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1.0 SUMMARY

Based on limited air sampling results, the potential for a significant incidence of overt mercury intoxication may exist for personnel within and residents surrounding the Olin-Saltville site.

Mercury vapor concentrations in ambient air recorded on June 28 and 29, 1983, in the vicinity of the former Olin-Matheson plant, ranged up to 26 ug Hg°/m³ (averaged over a 5 to 12 minute sampling period), with peak, instantaneous concentrations as high as 40 ug Hg°/m³. Highest concentrations of airborne mercury vapor were detected in an area proximate to numerous residences.

Several limitations of the preliminary sampling study preclude accurate assessment of the health risks posed to individuals working or residing in the area. For example, it is difficult to estimate exposure history from an isolated monitoring survey (i.e. average concentrations of mercury actually inhaled and the duration-frequency of exposure). Moreover, only elemental mercury vapor in ambient air was measured and it is probable, considering the nature of the pollution source, that some volatile methylmercury is generated and released into the air. Other pathways of mercury intake may also be significant.

If it is assumed that 26 ug Hg°/m³ represents a typical ambient level to which some neighboring residents may be exposed, it is probable that continuous exposure over a period of several weeks or longer could result in the insidious development of mercurialism. Chronic inhalation of elemental mercury vapor (as well as methylmercury) produces effects primarily on the central nervous system that are strikingly neuropsychiatric in nature. Characteristic emotional and psychomotor disturbances may be slow in onset and often difficult to perceive. The symptoms: excessive shyness, irritability, confusion, depression, excessive fatigue, insomnia, anorexia with weight loss, excessive salivation, headache, etc., are common. Objectively, fine tremors of the hands, eyelids, or lips may develop. Mercury, particularly alkylmercurials, is known to adversely affect the fetus and neonate, which are especially sensitive, by exposure of the mother during pregnancy and nursing. Neurological effects are slow to remit and some may be irreversible upon cessation of exposure.
Concentrations of mercury vapor monitored beyond the boundary of the plant site were considerably higher than the proposed ambient air Hg NESHAP of 1.0 ug Hg/m³ (30-day average). Other guidelines for recommended or acceptable ambient levels of airborne mercury or total mercury intake are comparable to the proposed Hg NESHAP.
SECTION 2
2.0 INTRODUCTION

Mercury can exist in a multitude of chemical species, and the more important of the separate chemical forms can exist at any given time in several physical states (e.g. liquid, dissolved, or suspended in an aqueous medium, aerosol, gas, complexed, insoluble precipitates, etc.); all variably intraconvertible and most forms exhibiting unique environmental physics and distinct toxicological properties. For example, elemental mercury as a liquid is relatively not very toxic when ingested in pure form, since it is absorbed to the extent of only about 0.01 percent. (Even intravenous injection of several hundred grams has been survived by humans, with embolisms of globular mercury representing the major life-threatening sequelae.) In contrast, inhalation of its odorless vapors, which readily form under typical ambient conditions, results in substantial absorption of the monoatomic element into the bloodstream and can result in very pronounced effects on the lungs, central nervous system, kidneys, or other organ systems, depending on the dose. Thus, even the level of a singular exposure pathway - that is, the rate of absorption of one form of mercury as well as the duration and frequency of exposure - may determine which target organ or system is predominantly affected and thereby profoundly influence the nature of the pathological picture which develops.

In comparison to the usual industrial experience with mercury, the environmental toxicology of this metal is extremely complex. The burden of elemental mercury in river sediments at Saltville would probably be quite considerable to profitably warrant commercial recovery. Even scant fractions converted to methylmercury by the biological organisms normally abundant in such aquatic systems, could result in bioaccumulation and biomagnification of this naturally generated and very toxic form of mercury in the food chain. Since fishes can bioconcentrate methylmercury in their edible tissues on the order of several thousand to perhaps more than a million-fold over concentrations present in waters they inhabit, even minute concentrations of methylmercury, well below the detection limits of standard methods of analysis, may pose considerable health hazards to those who consume locally caught fish.
In addition to the hazards posed to human health from eating fish taken from mercury-contaminated waters (as evidence by the Minamata Bay episode in Japan), organic mercurials generated both aerobically and anaerobically by microorganisms present in sludges, river sediments, river-bottom dredges, muck ponds, soil, etc. are even more volatile than elemental mercury. Methylated mercurials are thus effectively transported in the atmosphere and are very efficiently absorbed upon inhalation (95 percent). Mercurous and especially mercuric salts, formed by the oxidation of the element in the environment, can be fairly soluble and mobile in aquatic systems. They can also be transported via particulates to which they may be strongly adsorbed, either in water or airborne dusts as might occur from aeration and seiving of dried mercury-enriched dredge material. Ionic mercury can undergo reduction in the environment to generate the free metal. Competing redox and alkylation-dealkylation pathways are constantly transforming, recycling, selectively mobilizing certain forms of mercury in various environmental systems; the steady-state proportion of the various chemical species will depend on a large number of variables and is impossible to predict in any given situation without extensive empirical information.

In view of the complex, biogeochemical dynamics and the human toxicological variables associated with environmental mercury, it may be misleading to assess hazards based on only one chemical form and physical state of mercury monitored in an environmental "hot spot." In most industrial or occupational exposure studies, only one specific form or state of mercury is of concern due to production controls and/or exposure limits. However, in the environmental setting, consideration should be given to the possible contributions of other forms and other potential exposure pathways of mercury that are not probable in most occupational situations.

While it is likely that elemental mercury vapor represents the predominant form of the pollutant in the ambient air as monitored at Olin-Saltville, fully assessing the health risks posed exclusively by this form and physical state of the toxic metal is not possible without precise information regarding exposure history for individuals residing in the area. The limited air sampling, conducted on July 28 and 29, 1983 on and in the near proximity of the Olin-Saltville site, was limited to measurements of mercury in the form of elemental vapor over one or two brief sampling periods (5 to 12 minutes).
This preliminary air monitoring survey clearly suggests a possibility of significant off-site transport of atmospheric mercury at levels of potential toxicological concern. The spot-monitorings indicate a need to obtain additional information concerning potential and, if possible, estimations of past levels of mercury vapor exposures. In addition, concentrations of methylmercury and mercury-laden particulates in air, as well as other environmental media, need to be ascertained to properly estimate total mercury exposure and risks.

This toxicological review, therefore, is necessarily limited in any effort to assess the extent of potential adverse health effects posed to individuals living near or employed at the former Olin-Matheson site. Rather, available information regarding the relationship between exposure concentrations (based on occupational experience) and the onset, symptomology, and severity of mercuirialism resulting from the chronic inhalation of elemental mercury vapor is reviewed and emphasized. Because low-level prolonged exposure to elemental mercury vapor affects primarily the higher centers of the central nervous system (emotions, cognition, personality) primary consideration is given to available human data, since the more subtle behavioral changes often seen in man chronically exposed are often objectively nondiscernible in lower animals. It should be kept in mind, however, that the possibility exists for additional exposure in the Saltville area to forms of mercury (not monitored) at levels substantially exceeding those normally encountered by the general public or even most groups occupationally exposed to mercury. The more significant of these environmentally important chemical forms and their probable pathways are discussed briefly (for example, methylmercury in fish or air, or the possibility of uptake of mercurials in produce grown in neighboring areas which experience high atmospheric Hg fallout).
For all practical purposes there are three general forms of mercury: elemental (Hg°), inorganic salts (Hg⁺ and Hg⁺²), and organic derivatives such as methylmercury (MeHg). From the point of view of general environmental exposures, the methylmercury compounds are of greatest toxicological concern, while vapors of metallic mercury pose the most common occupational exposure hazard.

Because the chemical form of mercury has a profound influence on its biogeochemistry and pharmacodynamics, it is important to know the chemical form and probable exposure pathways when evaluating the hazards that environmental mercurials present to human health. However, it is equally important to realize that a given form of mercury released into the environment may not maintain its original chemical speciation, and in its most toxic organic form has a tendency to accumulate at higher trophic levels of food chains. In general, man comes in contact with Hg through air (Hg° vapor) and water (Hg⁺²), but is more likely to ingest toxic levels through his diet, largely from fish (MeHg). Only in the case of isolated "hot spots" does nonoccupational exposure to mercury vapor pose a serious threat to public health. The potential for this relatively infrequent circumstance appears to be the case at and nearby the Olin-Saltville site.

3.1 Airborne Mercury

Background levels of Hg in the air are approximately 0.0005 ug/m³ (Jonasson and Boyle, 1972 Bull. Can. Inst. Min. Metal 65, 32). In urban and industrialized areas, the Hg° vapor concentrations in the atmosphere rarely exceed 0.050 ug/m³. The average concentration of Hg in the ambient atmosphere appears to be about 20 ng Hg/m³ (0.020 ug/m³). Levels of 1.5 to 9 ug/m³ have been measured over Hg deposits and active volcanoes, and maximum air concentrations of 0.6 and 15 ug Hg/m³ have been reported near mercury mines and refineries, respectively (McCarthy, et al., 1970 Mercury in the Atmosphere. In U.S. Geol. Survey Prof. Paper No. 713, pp. 37). The off site measurements (5 to 12 minute averages) of 26 ug Hg°/m³ taken near the former chloralkali plant at the Olin-Saltville site represent atypically high levels of atmospheric mercury (only elemental mercury vapor was presumably measured).
Elemental mercury vapor is, generally, the predominant form of mercury in the atmosphere (NAS, 1978). However, observations by some authors indicate that alkylmercurs, such as MeHg, may amount to perhaps one-third of all the mercury present in air (Johnson and Braman, 1974, Environ. Sci. Technol. 8, 1003; Soldano, et al., 1975, Atmos. Environ. 9, 941). Mercury present in a particulate form usually accounts for less than 1 percent. While Hg° vapor would be expected to constitute the major airborne fraction of total mercury in an air sample near a site involved in the recovery of elemental mercury from dredge material, it should be noted that aeration processes employed have the potential to also readily generate airborne particulate fines that are rich in mercurials. In addition, the potential for significant levels of the more toxic organomercurs to form and enter the atmosphere could in itself present serious health concerns at and nearby this site.

3.2 Organic Mercurials in the Air

Hg-contaminated river sediments may generate MeHg at a rate of 170-6,900 ug/m²/day, depending on oxygen status, temperature, COD loading, total Hg levels, sulfide levels, and a host of other factors (Effects of Mercury in the Canadian Environment, National Research Council of Canada, 1979). MeHg is readily generated in natural environments from inorganic mercury (Hg°, Hg+, or Hg²⁺) and is rather volatile. Organic Hg forms have been detected in air near geothermal sites, but substantial contributions seem to arise from sewage treatment plants (Soldano et al. 1975. Atmos. Environ. 9, 941). Considerable organic Hg may also reach the atmosphere as a result of soil degassing (Rogers, 1975. Methylation of Mercury in a Terrestrial Environment. U.S. EPA Document No. EPA-603/3-75-014, Oct. 1975.), particularly from localized areas receiving unusual Hg° fallout.

Sludge drying processes have been found to produce airborne discharges of MeHg as high as 2 ug/m³ (Mercury in the Air, 1971. Environment 13, 24-33). Under aerobic conditions, 70-95% of the mercury input from raw sewage may be volatilized per day as organic Hg (predominantly MeHg chloride). The net affect is the generation of plumes of elevated total Hg downwind of sewage treatment facilities. For example, at one plant studied, 65 ng/m³ total Hg was measured at ground level at the plant site and 0.2 ng/m³, mostly as MeHg Cl, at a distance of nearly 10 kilometers from the sewage facility (Soldano et al., 1975. Atmos. Environ. 9, 941), demonstrating the mobility of mercury in the air.
The muck ponds and Hg\textsuperscript{0}-enriched river sediments at the Olin-Saltville site are particularly well-suited for maximal generation of MeHg, and aeration of dredged river sediments involves a near-ideal situation for additional methylation and volatilization to occur. For these reasons, it may be important to ascertain not only airborne levels of mercury vapor, but also organic and particulate forms.

### 3.3 Mercury Analysis of Ambient Air

Hopcalite or silver-amalgam detection systems are well-suited for monitoring air levels of Hg\textsuperscript{0} vapor. However, no information regarding particulates or organic Hg are provided by this technique alone, nor were available from the June 28-29, 1983 air monitoring survey at Olin-Saltville. For environmental air sampling and analysis of all types, particulate and gaseous, in industry, the NIOSH Manual of Analytic Methods (2nd ed., Vol. 3, April 1977) recommends for particulate Hg a membrane prefilter preceeding a two-stage, solid-phase tube. Organic Hg vapor is collected on the first section and metallic Hg vapor is amalgamated at the second. Each section can then be analyzed separately by thermal desorption to the cell of a flameless atomic absorption spectrophotometer (range 0.001 to 1.0 ug Hg, with a precision of 7.3 percent relative S.D. at 65 ng Hg vapor/liter).
4.0 TOXICOLOGY OF MERCURY

Outbreaks of mercurialism in small sectors of the population (nonoccupational) have with few exceptions been misdiagnosed for months or even years. Factors in such tragic delays included the insidious onset of the affliction, vagueness of early clinical signs, and the medical profession's unfamiliarity with the disease. Symptoms of intoxication may vary considerably depending on the form of mercury encountered, level and pathway of exposure and frequency and duration of exposure. Mercury has toxic effects involving numerous organs and systems. With mercuric salts, the kidney is the critical organ of injury, while Hg⁰ and methylmercury exert their primary effects on the central nervous system. Emphasis in this report will be given but not limited to effects from chronic inhalation of elemental mercury vapor since this is the form monitored near the Olin-Saltville site.

Exposure to extremely high concentrations of Hg⁰ vapor (greater than 1 mg/m³) can result in serious insult to lung tissue, causing acute mercurial pneumonitis. Frank acute intoxication is characterized by a metallic taste, nausea, abdominal pain, vomiting, diarrhea, headache, chest pain, labored breathing, and occasionally kidney damage evidenced by albuminuria. After a few days, the salvary glands swell, soreness and swelling develops in the mouth and gums, a dark line of HgS forms on the inflamed gums, the teeth loosen, and ulcers form in the lips and cheeks. In milder cases, recovery occurs within two weeks, but in others, poisoning resembling that of a chronic type may ensue, accompanied by muscular tremors and mental disturbances.

Prolonged or repeated exposure to lower levels of mercury vapor causes effects of a strikingly neurological and psychiatric nature, which develop slowly and insidiously. While psychic and emotional disturbances are characteristic, gradual behavioral changes are often difficult to subjectively discern, much less attribute to a chemical intoxication resulting from the unwitting or inadvertant exposure to odorless mercury vapor.
Observations of more than 1,000 individuals occupationally exposed to $\text{Hg}^0$ vapor indicate that intoxication occurs in workers following chronic inhalation (40 hours per week) of average air concentrations above 100 to 200 $\mu$g $\text{Hg}/\text{m}^3$ (NAS, 1978 Panel on Mercury). Common symptoms include depression, irritability, irascibility, exaggerated response to stimulation (ereethism), excessive shyness, insomnia, emotional instability, forgetfulness, confusion, and vasomotor disturbances such as excessive perspiration and uncontrolled blushing. Objectively, tremors are commonly exhibited, and are exaggerated when a fine motor task is initiated but are minimal when the victim is at rest or asleep. The tremor may affect the hands, eyelids, lips, tongue, or jaw. Writing ability, for example, is often grossly affected. Other effects can include allergic skin rash, headache, excess salivation, stomatitis, gingivitis, and other reactions described above for acute poisoning. Nonspecific symptoms such as anorexia, weight loss, anemia, and muscular weakness are also associated with exposure to inorganic mercury.

Simultaneous exposure to $\text{Hg}^0$ vapors and MeHg at even much lower levels will likely result in additive or possibly synergistic effects or potentiation of the toxic actions of $\text{Hg}^0$ vapor. If concomitant exposure to the organic form is sufficient, other effects not seen in $\text{Hg}^0$ vapor intoxication will also manifest themselves. As with $\text{Hg}^0$, MeHg exerts its most pronounced toxic effects on the central nervous system (CNS), which also include neuropsychiatric effects, but differs from $\text{Hg}^0$ vapor in that the CNS effects are largely sensorimotor in nature. Chronic exposure results in paresthesias (disturbances in sensation), concentric restriction of the visual field, ataxia and disturbances in locomotion, in addition to distinctive behavioral changes. Other sensory effects occur as MeHg exposure levels increase, such as loss of hearing, vestibular dysfunction (impaired sense of balance), and decreased senses of taste and smell (anosmia). These sensory effects are not known to occur in elemental mercury intoxication. Both produce tremor, but the shyness and irritability so common in $\text{Hg}^0$ vapor poisoning are not observed in MeHg intoxication. On the other hand, spontaneous fits of laughter and crying occur only in MeHg poisoning (Hammond and Beliles, in Toxicology, Eds.: Doull, Klaassen and Amdur, 2nd ed., Macmillan, New York, 1980, pp. 425). The fetotoxic and developmental affects (latent-onset psychomotor retardation) of prenatal exposure to MeHg are well documented. With both forms, the fetus and neonate represent the most sensitive population subgroups at risk of irreversible adverse effects.
Children suspected of prenatal and early postnatal MeHg exposures were found by age 8 to 16 to exhibit a higher incidence of neurological deficits, learning difficulties and poor performance on IQ tests than unexposed children (Med. Tribune, 1978).

The relationship between inorganic and methylmercury may be even more complicated because of a recent report on dentists in which MeHg levels were found to be five times higher in dentists exposed solely to Hg\textsuperscript{o} vapor than in controls not exposed to Hg\textsuperscript{o} vapor (Cross, et al. 1978, Lancet 8084, 312). Therefore, even exposure to Hg\textsuperscript{o} vapor alone may involve significant levels of MeHg accumulation.
5.0 DOSE-RESPONSE AND EXPOSURE LEVELS OF CONCERN

Dose-response relationships from low-level chronic exposure are difficult to define in man since such phenomena as fine tremor, shyness, irascibility, etc. are not readily amenable to accurate quantification. Precise information on dose-exposure history also is not always available and is a matter of conjecture in some epidemiological studies. Nevertheless, some valuable indications of the relation between ambient air concentrations and incidence and pathology of chronic mercurialism have emerged from studies of occupational exposures. What isn't clear is the exposure level of Hg° vapor which affords a confidence of no adverse health effects.

In a study of over 500 employees in the chlorine-producing industry, Smith, et al. (1970 Am. Ind. Hyg. Assoc. J. 31, 687) reported effects on the nervous system that were related to the time-weighted average air concentration of Hg° vapor. Objective tremors were noted in workers exposed to air concentrations above 100 ug Hg/m³ (the existing TLV at that time). Neuropsychiatric changes also appeared to be related to the amount of mercury absorbed. A syndrome (erethism) involving insomnia, sweating, emotional lability, shyness, and loss of appetite with corresponding weight loss was reported to a significant degree by workers exposed to average air concentrations in the range of 60 to 100 ug Hg/m³.

According to NIOSH, erethism, rather than tremor, may be the most characteristic symptom of chronic mercurialism. Erethism was found to be more prevalent (33%) in workers exposed at levels somewhat above the current TLV of 50 ug/m³, than among those (8%) with exposures below 50 ug/m³ (Turrian et al, 1956, cited in NIOSH: Registry of the Toxic Effects of Chemical Substances, 1977). Tremor, on the other hand, was observed in about 20 percent of the workers in both groups.

Extensive studies carried out in Russia (Trachtenberg, 1969, cited in Ambient Water Quality Criteria for Mercury, U.S. EPA, 1980) suggest that significant incidences of erethism occur in workers chronically exposed to mercury vapor concentrations in the range of 6 to 100 ug Hg/m³.
An epidemiological survey conducted in Lithuania revealed an increased incidence of abortion and mastopathies (breast disease) related to duration of time on the job of women employed in dental offices, where mercury vapor levels ranged up to 80 ug/m³ (Baranski and Szymczyk, 1973, cited in Ambient Water Quality Criteria for Mercury, U.S. EPA 1980). The same authors reported a high mortality rate among infants born to women who exhibited symptoms of mercurialism.

The time-weighted average air concentration of 50 ug Hg/m³ may be adequate as a current standard (TLV) for the protection of human health in the workroom environment, but it clearly provides little or no margin of safety.

Considerable uncertainty still exists with regard to health effects at ambient air concentrations of mercury vapor below 100 ug Hg/m³, or even 50 ug Hg/m³.
6.0 EXISTING GUIDELINES

Air emission standards for mercury are included under NESHAP, but are not alternately expressed as an ambient standard (maximum outplant concentration) as in the case of beryllium. A proposed Hg NESHAP of 1.0 ug/m$^3$ (30-day average) has been recommended as an ambient guideline. The value of 1.0 ug Hg/m$^3$ was derived based on the maximum safe daily intake of 30 ug Hg recommended by the Swedish Expert Group (1971) for methylmercury in the diet. Calculation of the proposed ambient Hg NESHAP assumes that the effects of ingested methylmercury and inhaled Hg$^0$ vapor are additive and dose-equivalent. At an average intake of 10 ug Hg per day (almost exclusively in the form of MeHg from the dietary intake of fish), the recommended daily maximum safe level is then approached by inhalation of 20 m$^3$ per day (24 hour) of air containing 1 ug Hg/m$^3$.

There are several other methods of deriving acceptable ambient levels for the continuous inhalation of elemental Hg vapor in the air. For example, the World Health Organization's Provisional Tolerable Weekly Intake for all forms of mercury is 300 ug total Hg, of which not more than 200 ug should be in the form of MeHg. If an average of 70 ug Hg per week is ingested in the U.S. population at large, absorption of 230 ug Hg/week by a 70kg adult would represent the maximum additional intake. Since about 80 percent of the inhaled Hg$^0$ vapor is retained as evidenced by observations of humans (Hurch, et al. 1976, Arch. Environ. Health 4, 302), and an average of 140 m$^3$ of air is inhaled per week by a 70kg adult, continuous exposure to ambient air concentrations of 2 ug Hg$^0$/m$^3$ represents the tolerable limit.

\[
300 \text{ug total Hg/wk} - 10 \text{ug Hg/day} \times 7 \text{ days/wk} = \text{allowable additional exposure} = 230 \text{ug.}
\]

\[
\frac{230 \text{ ug Hg/week}}{\text{inhalation rate of } 140 \text{ m}^3/\text{wk} \times 0.8 \text{ retention}} = 2.05 \text{ ug Hg total/m}^3
\]
It must be emphasized here, however, that these calculations presume no other unusual sources of significant exposure (skin absorption, contaminated drinking water, pica, non-fish dietary Hg, etc). This may not be the case in localized areas of substantial environmental mercury contamination. The average levels of MeHg ingested from fish are assumed to be about 10 µg Hg/day, but this value is based on nationwide surveys and includes estimates from segments of the population that rarely if ever consume fish. Typical fish eaters may ingest 20 µg MeHg/day and the consumption of fish from mercury-contaminated waters has given intakes of up to 5,000 µg MeHg/day (Kazantis, 1981, Environ. Health Perspect. 40, 143).

The time-weighed average TLV is defined by the American Conference of Governmental Industrial Hygienists (ACGIH) as "the average concentration for a normal 8-hour work day or 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect." TLVs provide useful information concerning general health hazards in the workroom environment for a segment of the population without regard for individual variation and susceptibility (e.g. infants, and the elderly, alcoholics, pre-existing disease). The TLVs are not intended as fine lines between safe and dangerous concentrations. Although most TLVs already include a safety factor (values set well below the minimum concentration which might be expected to result in apparent adverse effects, irritation or annoyance) many state, city, and federal agencies utilize TLVs for off-site emissions and incorporate an additional 10-fold or much greater safety factor in order to account for individual variation in susceptibility within the general public.

Michigan, for example, in forming a framework for setting air emission guidelines for non-criteria pollutants, utilizes TLVs as the best available and regularly reviewed information from industrial experience and from experimental studies to estimate acceptable off-site ambient ground-level concentrations to which the general public may be exposed without appreciable risk. To this end, a 10-fold safety factor is incorporated and adjustments made to account for differences in work shift and full-time exposures as follows:

\[
\text{Acceptable ambient air concentrations} = \frac{\text{TLV}}{24 \text{ hrs}} \times \frac{8 \text{ hrs}}{24 \text{ hrs}} \times \frac{5 \text{ days}}{7 \text{ days}} \times 10 \left( \frac{\text{additional safety factor}}{10} \right) = 0.024 \text{ TLV}
\]
Accordingly, for a continuous emission source, 2.4 percent of the TLVs at ground level under plume center at or beyond the emission source boundary line is considered by the state of Michigan to be acceptable ambient air concentrations. Higher emission rates based on the number of hours per day (not to exceed 10 percent TLV on a time-weighted average basis during any 8 hour work day, and never to exceed 80 percent of the TLV) may be considered acceptable for intermittent emission sources (Final Report of the Special Air Advisory Committee to the Michigan Air Pollution Control Commission, 1981.) With a TLV for elemental mercury vapor of 50 µg/m³, the acceptable ambient air level as determined by procedures adopted by Michigan is 1.2 µg Hg⁰/m³ and 0.24 µg Hg/m³ for methylmercury and other alkylmercury compounds.

Similar Ambient Air Quality Guidelines (AAQC) for 99 toxic air contaminants, including mercury, have been developed by the city of Philadelphia Air Management Services (City Council Bill #270, Feb. 5, 1981), which also utilizes TLV standards (ACGIH) where available as a preferred source of toxicological data for deriving recommendations for ambient levels of pollutants. The same mathematical adjustments for continuous versus normal work shift exposure have been applied; the effect being to keep the dose constant by reducing the allowable exposure level proportionately to compensate for the increase in potential exposure time. For mercury and compounds, with a divisor of 10 as an additional safety factor, a preliminary value of 0.24 µg Hg/m³ has been recommended (A Protocol for Establishing Ambient Air Quality Guidelines for Toxic Air Contaminants, Dept. Public Health, Air Management Services, Philadelphia, PA, 1982). This value, however, reflects the TLV for inhalation of the more toxic alkylmercury compounds for which the current TLV is 10 µg/m³. For elemental mercury vapor alone, the protocol employed to derive the AAQG would be 1.2 µg Hg⁰/m³.

Acceptable Ambient Air Levels (AAL) established by the New York State Department of Environmental Conservation are determined for most compounds by dividing current ACGIH TLVs by 300 for toxic (e.g. benzene) and moderately toxic (mercury) air contaminants, and 50 for low toxicity compounds. The recommended AAL for New York State is, accordingly, 0.167 µg Hg/m³ for Hg⁰ vapor and 0.033 µg Hg/m³ for alkylmercurials.
7.0 EXPOSURE HAZARDS AT OLIN-SALTVILLE

According to the air monitoring report (Evaluation of Ambient Mercury Vapor Concentrations in the Vicinity of the Former Olin-Matheson Chloralkali Plant Saltville, Virginia): "The residences in the area are being exposed to the highest concentrations measured."

Off-site mercury vapor levels recorded on June 28 and 29, 1983 averaged (over a testing period of 5 to 12 minutes) to 26 ug Hg°/m³ with peak concentrations up to 40 ug Hg°/m³. It should be noted that these measurements were taken during unstable weather conditions with winds over 5 knots. Moreover, intermittent thundershowers occurred during or prior to sampling, and precipitation is known to effectively scrub the air of mercury vapors, causing its deposition onto the local terrain, most of which subsequently revaporizes within a matter of days (Weiss et al. 1971. Science 174, 692). Thus, under dry, mild, static meteorological conditions it is possible that Hg° vapor concentrations have been considerably higher. On the other hand, it was suggested in the EPA monitoring report that Hg° vapor levels markedly decreased when screening operations ceased.

On the basis of spot monitoring at Olin Saltville, it is difficult to estimate the time-weighted average concentrations of elemental mercury vapor in the ambient air to which neighboring residents may have been and are now being continuously exposed. Moreover, as mentioned earlier, potential sources of mercury exposure other than inhalation of elemental mercury vapor may contribute significantly to the degree of risk associated with a measured average concentration of Hg° vapor alone.

If it is assumed that a measured concentration of 26 ug Hg°/m³ represents a typical level at any given time of mercury inhaled by residents bordering this site, it may also be assumed that mercury poisoning (erethismus mercurialis) is probable. Continuous exposure via inhalation of 26 ug Hg°/m³ is equivalent in terms of total absorption to an occupational (40-hour work week) exposure of about 109 ug Hg°/m³. As mentioned previously, epidemiological evidence clearly indicates a significant incidence of overt symptoms of mercury intoxication in those occupationally exposed to lower levels.
The fetus and the developing infant are particularly susceptible to mercury poisoning. Levels of MeHg, for example, causing no overt effects in the mother nevertheless cross the placental and the mammary barriers and may produce toxic effects in the fetus and/or neonate which may be immediately apparent, or which may only manifest themselves in later life (e.g. mental retardation). For methylmercury, Koos and Longo (Am. J. Obstet. Gynecol. 126, 390, 1976) concluded, based on all known incidents of prenatal exposure of human infants, that an intake of 25 ug MeHg/day by a 60kg mother involved an acceptably low risk of prenatal injury. Thus, what may be deemed "safe" for Hg° vapor exposure by healthy adults in the workroom environment as reflected by the current TLV of 50 ug Hg°/m³ for an 8-hour work shift, may not provide an adequate protection for the very young, the infirmed, the elderly, the nutritionally deficient, etc.

In addition, overt symptoms may not be sufficiently sensitive indicators of mercury toxicity. For example, the first observable clinical signs of MeHg toxicity in man appear to be parethesias, but the first biochemical signs in animals include inhibition of protein synthesis in neurons, and inhibition of DNA synthesis in brain cell mitochondria. Many toxic effects, therefore, may not be reversible following cessation of exposure, since, for example, information coding for the mitochondrial enzymes would be permanently lost from the affected DNA.

Finally, additional potential routes of exposure should not be ignored in any effort to assess effects associated with a known concentration of airborne mercury vapor. Transport of Hg° vapor and its inevitable fallout in land areas surrounding the Olin-Saltville site may also result in soil contamination, which can serve as an added source of mercury due to revolatilization (Hg° and MeHg), increased levels of ionic mercury in water, or dusts on locally grown food crops.
Absorption of inorganic or organic Hg from soil by plants is generally low. However, mercury in the top soil readily volatilizes and can be efficiently taken up through the leaves. Barley and soybeans, for example, act as scavengers for airborne Hg\(^0\) vapor. Some plants, such as conifers, when exposed to Hg\(^0\) vapor take up so much of the metal that droplets of the metal are found in woody tissues and even in seeds (Kothny, 1973. Adv. Chem. Ser. 123, 48). Tobacco can absorb up to 3000 mg/kg in its leaves and still mature without signs of damage or phytotoxicity; however, other plants including some crops are much more sensitive. Plants can also take up ionic Hg\(^{+2}\) and release it in the form of Hg\(^0\) vapor. Locally grown produce, therefore, may provide additional intake of mercury by individuals residing in the area at levels not normally encountered. Water, inhalation and ingestion of dusts, and skin absorption (e.g. from contaminated clothing to which mercury vapors condense) may further increase exposure to this toxic metal in any of its various forms.
EVALUATION OF AMBIENT MERCURY VAPOR CONCENTRATIONS
IN THE VICINITY OF THE FORMER OLIN-MATHESON CHLOR-ALKALI PLANT

SALTVILLE, VIRGINIA

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               U.S. EPA, Region III
               Air & Waste Management Division

Date: August 4, 1983
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SECTION 1

Introduction

In response to a request from the Waste Enforcement Section of the Superfund Branch, an evaluation was performed to determine the potential existence of significant ambient air concentrations of mercury around the former Olin-Matheson plant in Saltville, VA. Two distinct potential sources of Hg emissions exist in the area. The first is a 76 acre waste disposal pond (muck pond #5) which has been determined to contain a significant amount of elemental Hg. Adjacent and to the SW of muck pond #5 exists a second pond (muck pond #6). It was explained to us, by the Co., that there exists no elemental Hg in the soil of pond #6 since this pond received only the overflow from pond #5. The second source is the former site of the Chlor-alkali plant. At this site, the Company is presently processing dredged material from the adjacent river for the purpose of recovering elemental Hg. The process being performed effectively aerates the material by passing it through a series of mesh screens. From an air emissions point of view, this procedure is expected to greatly increase the mass emissions by exposing more of the Hg to the air.

The evaluation consisted of a review of past air monitoring studies as well as the actual collection of Hg vapor samples in the vicinity of the two sources. This study took place on June 28 and 29, 1983 and represents a limited look at peak ambient air concentrations of Hg under a small set of meteorological conditions. The basic purpose of this study was to gather additional information to help in deciding whether a comprehensive air monitoring study is warranted.

In the following sections of this report, the specifics of the evaluation are presented. Section 2 contains a summary of past studies; Section 3 describes the emission sources, the general area and the monitoring sites of the June 3, 1983 study; Section 4 discusses the instrumentation used; Section 5 describes the general study procedure as well as the specific procedure used in sample collection; Section 6 presents a discussion of the results and Sections 7 and 8 present conclusions and recommendations respectively.
SECTION 2

Summary of Past Studies

There have been three ambient air studies performed in the area prior to the June 1983 study. The first study was performed by the Oak Ridge National Lab during the period of 7/29/75 through 8/1/75. The other two studies were performed by the Va. Air Board and were conducted 9/21/76 through 10/13/76 and 5/19/77 through 9/28/77. Each of these studies measured both particulate and gaseous mercury. It is important to note that during each of these studies there was no screening activity present at the Chlor-alkali plant site. Therefore, when comparing the results from these studies with the results from the June 1983 study, one would expect the 1983 results to be higher.

There was no comprehensive on-site meteorological data taken at the time of the two Va. studies so that the link between source and receptor was difficult to make. However, in our attempt to analyze source/receptor relationships, we acquired meteorological data from the Bristol Airport which covered the study periods. Caution should be exercised when using the Bristol meteorological data since it may not be representative of the Saltville area. This is due to the complex topography about the plant site and the low level nature of the emission sources.

The Oak Ridge study was the first study done in the area. One monitoring site was established between muck ponds #5 and #6 (see Figure 1). At this site both particulate and gaseous Hg were sampled. The three day average concentrations were found to be approximately 0.0003 ug/m³ and 0.99 ug/m³ for particulate and gaseous Hg respectively.

Meteorological data for the period indicated that for approximately 70% of the time the winds were from the NE; i.e., directly off of muck pond #5.

The authors of this study compared their results to typical values found in urban environments. Based on these comparisons, they concluded that the concentrations of particulate Hg were extremely low while the concentrations of gaseous Hg were quite high.

Based on the monitoring results, an approximation of the Hg emissions off pond #5 was made. The authors estimated the emission rate to be on the order of 50.0 kg/yr.

The second and third studies conducted in the area were performed by the Va. Air Board. Three monitoring sites were established in the area (see Figure 1). One in the town of...
Saltville (X-15-L) which measured particulate Hg only; one on the western boarder of the former plant site which measured both particulate and gaseous Hg (X-15-M); and one at the western extreme of the residential area to the northeast of muck pond #5 (X-15-K) which measured both particulate and gaseous Hg.

The results of these efforts are summarized in Table 1. Since there was no on-site meteorological data taken during these studies, the wind directions reported in Table 1 were acquired, for this summary, from the Bristol Airport. Table 1 does not contain the results of the particulate Hg sampling since the concentrations found were consistent with the Oak Ridge Study; i.e., extremely low values.

The September 1976 study found essentially non-detectable levels of gaseous Hg. This result is inconsistent with the Oak Ridge Study findings. It is our belief that this is due in part to the following:

1. Ambient temperature during this study were relatively low. Temperature maximums ranged from 57° F to 79° F. The volatilization rate of Hg is very sensitive to temperature.

2. During the course of the study, there was considerable precipitation causing standing water on pond #5.

3. Site X-15-M was poorly located for the purpose of measuring concentrations from the former plant site considering the transport winds which occurred during the study period.

The summer 1977 study, on the other hand, found detectable levels of Hg vapor at both sites. At site X-15-K, 24 hr. average concentrations ran from 0.01 to 0.34 ug/m³. At site X-15-M, the concentrations ran from 0.21 to > 3.5 ug/m³.

Obviously, at site X-15-M, significantly higher concentrations were monitored than at site X-15-K. This is quite puzzling when one considers the following:

1. It is our understanding that during the course of this study there was no activity at the former plant site.

2. In general, wind directions during the study period would not transport Hg vapor from the plant site to monitor X-15-M.

3. Although monitor X-15-M is considerably farther away from muck pond #5 than is monitor X-15-K, there were a number of days when the winds were out of the W and SW and monitor X-15-M registered higher readings.
Upon comparisons of wind direction and concentrations, there appears to be essentially no correlation. For example, consider the sample taken on 5/25/77. The measured concentration was 0.8 ug/m³ (greater than the mean value of the study) which occurred with a North wind. Under a North wind there exists no known sources of Hg vapor up-wind of monitor X-15-M. Upon close examination of the data set other similar examples can be found.

In general, the above data does not show expected source-receptor relationships. In attempting to explain this finding, one should consider:

1. Bristol meteorological data may not be representative of the Saltville area.
2. There may exist additional sources of Hg in the area other than pond #5 and the old plant site.
3. There may have been activity at the plant site that we are unaware of.
TABLE 1: SUMMARY OF Hg VAPOR SAMPLING RESULTS FROM TWO PAST VA. STATE STUDIES

(Concentrations listed are in units of ug/m³ and represent 24 hr. averages)

<table>
<thead>
<tr>
<th>DATE</th>
<th>SITE X-15-K</th>
<th>SITE X-15-M</th>
<th>WIND DIRECTION</th>
<th>MAX. TEMP. (°F)</th>
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</thead>
<tbody>
<tr>
<td>9/21/76</td>
<td>ND*</td>
<td>.25</td>
<td>W</td>
<td>72</td>
</tr>
<tr>
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<td>ND</td>
<td>ND</td>
<td>S</td>
<td>71</td>
</tr>
<tr>
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<td>79</td>
</tr>
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<td>W</td>
<td>74</td>
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</tr>
<tr>
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<td>ND</td>
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<td>S</td>
<td>69</td>
</tr>
<tr>
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<td>ND</td>
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<td>76</td>
</tr>
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<td>W</td>
<td>64</td>
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<td>W</td>
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</tr>
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<td>NW</td>
<td>87</td>
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<td>0.58</td>
<td>W</td>
<td>90</td>
</tr>
<tr>
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<td>0.75</td>
<td>NW</td>
<td>86</td>
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<td>0.69</td>
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<td>83</td>
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<td>0.21</td>
<td>SW</td>
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<td>89</td>
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<td>SW</td>
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</tr>
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<td>0.29</td>
<td>W</td>
<td>82</td>
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<td>87</td>
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<td>0.58</td>
<td>SW</td>
<td>92</td>
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<tr>
<td>9/10/77</td>
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<td>0.23</td>
<td>SW</td>
<td>90</td>
</tr>
<tr>
<td>9/16/77</td>
<td>0.12</td>
<td>0.35</td>
<td>W</td>
<td>76</td>
</tr>
<tr>
<td>9/27/77</td>
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<td>0.41</td>
<td>NW</td>
<td>79</td>
</tr>
<tr>
<td>9/28/77</td>
<td>0.12</td>
<td>0.35</td>
<td>N</td>
<td>74</td>
</tr>
</tbody>
</table>

*ND: Non-Detectable
**--: No sample taken
SECTION 3

Site Description

In the Saltville, Va. area there are two distinct sources of Hg vapor emissions that were investigated during the June 1983 study; they are muck pond #5 and the former site of the Chlor-alkali plant. These sources are located in the valley of the North Fork of the Holston River, approximately 1.0 km Northwest of the town of Saltville, Va. The two sources are separated by approximately 600 m with the muck pond being SW of the former plant site (see Figure 2). The Valley runs SW to NE with its northern ridge being much higher than its southern ridge.

Based on the orientation of the valley and the overall climatology of the area, wind direction during the summer months should strongly favor a SW flow in the valley. During periods of strong atmospheric stability the general transport flow in the area does not affect the developing local valley flow, therefore a local SW flow will develop due to the orientation and drainage characteristics of the valley. There exists one major complicating factor to the Valley's flow field. On the northern side of the valley, directly across from the former plant site, there is a break in the otherwise continuous ridge. This break, known as a feeder valley, will, during periods of strong atmospheric stability, cause a local drainage flow to develop which will be perpendicular to the general drainage flow in the valley. During periods of general NW flows, one might expect a channeled north wind to develop out of this feeder valley. Therefore, since the plant site is located directly across from this feeder valley, while the muck pond is some 600 m up-valley, one might expect different wind directions occurring at the two sites under certain meteorological conditions. However, under a synoptically generated SW flow, one would not expect the feeder valley to perturb the flow in the vicinity of the two sources.

Hg vapor emissions from the muck pond are caused by the volatilization of elemental Hg which is contained in the soil of the pond. The distribution of Hg in the pond was found, through borehole sampling, to vary significantly across its surface. Therefore, under any given meteorological condition one might expect a significant spatial gradient of ambient Hg vapor concentration to exist in the vicinity of the pond. Thus, the location of monitoring sites, designed for the purpose of determining maximum ambient air concentrations, should be carefully selected.
At the former Chlor-alkali plant site the source of Hg emissions is quite different. On the plant site, the Com is presently processing material which has been dredged from the river to recover its content of elemental Hg. The processing requires the screening of the dredge material. This activity aerates the material and greatly increases the rate of volatilization of the Hg. This we believe to be the primary source at the plant site. It is important to note that this activity is expected to cease sometime in late summer or early fall of 1983.

Figure 2 shows the sites at which Hg vapor samples were taken during the June 1983 study. During all sampling periods for one, flow in the valley was from the W and SW. Thus sites #1 and #2 represent locations of expected high concentrations due to the plant site and muck pond combined. A sample at site #3 will provide area background. Site #4 was selected as the location of expected high concentration resulting from the emissions off the muck pond. And finally, site #5 was selected to establish local background for the plant site.
FIG2: MAP SHOWING MONITORING SITES
SECTION 4

Instrumentation

The following describes each of the instruments (including operating procedures) which were used during the course of this study.

1. Mercury Sniffer - the mercury "sniffer" was obtained from the Philadelphia area office of OSHA. Manufacturer: Bacharach Instrument Co. (Division of AMBAC Industries).

Other I.D.: U.S. Department of Labor/OSHA

66484 Item Code, Model BAC 02, 7F65A23
Serial #30506002-1 Phila. C-0021
OSHA: Calibration dates 5/17/83
Due Date 11/17/83 + 5% full scale

Associated Equipment:

b. MV2 charger (battery) - OSHA Inspected

Operation - Use of the instrument was rather straight-forward. The first step was to check the battery condition by turning the indicator switch to the V position. The scale needle in all cases swung sharply to the green area of the scale or above indicating adequate battery energy.

In Step 2, the indicator knob was switched to .2 ug/m^3 and the inlet knob was turned to the filtered position. The needle is then adjusted to the zero point with the zero adjust knob.

Sampling was begun by turning the sample inlet knob to the ambient position. After needle stabilization (about 15 sec.) the mercury level can be read directly from the meter.

Interferences that could be caused by other compounds in the air were most likely not a problem since the level of these compounds would have had to be very high. The high relative humidity during sampling probably caused a small negative interference.

2. Wind Measurements - This instrument is shown in Figure 3. The manufacturer and nomenclature are: "Wind Instrument" wind measuring set, cat #6052

Belfort Instrument Company
1600 S. Clinton Street
Baltimore, MD.

Operation: The set comprises a complete wind measuring system which gives a visual indication of wind direction through 360 degrees and of wind speed from 0-60 knots. The instrument is hand held during operation.
The on-site wind speed was measured using a wind speed indicator (voltmeter) which had a dual scale. The lower scale had a range of 0-15 knots and the upper scale had a range of 0-60 knots.

The instrument was held at arm's length with the sight at eye level. The instrument was aimed at a fixed north orientation point by aligning the hair of the front right sight with the center of the opening in the sight nearest the eye. By pressing the range selecting trigger, the wind speed was observed on the 0-15 knot scale. The reading taken is an instantaneous value at wind speed. The starting threshold for the instrument is 1.0 knot/sec.; therefore any wind speed below 1.0 knot/sec. was recorded as calm.

Wind Direction: To activate this system, the set was exposed to an air stream and the brake was released by depressing the vane locking trigger. The air stream caused the vane tail to rotate and align itself with the flow direction. The associated index pointer then indicates a degree marking on the direction dial scale. When the vane locking trigger is released, a brake is engaged which permits the degree direction to be recorded. The reading taken is an instantaneous value of wind direction.

3. **Mercury Detector** — Due to mechanical problems with our automatic sampler, a hand pump sampler was used on-site.

Samplair part 464080, pump kit, Model A, manufactured by MSA (Mine Safety Appliances) Pittsburgh, PA, U.S.A. 15208

Mercury detector, tubes, MSA part #83089

expiration date: September 1982, Lot #26.

Operation: The MSA mercury tube was inserted into the hole located in the pump body. Each tip was broken by quickly changing the insertion angle. The de-tipped tube was inserted into the rubber sample holder. In order to increase sensitivity, 35 pump strokes were made. Before each stroke the marks on the pump body and handle had to be aligned. A minimum of 40 seconds was allowed between each stroke. From a practical standpoint, the lowest obvious color change for this instrument is approximately 50 ug/m³; a reading between 20 - 50 ug/m³ is vague and less than 20 ug/m³ the color change cannot be detected. Since the only tubes were out of date, the ability to detect a color change would probably be diminished.

4. **Compass** — A lensatic compass was used to measure sample site selection locations by determining direction to a prominent reference point such as the Olin-Metheson smoke stack and distance with the aid of a range finder.
The black needle in the liquid filled compass was allowed to spin freely and the compass was positioned until the north point was obtained. Magnetic azimuth was then obtained by rotating the red arrow on a line with the sample site.

5. **Thermometer** - Temperature measurements were made with a mercury thermometer that had gradations to the nearest degree centigrade. All measurements were made in the shade.

6. **Range Finder** - The device used was called a "Ranging Rangematic", model MK2 - Distance finder (50 yards - 2 miles, eye piece 6 x 18). Manufactured by Ranging, Inc., 90 Lincoln Road, North, East Rochester, New York, 14445.

The distance was determined by viewing through the eyepiece the object of interest. The object initially appears as a double image. By rotating the distance dial (yards), a sharp focus could be obtained that corresponded to the object's distance.
1. WIND SPEED TRANSMITTER
2. WIND DIRECTION VANE
3. BODY ASSEMBLY
4. SPEED METER ASSEMBLY
5. RANGE; SWITCH
6. SIGHT
7. ZERO ADJUSTMENT SCREW

Figure 3 - WIND MEASURING SET
SECTION 5

Procedure

The general intent of the study was to measure the highest peak concentrations of gaseous Hg in the area and to determine the source of such concentrations. It is important to note that the concentrations measured may not represent the highest concentrations possible in the area because of the limited set of meteorological conditions under which the samples were taken.

Prior to each sampling period a determination of the transport wind direction was made and sampling sites were located.

In order to determine maximum peak concentrations from the major source (plant site), sampling sites were chosen directly downwind and at the fence line of the source. Two such locations were selected, sites #1 and #2 (see Figure 2). During the course of the study, four samples were taken at site #1 and one at site #2. Each of the measurement periods were between 5 and 10 min. in duration.

To determine maximum peak concentration due to the muck pond, site #4 was chosen. This site was located on the pond at its extreme northeastern edge. One sample was taken at this site.

In order to determine the contribution of each source to measured peak concentrations, two background sites were selected: sites #3 and #5. Site #3 was located at the extreme southwestern edge of muck pond #5. One sample was taken when the wind was out of the southwest. Site #5 was located on the southwest edge of the plant site. One sample was taken at this site. It was expected that during this sample the winds would be out of the southwest. However, during the course of the sample the winds shifted to the northeast causing a contribution to the measurement from the plant site. Unfortunately, we were unable to take both background and downwind measurements concurrently since we had only one instrument. However, based on the results obtained (see Section 6) it is our feeling that such concurrent sampling would have been unnecessary.

The actual sampling procedure was designed such that both Hg concentrations and meteorological data would be taken concurrently. The sampling periods varied from 5 to 10 mins. depending on the results obtained during a particular sample. This sampling period range allowed from 2 to 6 instantaneous Hg readings to be taken.

The Hg sniffer was operated by one person as described in Section 3 (Instrumentation). A second person operated the wind instrument. During the course of each sample, an instantaneous reading of wind speed and direction was taken every 30 seconds. This allowed for from 10 to 20 discrete measurements to be taken during a particular sampling period.
SECTION 6

Results

An overall summary of the results obtained are presented in Table 2. Figures 3 through 16 present specific information which relates to each sample individually. That is, graphs of wind speed, Hg concentration and wind direction vs. time are presented. Also an aerial photograph for each sample is given showing the source, the sampling site, and the mean wind direction which occurred during the sampling period.

As one can see from Table 2, the ambient air temperature for all samples ranged between 81° F and 86° F. These temperatures represent moderately good conditions for the volatilization of elemental Hg. However, such conditions may have been adversely effected by thunderstorm activity which occurred during the study. In the early afternoon of 6/28, prior to the collection of sample #1, the area experienced a thunderstorm which certainly caused a cooling off of the ground surface. Thus the high relative air temperatures may be misleading as an indicator of the Hg volatilization rate. On 6/29, a second thunderstorm occurred in the area. This storm began at the end of sample #6 (see Table 2 and Figure 11) and finished prior to the start of sample #7.

Samples #1, 2, 6 and 8 were taken for the purpose of monitoring maximum concentrations due to emissions emanating from both the plant site and the muck pond. As one can see from the figures, the wind direction during each of these samples placed the monitoring sites (#1, #2) directly downwind of the two sources. The highest concentration found occurred at site #1 during sample #6. That is, an average concentration of 26.0 ug/m³ and an instantaneous concentration of 40.0 ug/m³.

Sample #3, which is not mentioned in either the table or figures, was designed to mimic sample #1 but with the use of a different instrument (see Section 3, Hg Detector). Using this instrument we were unable to detect any Hg vapor. As discussed in Section 3, this instrument is comparatively insensitive, that is, a concentration of greater than 50 ug/m³ is needed to see an obvious color change.

Sample #4 (see Figures 7 and 8) was taken to determine the overall background of the area. Results from this sample gave concentrations below the detectable limits of the instrument.

Sample #5 (see Figures 9 and 10) was taken to determine the maximum concentration resulting from Hg emissions due to muck pond #5. Based on the results of sample #4, any detectable concentration would be due to muck pond #5 alone. Results from
this sample were again below the detectable limits of the instrument. This result was quite surprising since:

1. Previous borehole sample results have shown a substantial amount of elemental Hg in the soil.

2. Air temperature was quite high and it had not rained since the previous afternoon.

3. Wind direction during the sampling period was directly off of the pond.

4. Subsequent to the study, muck pond #5 was modeled in a relative sense to see where, based on the meteorology that existed during sample #5 and the distribution of Hg throughout the pond, one might expect a spatial maximum. Results indicated site #4 to be a good candidate.

The results of sample #5 would indicate that the high concentrations measured at sites #1 and #2 are a result of emissions from the plant site alone.

Sample #7 (see Figures 13 and 14) was taken for the purpose of defining a background for the plant site. Although the results of sample #5 clearly indicate that Hg concentrations upwind of muck pond #5 are less than 1 ug/m³, a ND reading from sample #7 would remove any suspicion of a Hg source between pond #5 and the plant site. However, as can be seen from Figure #13, during sample #7 the wind shifted and blew from the NE for most of the sampling period, thus causing emissions from the plant site to impact the monitor.

Sample #8 (see Figures 15 and 16) taken at site #1 is interesting in that the concentrations measured are on the order of 1/2 the concentrations measured at site #1, during samples #1 and #6. This large difference we believe is due, in part, to the fact that during the course of the sample it was noticed that the screening activity had ceased at the plant site.
### TABLE 2: SUMMARY OF SAMPLING RESULTS FROM JUNE 1983 STUDY

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>SAMPLE #</th>
<th>SITE #</th>
<th>AVERAGING TIME (mins)</th>
<th>AVERAGE Hg CONCENTRATION (ug/m³)</th>
<th>PEAK Hg CONCENTRATION (ug/m³)</th>
<th>MEAN WIND SPEED (Knots)</th>
<th>MEAN WIND DIRECTION</th>
<th>TEMP (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/28/83</td>
<td>5:00 p.m.</td>
<td>1</td>
<td>1</td>
<td>10.0</td>
<td>21.0</td>
<td>30.0</td>
<td>5.0</td>
<td>234°</td>
<td>84</td>
</tr>
<tr>
<td>6/28/83</td>
<td>5:15 p.m.</td>
<td>2</td>
<td>2</td>
<td>12.0</td>
<td>26.0</td>
<td>30.0</td>
<td>5.0</td>
<td>260°</td>
<td>84</td>
</tr>
<tr>
<td>6/29/83</td>
<td>12:30 p.m.</td>
<td>4</td>
<td>3</td>
<td>5.0</td>
<td>ND*</td>
<td>ND</td>
<td>6.4</td>
<td>268°</td>
<td>82</td>
</tr>
<tr>
<td>6/29/83</td>
<td>12:50 p.m.</td>
<td>5</td>
<td>4</td>
<td>7.0</td>
<td>ND</td>
<td>ND</td>
<td>7.5</td>
<td>243°</td>
<td>86</td>
</tr>
<tr>
<td>6/29/83</td>
<td>1:15 p.m.</td>
<td>6</td>
<td>1</td>
<td>8.0</td>
<td>26.0</td>
<td>40.0</td>
<td>5.5</td>
<td>254°</td>
<td>86</td>
</tr>
<tr>
<td>6/29/83</td>
<td>2:30 p.m.</td>
<td>7</td>
<td>5</td>
<td>10.0</td>
<td>7.0</td>
<td>19.0</td>
<td>1.7</td>
<td>32°**</td>
<td>81</td>
</tr>
<tr>
<td>6/29/83</td>
<td>2:55 p.m.</td>
<td>8</td>
<td>1</td>
<td>8.0</td>
<td>10,0***</td>
<td>20.0</td>
<td>3.0</td>
<td>262°</td>
<td>81</td>
</tr>
</tbody>
</table>

*ND: Non-Detectable

**: This represents a 5 min. average in the middle of the period. Calm winds existed at the beginning and end of the period.

**: For most of the sampling period the screening activity had ceased.
FIG3: WIND SPEED WIND DIRECTION AND HG CONCENTRATION GRAPHS FOR SAMPLE #1
FIG4: AERIAL PHOTO SHOWING SPECIFICS OF SAMPLE #1
FIG5: WIND SPEED, WIND DIRECTION, AND Hg CONCENTRATION GRAPHS FOR SAMPLE #2
FIG6: AERIAL PHOTO SHOWING SPECIFICS OF SAMPLE #2
FIG 7: WIND SPEED, WIND DIRECTION AND HG CONCENTRATION GRAPHS FOR SAMPLE #4
SAMPLE #5
LOCATION: SITE #4
DATE: 6/29/73
START TIME: 12:48 AM
END TIME: 12:50 AM

FIG9: WIND SPEED, DIRECTION AND HM CONCENTRATION GRAPHS FOR SAMPLE #5
FIG10: AERIAL PHOTO SHOWING SPECIFICS OF SAMPLE #3U134
FIG 11: WIND SPEED, WIND DIRECTION AND Hg CONCENTRATION GRAPHS FOR SAMPLE #6
FIG 15: WIND SPEED WIND DIRECTION AND HG CONCENTRATION GRAPHS FOR SAMPLE #8
SECTION 7

Conclusions

Based on the results presented in Section 6, the following conclusions can be made:

1. All Hg vapor concentrations measured appear to be due exclusively to emissions from the former site of the Chlor-alkali plant.

2. The residences in the area are being exposed to the highest concentrations measured. At study site #1, a number of trash dumpsters are located. These dumpsters are heavily used by the residences in the area.

3. There does not appear to be enough evidence to support a conclusion that the screening activity is the sole source of the high concentrations measured downwind of the plant site. Sample #8 was the only sample taken downwind of the plant site when there was no screening activity. Although sample #8 did show significantly lower concentrations, such concentrations were significantly above the detectable limit of the instrument. Also, lower air temperature, recent thunderstorm activity and variable winds may have been important contributors to the lower measured concentrations.

4. It would appear that muck pond #5 does not cause high short term Hg concentrations. However, this does not preclude the possibility of significant long term concentrations being caused by the pond considering the proposed Hg NESHAP standard of 1.0 ug/m³ (30 day average).

5. It cannot be concluded that the highest concentrations measured during this study are the highest that can occur. This study represents a very limited sampling of the existing spacial and temporal distribution of Hg concentrations that is present in the area. Although it is true that the air temperatures and wind directions were conducive to high Hg concentrations, it is also true that during each measurement period the atmosphere was in a state of high instability. Such instability causes a high degree of pollutant dispersal. Assuming constant emissions from the sources, one would expect the highest concentrations to occur during stable atmospheric conditions.
6. Based on the high instability of the atmosphere during the measurement periods, one can expect concentrations within the fence line of the former plant site to be significantly higher than concentrations measured at sampling sites #1 and #2.
SECTION 8

Recommendations

If it is decided to perform a comprehensive air quality study in the area, which would examine both long and short-term Hg concentrations, we would recommend the following:

1. A comprehensive meteorological data collection program should be conducted at locations within the valley. This program should begin a number of months prior to the beginning of the Hg vapor monitoring program and should continue until the end of the monitoring program. Data collected during the pre-monitoring phase of the meteorological program would be used to help characterize the wind field for the purpose of selecting the long-term monitoring sites.

We recommend that two meteorological towers be located since there exists a feeder valley which runs perpendicular to the main valley and is located directly across from the plant site. This topographic situation will cause a non-uniform wind field and therefore winds at one point may be quite different from winds at another. Since there exists two sources of concern, we recommend that a tower be placed in the vicinity of each.

2. We would suggest that the monitoring to be done in the vicinity of muck pond #5 should concentrate on long-term rather than short-term averages.

3. In order to determine the highest short-term concentrations, monitoring should be performed under a variety of meteorological conditions. In addition to the conditions which existed during this study, two other important conditions would be:
   - warm stable atmosphere (clear summer night)
   - warm neutral atmosphere with persistent W or SW winds (windy, cloudy summer day).

4. In order to determine the magnitude of the effect of the screening activity, samples should be taken during similar meteorological conditions but with and without the presence of the screening activity.

5. Due to the strong relationship between the volatilization rate of Hg and temperature, we suggest that soil temperature and soil moisture content be measured concurrently with the Hg vapor sampling.