. What follows is a discussion of the basis of this conclusion.

1. A uniquely important ecosystem, Pambar Shola forest, lies downhill of contaminated soil at the HUL Factory site; the two reports lack any analysis of whether the proposed clean-up is adequate to protect the ecological integrity of the Pambar Shola forest and watershed that exists within it

The Site-Specific Target Level of 25 mg/kg was established only with regard to the protection of public and without regard to protection of ecological values. The October 2006 report uses a methodology involving potential exposures to children under the age of six from various pathways that include: soil ingestion, and dermal contact, indoor dust inhalation, outdoor dust inhalation, and vegetable ingestion. See table 6 on page 29 of the October 2006 report. The report concludes that vegetable ingestion would be the dominant pathway for exposure to any mercury that is left in soil after the cleanup. Table 7 on page 30 of the report concludes that vegetable ingestion would comprises 93% of the overall hazard quotient for residential exposure to mercury and derives a Site-Specific Target Level of 25 mg/kg solely on this basis.

The obvious inadequacy of this analysis is that it overlooks ecosystem components that might be seriously affected in the long-term by a cleanup that proposes that soil containing less than 25 mg/kg of mercury would be left in place untreated.

The first ecosystem component that the report overlooks is aquatic life within the Pambar River.

In order to protect fish and human health, the U.S. EPA recommends that freshwaters not contain total mercury at levels exceeding 0.77 micrograms per liter (0.77 ug/L) or a lower (more strict) level of 0.01 ug/L if humans consume fish from the river segment in question.[1]

It is obvious that mercury could migrate into the Pambar River from the HUL Factory site: According to a 2006 scientific publication:

> "The primary direction for surface water run off from the factory site is to the south into the Pambar Shola leading to the Kumbhakarai falls. Earlier reports have found mercury levels as high as 330 mg/kg in the sediment in a small depression from where the factory run off merged with the Pambarai stream and dropped into the Kumbhakarai falls."[2]

Page 6-3 of the May 2002 report states:

> "As surface water run-off occurs predominantly to the south of the site into the forest, there is limited potenital for ingestion of surface water that may be affected by mercury attached to suspended sediment."

This statement indicates that planning for the cleanup of mercury-contaminated soils at the HUL factory site is not taking into account ecological damage.

Despite this, the four reports listed above have not evaluated the potential for mercury to migrate into the Pambar River from the HUL Factory site. In fact, there is a paucity of data in the reports about mercury in the Pambar River. The February 2007 report states:

> "There are two open wells at site and two-storm water drains running across the site leading to Pambar Shola. It may be observed from Table 1 that the water samples collected across the site contain mercury concentration below laboratory detection limit (< 0.0003 mg/L), which is well below the WHO 1999 drinking water guideline value of 0.001 mg/L."

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1 U.S. EPA National Recommended Water Quality Criteria http://www.epa.gov/waterscience/criteria/wqctable/index.html (Accessed on 5 March 2010).

2 D. Karunasagar et al. "Studies of mercury pollution in a lake due to a thermometer factory situated in a tourist resort: Kodaikkanal, India " Environmental Pollution 143 (2006) 153-158

A detection limit of 0.0003 mg/L is equivalent to 0.3 ug/L, which is 30 times higher than the level of total mercury that the U.S. EPA recommends for freshwaters if humans consume fish from the river segment in question.[3]
The February 2007 report further states:

> "It may also be noted that the elevated concentrations of mercury (0.031mg/L and 0.085 mg/L) were reported for two surface water samples that were collected on site following a heavy storm, URS considered these levels as anomalous readings since both samples contained silt and were reported to have been analysed unfiltered and hence not representative of surface water concentrations."

This reflects a fundamental misunderstanding of the fate of mercury in the aquatic environment. Mercury tightly binds to small particles of silt. The fact that two surface water samples had high levels of mercury following a heavy storm strongly suggests that rainfall is washing mercury (in the form of mercury-bound silt) from contaminated soil into surface water.

Analysis of filtered samples only provides information about dissolved mercury levels, not potentially dissolvable mercury levels.[4]

Considering these obvious deficiencies, any proposal for the Site-Specific Target Level of the proposed cleanup needs to contain a thorough assessment of the potential for off-site migration of mercury from contaminated soil into the Pambar River and adjacent wetlands.

A less obvious inadequacy of the analysis is that the scientific literature clearly demonstrates that soil microbes are adversely impacted by soil mercury levels that are below the Site-Specific Target Level of the proposed cleanup. According to a recent study published by scientists with the Universite Paris (University of Paris):

> "In gold mining regions, the risk of soil pollution by mercury is a major environmental hazard, especially in tropical areas where soil microflora plays a major part in soil functioning, major bio-geochemical cycles and carbon turn-over. The impact of mercury pollution on soil microflora should thus be carefully assessed in such environments while taking into consideration the specificities of tropical soils. The aim of this study was to compare the effects of mercury (0, 1 and 20 μg of inorganic mercury per gram of soil) on the functional diversity and genetic structure of microbial communities in a tropical soil. …. Results obtained for the microcosms enriched with only 1 $\mu g\ g^{-1}$ mercury were indistinguishable from controls. Conversely, in the presence of high mercury contents (20 $\mu g\ g^{-1}$), an immediate effect was measured on soil respiration, functional diversity (ECOLOG plates) and genetic structure (DGGE), although no significant effect was observed on plate counts or microbial biomass. In addition, whereas microbial activities (respiration and functional diversity) rapidly regained control values, a lasting effect of

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3 U.S. EPA National Recommended Water Quality Criteria http://www.epa.gov/waterscience/criteria/wqctable/index.html (Accessed on 5 March 2010)

4 See, for example: EVALUATION FOR TOTAL MERCURY CONTAMINATION IN BROWNLEE RESERVOIR TRIBUTARY STREAMS, SNAKE RIVER-HELLS CANYON TMDL, IDAHO AND OREGON http://www.deq.state.id.us/WATER/data_reports/surface_water/monitoring/mercury/brownlee_trib_report_0607.pdf

the high mercury concentration was observed on the genetic structure of the soil microbial community. These modifications took place during the first week of incubation when total mercury concentration was declining and bioavailable mercury was at its highest."[5]

Thus, adverse impacts to soil microbes in tropical soils occurred at a level of 20 µg $g^{(1}$, whichis equivalent to a soil mercury level of 20 mg/kg, 20% below the Site-Specific Target Level of the proposed cleanup.

2. Even if the potential mercury exposures to children under the age of 6 were the only appropriate basis for a Site-Specific Target Level of the proposed cleanup, the September 2006 Report mischaracterizes the site-specific risk to public health of allowing soil containing less than 25 mg/kg of mercury to be left in place untreated

The report uses a methodology involving potential exposures to children under the age of six from various pathways that include: soil ingestion, and dermal contact, indoor dust inhalation, outdoor dust inhalation, and vegetable ingestion. See table 6 on page 29 the report concludes, probably correctly, that vegetable ingestion would be the dominant pathway for exposure to mercury. If you see table 7 on page 30, that vegetable ingestion comprises 93% of the overall hazard quotient for residential exposure to mercury (0.0374 / 0.0402 x 100%).

However, the report is seriously problematic with it its assumptions about vegetable consumption rates. These assumptions are laid out in table 5 on page 27 the largest problematic assumption is that a homegrown fraction of vegetables consumed by residents would be only 10%. My understanding is that Kodaikanal remains a small city (population of only 30,000) where many residents in the vicinity of the phenomena factory may still grow vegetables for their own consumption. For example, for families who grow 50% of the root and leafy vegetables that they consume, the overall hazard quotient for exposure to mercury would be nearly five times higher (0.190 versus 0.0402) and the site-specific target level for the mercury cleanup would be only 5.2 mg/kg versus 25 mg/kg (1/0.190 versus 1/0.0402).

Also, although children are an appropriate focus of a study that calculates site-specific target levels for a mercury cleanup. However, pregnant women (and their developing fetuses) are another sensitive sub-population who are extremely vulnerable to mercury exposures. What's more, pregnant should (and do) consume green leafy vegetables at a rate disproportionately higher than the general population. According to a study of scientists with the Agharkar Research Institute, Pune, India:

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[5] Jennifer Harris-Hellala, Tatiana Vallaeysb, Evelyne Garnier-Zarlia and Noureddine Bousserrhine (Januar 2009)
"Effects of mercury on soil microbial communities in tropical soils of French Guyana" Applied Soil Ecology, 41(1):59-68.

> “The [green leafy vegetables] GLV eaten frequently (more than once a week) in this community were fenugreek leaves (57% of women), spinach (33%), coriander (16%) and colocasia (15%). The frequency of consumption of GLV at 28 wk was strongly related to all birth measurements (Table 3 Citation). These relationships remained significant after adjustment for prepregnancy weight (or height and BMI), energy intakes, physical activity score, weight gain during pregnancy and socioeconomic status (Table 4Citation). An increase in frequency of consumption from one group to the next higher group was associated with an increase in birth weight of 19 g [95% confidence interval (CI), 8–30] after adjustments for all of these factors. The trend with birth weight was stronger (value of partial regression coefficient increased to 30 g; 95% CI, 13–47) among the lightest mothers, those with a prepregnancy weight below the lowest tertile (40 kg). The odds ratio for delivering a low birth weight baby was 0.43 (95% CI, -0.12 to 0.99) in mothers who ate GLV at least every other day compared with 1.0 in mothers who never ate them.”

> “Birth size was strongly related to intakes of GLV and fruits at 28 wk gestation and of milk at 18 wk gestation. These three food groups are particularly rich in micronutrients. Our observations therefore suggest the importance of specific micronutrients, or their combinations, for fetal growth. For example, GLV are a rich source of folate, iron, provitamin A carotenoids and antioxidants. Increased frequency of the consumption of GLV was associated with an increase in all neonatal anthropometry, and the relationship with birth size remained significant even after correction for red cell folate concentration in blood, suggesting that nutrients other than folate contribute to the relationship.” [6]

Therefore, the September 2006 report by environmental resources management (ERM) Australia cannot be a basis for a site-specific target cleanup level for mercury that is protective of pregnant women (and their fetuses) because the study did not take into account pregnant women as a driver of the risk assessment process (see page 11 of the report). A site-specific target cleanup level for mercury that is protective of pregnant women (and their fetuses) would require re-doing the study and focusing on (at least) vegetable consumption rates for pregnant women in the study area and the actual percentage of home grown vegetables that might be reasonably consumed.

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[6] Rao, S., et al (2001) "Intake of Micronutrient-Rich Foods in Rural Indian Mothers Is Associated with the Size of Their Babies at Birth: Pune Maternal Nutrition Study" Journal of Nutrition, 131:1217-1224 http://jn.nutrition.org/cgi/content/full/131/4/1217