INTEROFFICE MEMORANDUM

TO: COMMISSIONER CAMPBELL

FROM: ZOE KELMAN, SITE REMEDIATION AND WASTE MANAGEMENT PROGRAM

SUBJECT: NEW JERSEY CHROMIUM WORKGROUP REPORT

DATE: 11/11/2005

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I have authored the attached report to inform you in detail of the serious problems related to the recommendations contained in the New Jersey Chromium Workgroup Report. In your March 23, 2004 memorandum, you empanelled this workgroup to *review* the Department's current clean-up criteria for chromium and their application.[1]
Although many members of the workgroup sought diligently to respond to your charge they were frustrated in their efforts. In fact, as I document in the attached report, the workgroup members were specifically forbidden reviewing the current chromium standards or past remedial decisions. While much of the discussion in my report is technical and finds fault with the workgroup report's reasoning and conclusions, my motivation is simply to protect public health. As we discussed in our previous e-mail correspondence, the New Jersey Chromium Workgroup Report does not reflect the consensus of the Workgroup members and was written largely by NJDEP management with a clear bias for preserving the status quo and leaving the chromium cleanup criteria and remediation program unchanged.

REPORT TO THE COMMISSIONER

New Jersey Department of Environmental Protection

RECOMMENDATIONS ON CHROMIUM

A Counter – Argument to the New Jersey Chromium Workgroup's Recommendations

By
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October 2005

Acknowledgement: Special thanks to: Robert Hazen, Ph.D., John Froines, Ph.D., Roger Page, Ph.D., Julia Barringer, Ph.D., Thomas McKee, and Robert Posey

REPORT TO THE NJDEP COMMISIONER ON NJDEP's CHROMIUM CLEANUP CRITERIA

Purpose of this Report

As a participant in the New Jersey Department of Environmental Protection (NJDEP) Chromium Workgroup, I file this report to alert the Commissioner to serious errors and omissions in the workgroups report and the harmful effects that adoption of the recommendations would have on the health of New Jersey residents in areas of the state with chromium contamination. This report is a follow-up to the public comments I submitted on June 3, 2005. It is intended to technically validate my original comments and offer recommendations on how the Department should proceed.

While much of the discussion is technical, the motivation behind this report -- and the standard to which I believe we in NJDEP should hold ourselves – is simple. In one of the many workgroup meetings in which I participated, a question was asked of one of the Site Remediation and Waste Management Program (SRWMP) staff members that unexpectedly touched a nerve: "Would you live beside one of the chromium sites that's been cleaned up using NJDEP's current standards?" This co-worker – who had approved many of the cleanups using these criteria – gave what seemed to be a reluctant but honest answer: "Probably not."

Based on the extensive studies and data that I reviewed as part of this workgroup and afterwards, I would have emphatically answered "NO" to that question. I would not expose my family to avoidable and serious health risks by living or working on or near a chromium waste site that was remediated under NJDEP's current criteria.

And yet NJDEP's workgroup report has concluded that the Department's overall approach to chromium waste sites is sound. It has concluded that the chromium cleanup standards in use since 1998 (the "1998 criteria") are "based on the science currently available," and has recommended their continued use. It has recommended no substantive changes to the Department's practice of allowing "capping" remedies for chromium sites, even in residential and recreational areas.

By adopting the workgroup's recommendations, NJDEP would continue to expose families in New Jersey to unnecessary health risks for generations to come – risks that many of us in the Department would never subject our own families to.

This paper argues for a more precautionary approach and, I believe, a more responsible and decent approach.

RECOMMENDATIONS TO THE NJDEP COMMISIONER ON CHROMIUM CLEANUP CRITERIA

A Counter – Argument to the NJDEP "Chromium Workgroup's" Recommendations to Defend the Status Quo

Executive Summary

Despite two federal court decisions, a series of in-depth newspaper articles, and an internal review by New Jersey Department of Environmental Protection ("NJDEP") scientists all of which highlighted serious flaws in NJDEP's efforts on chromium remediation, the NJ Chromium Workgroup report maintains that the current chromium cleanup criteria and their application are protective without change. This conclusion can only be supported by ignoring the growing body of evidence showing that chromium is more toxic than assumed in the 1998 criteria. Most importantly, this position does not represent the consensus of the Workgroup but only the opinions of those members with the greatest interest in defending the *status quo*.

The Chromium Workgroup was charged "with reviewing the Department's current clean-up criteria for chromium" and their application.[2] This charge represented a vitally important opportunity for NJDEP because the current cleanup criteria (proposed in 1998) and the written rationale for them, had never been subjected to peer review. (In contrast, the more protective chromium cleanup criteria they replaced had been independently peer reviewed). Much of the scientific evidence on which the 1998 criteria are based had been generated through studies funded by the companies responsible for chromium waste sites in New Jersey. Legitimate questions had been raised about both the process through which these criteria were developed as well as the science on which they were based. It made sense to conduct a thorough, objective review to address these questions. This was especially urgent given the accelerating pace of development and the resulting changes in land use in Hudson County – the densely populated urban area where the state's chromium waste sites are concentrated.

However midway through the process, the workgroup was directed NOT to review the 1998 criteria after all, but rather to presume their validity. Members of the Workgroup objected to this decision. Eileen Murphy, Chair of the Workgroup, sought and obtained concurrence for this decision from Dr. Robson, Supervising Chair of the Workgroup and from Assistant Commissioner Jeanne Herb.[3] Despite this shift, the "final workgroup report" took the extraordinary liberty of declaring:

> *"After six months of meetings and review, the NJDEP Chromium Workgroup has determined that the cleanup criteria for Cr(III) and Cr(VI), initially proposed in 1998 (Table 1.1),* ***are based on the science currently available."*** *(Page 6 chapter 1, Executive Summary : New Jersey Chromium Workgroup Report)*

This statement is very problematic because the workgroup not only did not conclude that the current 1998 chromium criteria are scientifically supportable, we did not even examine that question. It is difficult to understand how after directing the Chromium Workgroup to not review the 1998 chromium criteria, that the main conclusion of the Workgroup's report is that the 1998 chromium criteria are based on the science currently available.

The management directive proved to be a crucial shift. By giving the presumption of validity to the current cleanup criteria and practices, the "burden of proof" was placed on any proposals for change.

The effect was to turn upside down the workgroup's professional and legal obligation to err on the side of precaution and public health. Ordinarily, a public agency in the field of environmental protection or public health is required, when confronted with scientific uncertainty about risks, to take precautions to protect the public. Instead the workgroup responded to uncertainty by erring – systematically – on the side of the Department's status quo.

On several vital issues –the report acknowledged uncertainty based on the scientific literature. But in response to this uncertainty, the report only recommended more research. The final workgroup report took what was a rare opportunity to contribute to the scientific understanding of one of the worst demonstrated human carcinogens, and instead distorts that understanding following in the tradition of corporate science on issues such as lead, asbestos and tobacco.

The workgroup report recommended no substantive changes, either in the cleanup criteria or in the way they are applied. The recommendations greatly understate the public's exposure by neglecting to account for the factors specific to urban environments. It is important to note given that most chromate sites are located in Hudson County, which is under tremendous pressure to redevelop, these sites are being targeted for residential development, golf courses and playgrounds

The flaws were built into the NJDEP Workgroup from the outset, and permeated the workgroup's deliberations:

- A presumption that the current criteria and their application are protective, prohibited reviewing past decisions. In fact, this presumption inhibited the entire review process. The report fails to disclose the level of uncertainty, assumptions, and limitations inherent in these criteria.

- The body of data and sources that the Workgroup reviewed was incomplete and skewed. It included studies funded by the chromium polluters, and in fact the Workgroup report relies heavily on these to support its conclusions. It excluded many other more reliable sources that support more precautionary conclusions.

Had we fully and fairly examined the criteria in the proper context (urban redevelopment), I believe that most of the scientists on the Workgroup would have determined that the weight of scientific evidence supports the following conclusions:

- The 1998 criteria fail to account for a number of well-documented physical processes and soil characteristics that tend to concentrate hexavalent chromium ("Cr(VI)")by hundreds of times over average soil concentrations. Thus, the concentrations of Cr(VI) available for human exposure on surfaces may frequently be far higher than a given measurement of chromium in soil. This was the conclusion of the one group that did conduct a review of the 1998 criteria (Hazen et al).

- The 1998 criteria fail to account for compelling evidence showing that Cr(VI) – long known as a carcinogen via inhalation – may also cause cancer and other non-carcinogenic effects via ingestion.

- The allergic contact dermatitis (ACD) standard recommended by the workgroup report fails to protect children. NJDEP's previous cleanup criteria were based on its own research on contact dermatitis, which was peer-reviewed and widely adopted by other agencies. The much weaker ACD criteria recommended in the workgroup report is based on the selection of the wrong studies (by Finley and Horowitz, chromium polluter funded researchers) which uses a soil loading factor of 0.2 mg/cm^2 . This value is too low to protect children. Using a more appropriate soil-loading factor of 2 would have the effect of lowering the NJDEP upper range for contact dermatitis from 400 to 40. For contact dermatitis it is not appropriate to use the overall average because the site of action is the skin where the highest reasonable loading anywhere on the body is the correct value to use. From other current EPA references (RAGS Part E, Exhibit C-2, pg C6) children's exposure could be up to one thousand times greater than the workgroup's estimate resulting in a target soil concentration of 0.4 ppm for dermatitis.

- The 1998 criteria do not protect groundwater and surface water from chromium contamination. The leaching of chromium from soils into groundwater is a natural resource injury in and of itself. But it can also create a public health hazard; groundwater is a vector for the transport of hexavalent chromium and the contamination of additional soils and structures. Leachate evaporation at interfaces results in localized accumulations of highly enriched solid-phase hexavalent chromium on soil, building or other surfaces. The final report of the workgroup ignores the issue altogether; it proposes no soil standard to protect against leaching to groundwater.

* The 1998 criteria do not account for the oxidation of trivalent chromium to the much more toxic hexavalent chromium – Cr(III) to Cr(VI). The current criteria allow for extremely high levels of trivalent chromium to remain in soil (120,000 ppm). If the majority of studies on this subject are correct, at least some of this Cr(III) will convert to Cr(VI) through oxidation. Oxidation of only a small fraction of this concentration of Cr(III) would cause levels of Cr(VI) to spike far higher than measured concentrations, endangering public health.

* Perhaps most importantly, DEP's practice of approving non-permanent remedies for chromium waste sites fails to protect public health. Capping is an appropriate remedy for some hazardous wastes, under some conditions. With the type of chromium waste found in Hudson County – chromite ore processing residue (COPR) – capping at best provides short-term containment by temporarily preventing moisture from entering the waste area. Liners, soil caps, asphalt and other components of approved caps will fail over time at any site; at COPR sites, this process is accelerated.

* DEP's practice of approving remedies that leave high concentrations and large volumes of hexavelent and trivalent chromium in the soil is especially irresponsible in crowded urban areas. Hudson County is the most densely populated county of the most densely populated state in the nation. There is human use almost everywhere; and winds and waters can easily transport chromium from an abandoned industrial site to nearby residential or public areas. The assumptions about land usage that are factored into the 1998 criteria fail to account for the actual conditions in a rapidly redeveloping and crowded urban area.

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- ♦ Sampling methods underestimate exposure to Cr(VI) concentration in soils. *NJDEP average bulk soil sampling technique "fails recognize the importance of measuring* *chromium in those particles most likely to be respired, that is, the clay and silt fraction*." McBride, Cornell University, submitted public comments on behalf on the Sierra Club. McBride emphasized in his comments that *"the important concentration for human exposure is not the average in the bulk soil, but the concentration that can accumulate at surfaces accessible to humans, particularly in the fine respirable particles likely to be found in air-borne dust."*[4]

These factors, taken together, invalidate the 1998 criteria and the Department's overall approach to chromium. The final workgroup report fails to adequately address any of these issues.

Thus, I am convinced that based on the evidence presented in my report, New Jersey's current soil criteria and its remedial approach for chromium are not protective of human health. I file this report to document my objections because I feel strongly that the "errors and omissions" in the Chromium Workgroup Report expose the public to unnecessary health risks. I urge Commissioner Campbell to reject the recommendations of the NJ Chromium Workgroup and to either continue the moratorium on the issuance of No Further Action letters until protective criteria are developed or go back to the peer-reviewed soil standard of 75 ppm total chromium as an interim chromium cleanup criteria. The weight of scientific evidence supports the protective cleanup criteria of 75 ppm total chromium[5] as clearly in 2005 as it did in 1991, when it was adopted.

Regarding application of the soil criteria, the weight of evidence very strongly supports a moratorium on the capping and use of deed restrictions at COPR sites. Thus, NJDEP should adopt a groundwater impact standard for chromium. I recommend adopting EPA Region VI criteria of 2.1 ppm.

Background and Context of Chromium Review

In the 1990s, New Jersey's chromium soil cleanup criteria for Cr(VI) increased from 10 ppm to levels that range as high as 6100 ppm and Cr(III) increased from 500 ppm to 120,000 ppm (see Table 1).

These increases can be attributed in part to the studies funded primarily by one of the parties legally responsible for chromium waste in New Jersey (Maxus Energy). One of the scientists who conducted these studies, Dr. Dennis Paustenbach (formerly of ChemRisk now with Exponent Inc.), testified in a California lawsuit that his firm had received approximately $7.1 million from Maxus Energy for its work on New Jersey's chromium criteria. (The NJDEP Workgroup relied on some of these same studies to reach its conclusions on chromium risk via inhalation, ingestion and dermal contact).

Table 1
History of Chromium Soil Clean-up Levels in New Jersey

Year	Chromium Clean-up Level, mg/kg dry weight (ppm)
1989	75 ppm total Cr; based on 10 ppm Cr(VI)
1993	10 ppm soil Cr(VI) 500 ppm soil Cr(III)
Sept. 18, 1998	Multiple exposure pathways for Cr (VI) and Cr (III) Soil Ingestion 240 ppm Cr (VI) Inhalation of soil particles 270ppm Cr(VI) Industrial – 6100 ppm Cr(VI) Impact to Groundwater None Cr(III) 120,000 ppm
December 2004	Proposed Allergic Contact Dermatitis of 400 ppm

During the past two years, New Jersey's cleanup criteria and its overall remedial approach have come under scrutiny. In 2003 and 2004, two federal court decisions, a series of in-depth newspaper articles, and an internal review NJDEP scientists all highlighted serious flaws in the Department's efforts on chromium. In response, NJDEP convened a "Chromium Workgroup" to review the criteria and their application and make recommendations to the NJDEP Commissioner.

The Workgroup report, after approximately 6 months of contentious deliberation, reached conclusions that were sharply at odds with many members of the workgroup who had examined these efforts. The workgroup found that the 1998 proposed cleanup criteria and overall remedial approach were "based on the science currently available"[6] and should be maintained with no significant changes.

Initially, the workgroup was charged with "reviewing the Department's current cleanup criteria for chromium" and their application. This charge was explained both to workgroup members and the public, amid growing concerns inside as well as outside the Department about DEP's performance on chromium cleanups.

This charge represented an important opportunity for NJDEP. The 1998 criteria, and NJDEP's written rationale for them, had never been subjected to peer review. (In contrast, the more protective chromium cleanup criteria they replaced had been approved through extensive independent review.) Much of the scientific evidence on which the 1998 criteria are based had been generated through studies funded by the companies responsible for chromium waste sites in

New Jersey. Legitimate questions had been raised about both the process through which these criteria were developed as well as the science on which they were based. It made sense to conduct a thorough, objective review to address these questions.

This report attempts to outline, in detail, why the workgroup report's conclusions and recommendations are flawed and why they will, if adopted, result in avoidable and unacceptable health problems (including an increased incidence of cancer, perforations and ulcerations of the septum, decreased pulmonary function, asthma, kidney and liver problems, gastrointestinal and immune systems effects, contact dermatitis and ulceration of the skin) to people who live and work near chromium sites.

Findings of the Federal Courts

In May 2003, in the case of ICO v. Honeywell International, Inc., the federal District Court in New Jersey ruled that the presence of over 1 million tons of chromate chemical production waste at one site in Jersey City constituted an "imminent and substantial threat to human health or the environment," and ordered Honeywell, the responsible party in the case, to excavate and remove all of the chromium waste from the property. The judge also ordered the remediation and cleanup of the groundwater at the site, as well as the sediments in the Hackensack River that had been contaminated with chromium from the site. The court's decision was based on extensive testimony of ten "exceptionally qualified" experts in the fields of health and environmental risk, ecological and aquatic toxicology, hydrogeology, environmental engineering and geochemistry, environmental remediation, and dermatology.

The site in question was one of some 200 chromium sites in Hudson County, and had been under NJDEP oversight since 1983. A temporary asphalt cap had been placed over the site, but had cracked badly, and extremely hazardous levels of hexavalent chromium were found on the surface of the site. The supermarket that had been built on the site had been shut down, destroyed by the "heaving"[7] of the chromium waste. Although a cleanup agreement for the site has existed between NJDEP and Honeywell since the early 1990s, the extent of chromium contamination has yet to be delineated.

At the case trial, Honeywell argued for "the right to continue to work with the DEP," and reminded the judge that "we have an agreement with the DEP." The court rejected this "right," finding that NJDEP had permitted 20 years of "dilatory tactics" by the company. The court ruled that the capping remedy proposed by Honeywell would not protect public health and the environment, and that a complete excavation was the only adequate remedy.

Honeywell appealed this ruling to the Third Circuit U.S. Court of Appeals, arguing that the District Court erred in ordering the excavation remedy, that capping was an adequate remedy, and that the court overstepped its authority in removing the case from NJDEP's jurisdiction. The Appeals Court strongly and unanimously upheld the District Court ruling, and again found that NJDEP had failed to protect public health and the environment:

> "Honeywell's final argument is that the District Court improperly overrode an ongoing administrative process. ...[A] fair reading of the record casts strong doubt as to whether there is a process to override in this case."
>
> ...[T]he court finds that the evidence demonstrates a substantial breakdown in the agency process that has resulted in twenty years of permanent clean-up inaction.

The Supreme Court refused to hear Honeywell's appeal this summer, so the District Court ruling stands, under the supervision of a special master appointed by the court.

Newspaper Reports

In the spring of 2004, a large state newspaper, the Star Ledger, began a series of front-page investigative articles on NJDEP's performance in cleaning up chromium waste sites in Hudson County. The articles detailed the success of lobbyists and science consultants working for the responsible parties in weakening the state's cleanup efforts.

Internal NJDEP Review

At the request of Commissioner Campbell, a team of NJDEP scientists headed by Robert Hazen, Ph.D.,[8] conducted a review of NJDEP's chromium cleanup criteria. This review team (Hazen et al. 2004) wrote a memorandum to the Commissioner in March 2004 summarizing its findings and making recommendations. Specifically, the Hazen report identified that the actual risk at a site (based on monitoring results) far exceeded the predicted risk of the model. The soil standard (or ARS) is based on this predicted risk. The excess cancer risk based on monitoring data was calculated to be 1 out of 10. The predicted risk base on the model is 1 out of a million. The recommendations in the air transport section (better documentation) will not correct this problem.

The review team found that NJDEP's chromium cleanup criteria failed to take into account a number of properties and characteristics specific to the chromium waste found throughout Hudson County – chromite ore processing residue (COPR) – and therefore jeopardized the health of Hudson County residents. For example, the review team found that the analytical methods used by the Department underestimated the actual levels of hexavalent chromium in soils, leading to further risk to the public (as NJDEP scientists had warned about a decade earlier, when NJDEP management adopted this analytical method at the request of the responsible parties). They found that Site Remediation staff had not reviewed the Quality Assurance/Quality Control (QA/QC) data for chromium cleanups, and that chromium case files had been closed without evaluation of this data. A brief analysis (Hazen et al. 2004, Appendix E) shows examples of ways that the Alternative Remedial Standards (ARS) process dramatically failed to protect human health by ignoring some inhalation exposure risks. Indoor air risks from evaporite crystals and outdoor air risks from particles entrained by wind in the absence of vehicular traffic. When the review team examined the air monitoring data for one "remediated" site (Site 49, Arden Chemical), they found measured chromium levels thousands of times higher than the 1996 ARS justification anticipated. This was, perhaps, the clearest warning sign that the Department's approach was, on the whole, failing to protect the public from a carcinogen.

One of the recommendations this review team submitted to the Commissioner was to change the Department's chromium soil cleanup criteria back to 100 ppm total chromium (based on 10 ppm Cr(VI))[9].

The Commissioner did not adopt the recommended cleanup criterion. Instead NJDEP assembled the "chromium workgroup" to review, again, the Department's cleanup criteria and their application.

The Workgroup never examined the specific issues and phenomena discussed by Hazen et al., never reviewed the expert testimony and reports of the “exceptionally qualified” expert witnesses in ICO v. Honeywell, and never examined the extent to which science consultants working for the responsible parties might have unduly influenced the Department’s cleanup criteria and overall approach to remediation of chromium sites. In short, the Workgroup failed to examine the central questions, failed to evaluate the most useful data, and failed to draw upon the most qualified experts.

FINDINGS

The most significant overall finding is that in spite of compelling evidence of potential harm from the unusual human exposure routes presented by COPR, at every turn the workgroup report abandons precaution as a guiding principle for dealing with scientific uncertainty. This becomes evident in a review of the following elements of decision making where artificial and inappropriate barriers interfered with a commonsense understanding of the potential of chromium contamination to affect human health and the environment.

The current criteria for chromium:

A) Ignore the precautionary principle and are counter to the Federal Court Decision.

B) Ignore the compelling evidence that Cr(VI) is a carcinogen by ingestion

C) Fail to protect against non carcinogenic health effects

Application of the current criteria:

D) Neglect to account for accumulation of Cr(VI) on soil surfaces and structures.

E) Neglect to account for Cr(VI) enrichment on finer particles which is an important mechanism for Cr(VI) to become airborne and enter the lung

F) Neglect to provide protection of groundwater and surface water.

G) Neglect to account for the oxidation of Cr (III) to the much more toxic Cr(VI).

H) Neglect to protect against long term release of chromium from COPR.

The Chromium Workgroup Report fails to point out that many of these issues polarized the Workgroup. The Workgroup should have resolved these controversial issues by either contacting experts in soil chemistry and engineering or chosen to adopt a precautionary position. The Chromium Workgroup did neither. The Chromium Report was finalized with no adjustment recommended to the chromium criteria but with no consensus about the protectiveness of those criteria.

A. Current Criteria Ignore Precaution and are Counter to Federal Court Opinion

The Federal Courts have weighed in on NJDEP's chromium cleanup program all the way to the United States Supreme Court in ICO et al. v. Honeywell, et al. In this decision, the Federal District Court clarified its position on uncertainty:

> "If an error is to be made…, the error must be made in favor of protecting public health, welfare and the environment.[10]"

This precautionary approach is contrary to the reactive approach chosen by the Chromium Workgroup Report. The report states that recommendations have been made "*only where* definitive scientific evidence *was presented*." [11] This statement reveals a fundamental flaw in the Workgroup Report 's reasoning. It assumes absence of evidence means evidence of absence of risk and exposure. Many studies were interpreted as theoretical possibilities rather than in terms of potential risk.

USGS Workgroup member, Julia Barringer, Ph.D.,[12] argued in a memo:

> *"There are lots of important scientific questions that currently are being investigated for which there is as yet little if any published material, and there are other important questions that have yet to be studied. Whether something is studied or not (and therefore published or not) depends largely on whether funding is available to study."*[13]

In addition, the report states recommendations are *"not intended to result in retroactive application"* of any new criteria/standards. This statement is of particular concern because we are knowingly condoning past mistakes.

The Federal District Court found that chromium ore process residue (COPR) to be an "imminent and substantial endangerment to health or the environment" under the Resource Conservation and Recovery Act ("RCRA"). Testimony from "exceptionally qualified" professionals in the fields of health and ecological risk, and environmental engineering provided the Court with the technical justification to order complete excavation and removal of COPR from the site. Theses technical issues are listed below and compared to how the Workgroup Report responded:

1. ***Federal Court***: The Court found Cr(VI) to be highly toxic and highly soluble and leaching to surface and groundwater. The Court further determined that the chromium posed a risk *"to trespassers, utility and construction workers, future commercial workers, future residents, and others"* who come into contact with the site.

   Workgroup Report: The Report avoids directly addressing protection of groundwater and surface water by defining COPR as a *"continuous source."* The Workgroup Report claims this designation does not require a groundwater cleanup standard.[14] The term *"continuous source"* has no regulatory meaning and thus does not address future risks this waste would pose.

2. ***Federal Court***: Based on expert testimony, the Federal District Court concluded that the geotechnical conditions at the site promoted capillary transport of chromate to surface soils and buildings. The Court concluded that capillary transport would most likely increase the public's risk of exposure to the chromium.[15]

   Workgroup Report**:** Despite the weight of evidence, the Workgroup addressed capillary transport of Cr(VI) as a theoretical possibility rather than acknowledging that it has already been found to occur at many COPR sites.

   "While it is theoretically possible that Cr(VI) can migrate upward via evaporation, the net downward flow dominant in NEW JERSEY soil systems ***seems*** *to prevent the Cr(VI) from accumulating to any significant extent."*

   Seems is not supported by any data.

3. ***Federal Court***: The Court found remediation involving engineering and institutional controls not protective for COPR sites. The Court Decision recognizes that "*future generations would be required to abide by whatever restrictions were placed on the property. The court realizes that to cap or otherwise wall off and treat this property would create maintenance problems for decades into the future. Human nature being what it is, I am not satisfied that future generations will necessarily abide by today's restrictions. Accordingly, the only viable remedy is excavation, removal and treatment and refilling with clean fill.*"

   ***Workgroup Report*:** Throughout the report a presumption exists that the Department's application of these criteria, principally by capping and deed restrictions, is effective. This advocacy tone persists in the report despite a 2003 National Academy of Science (NAS) report that found that there was no evidence that institutional controls are effective long term.[16]

Given that most COPR sites are located in Hudson County, which is under tremendous pressure to attract redevelopment, remedial decisions should be based on the most stringent standards.

B) Current Criteria Ignore Compelling Evidence that Cr(VI) is a Carcinogen by Ingestion

Establishing a causal relationship for environmental cancer has proven to be very complex. Cancer, one result of chromium exposure, can take decades to develop, making the assessment of a link between exposure and disease difficult. Epidemiological studies provide the most direct evidence of adverse health effects yet to determine cancer causation can take years to record a statistically significant number of cancer incidences. In the case of Cr(VI), there are numerous epidemiological studies in the literature. These studies, however, tend to focus primarily on lung cancer because the fatality rate of lung cancers is much higher than other cancers. Consequently, Chromium VI (Cr(VI)) is regulated as a known human carcinogen by the inhalation route (IARC, 1990; ATSDR, 1998; U.S. EPA, 1998; NTP, 1998). It is because these studies did not focus on GI tract cancer, that regulation of Cr(VI) as carcinogen by ingestion is very controversial.

The workgroup report excluded some significant sources of data, interpreted others in a contradictory fashion, and gave excessive weight to some biased sources that should have been excluded. Its analysis of these sources is permeated with the workgroup's presumption in favor of the status quo and its abandonment of precaution.

The Chromium Workgroup Report asserts that the epidemiological evidence is <u>*insufficient*</u> to conclude that Cr(VI) is a carcinogen by ingestion. Although the report concedes that its conclusion is *speculative*, it declines to recommend a thorough meta-analysis of the studies, claiming that it is unlikely to provide enough qualitative information to estimate a cancer potency factor. The report also "*recognizes that such an examination and analysis could not be completed within the allotted time frame.*"[17]

Epidemiological Meta-Analysis of Gastrointestinal Cancer associated with Chromium

The purpose of meta-analysis study is to examine the literature and published results in order to clarify the association between chromium exposure and gastric cancer. The intention is not to develop a cancer potency factor as the workgroup report suggests.

Dr. John Froines, Professor of Toxicology at the UCLA School of Public Health, UCLA and his colleagues conducted a meta-analysis across these studies (Froines et al. 1999). Dr. Froines, chair of California Scientific Review Panel under the Air Resources Board, presented the results of his analysis as part of his testimony to the to the California Senate Committee on Health & Human Services on "Health Effects of Chromium VI Contamination of Drinking Water" on October 24, 2000. [18] Overall, he concluded there was "clear evidence" exposure to chromium may lead to an "increase in the risk of gastric cancer."[19]

Dr. John Froines, Professor of Toxicology at the UCLA School of Public Health, made some very important observations in his testimony. He compared his findings to the work conducted in developing California's diesel exhaust standards.[20] The scientific review panel approved a noncancer health value for diesel exhaust of 5 g/m to protect against respiratory problems.

Summary of Froines Testimony

"A meta-analysis is simply a way of combining studies to see what the ultimate overall impact is of those studies and to determine whether or not we have a better sense, in this case, of the risk of chromium from all those studies. A meta-analysis allows us to hopefully get closer to the truth of an issue by combining all the studies in the literature. A meta-analysis can explore the basis for differences among studies and in doing so provide evidence bearing on causal inference.

The review identified about 59 papers. The nature of these studies all focused on lung cancer. The studies that we're looking at, then, have a certain lack of bias associated with them precisely because of that. In the end, 22 human studies, fulfilled all the pre-established requirements by the experts panel evaluation. This is considered an enormous amount of literature (for diesel, 30 studies were used).

Of the 22 studies, 15 revealed an increased risk of GI tract cancer. Of the 15 studies, 7 were statistically significant. When we take Type A studies, which are the ones we consider to be the best studies, then, in fact, you find that there are 11 of the highest quality studies and 8 with increased risk of cancer, and 5 of those are significant.

The random effect estimation of the 22 studies finally selected gave a "Pooled Relative Risk" of 1.45. What that means is that there's a 45 percent increase in gastrointestinal cancer over a person in the average population. This is the same kind of data you see with diesel.

The best quality studies produced relative risk actually goes up to 1.9.

Dr. Froines concluded in his testimony by stating:

"This data is the best we have. It's the best we're going to get for a long period of time. It demonstrates to me, that there is an increased risk of gastrointestinal cancer associated with at least occupational exposure to chromium….All I can tell you is that in the studies that exist in the literature, there is obviously an increased risk of gastrointestinal cancer associated with chromium."

California Decision

In 1999, the Office of Environmental Health Hazard Assessment California Environmental Protection Agency (OEHHA) reviewed the available evidence, and concluded that a prudent public health decision is to regard Cr(VI) as a carcinogen by the oral route(OEHHA, 1991; Siegel, 1990, Siegel, 1991). OEHHA's supported its position by citing the following evidence points:

- Chromium is a known human carcinogen by the inhalation route.
- Non-respiratory cancers in workers exposed to Cr(VI) by inhalation have been documented.
- Inhaled Cr(VI) causes respiratory tumors in rats.
- Cr(VI) causes contact site tumors in laboratory animals Ingested Cr(VI) has been associated with stomach tumors in mice.
- Cr(VI) has been positive in a number of assays for genotoxicity.

OEHHA concluded "it is safer to assume" a substance known to be a carcinogenic by one route to be a carcinogenic by other routes. "This assumption better protects the public in light of the high degree of uncertainty regarding this issue." [21]

OEHHA derived the cancer slope factor from the Borneff et al. (1968) study. Based on total tumors (malignant and benign) in female mice, OEHHA used a cancer slope factor of 0.19 $(mg/kg\text{-}day)^{-1}$. This slope factor correlates to a drinking water standard of 0.2 ppb for Cr(VI) or 2.5 ppb for total chromium

In 2001, based on the conclusions of a state Blue-Ribbon panel claiming "Cr(VI) does not cause cancer by ingestion," California withdrew its revised drinking water standard. In 2003, members of the same panel were accused of potential fraud, misconduct, and of being bias. Dr. Dennis Paustenbach, a science consultant and then principal with the firm Exponent, was accused of manipulating the panel and failing to disclose his ties to industries responsible for chromium contamination in California. After these revelations, California resumed development of a chromium drinking water standard.

California recently released the peer review comments on its proposed Public Health Goal (PHG) for chromium in drinking water. The comments indicate a significant change in the risk analysis for the non-cancer effects from their previous report. The PHG for non-cancer effects has been lowered from 70 ppb to 3 ppb. Although the California report has yet to be released, a review of the peer review comments reveal that new data from the National Toxicology Program[22] was used to arrive at this new lower number.

California's Precautionary Approach vs. New Jersey's Reactionary Approach to Public Health

California's EOHHA base their decisions solely on scientific and public health considerations without regard to economic cost considerations. This position is contrary to the position taken by workgroup report. The workgroup report's decisions and recommendations are based on a very narrow interpretation of the New Jersey's Brownfield Act, requiring "*definitive scientific evidence"* before taking action or making recommendations.

Although EOHHA acknowledges that there is some evidence that weighs against considering chromium VI an oral carcinogen, EOHHA believes there is stronger evidence arguing in favor of its carcinogenicity. OEHHA has chosen to make the health protective assumption that it is based on a number of lines of evidence. Individual epidemiological studies can yield misleading results for a number of reasons (confounding, lack of statistical power). A single epidemiological study cannot outweigh other positive evidence.

Single epidemiological studies sometimes yield misleading results either by chance or because of confounding or other problems. When numerous epidemiological studies are compared, often there are both positive and negative studies for the same chemicals. For this reason, negative results in a single epidemiological study cannot outweigh a strong set of positive evidence, including a positive result in an animal study (Borneff et al., 1968), and positive genotoxicity information.

Other Studies and Evidence

The workgroup report and the California EOHHA reviewed the animal studies (Borneff et al. 1968; Davidson et al. 2004) on Cr(VI) ingestion carcinogenicity with the potential to yield a cancer potency factor.

Borneff et al. (1968)

The workgroup report claims the Borneff et al. (1968) study was not useful for risk assessment purposes. The report states that the study was "not clearly reported, leading to several important uncertainties (this does not appear to be a translation issue)." OEHHA also acknowledged that the study had several problems. However, in the absence of a better animal study and until the NTP study is completed it used the study as a precaution.

OEHHA acknowledge that the malignant tumors incidences were not statistically significant in Borneff et al. OEHHA decided to calculate the cancer potency based on combined data for malignant and non-malignant tumors. The combined incidence was statistically significant. This was the only data set that could be used to calculate cancer potency for chromium VI.

Having reviewed all the available evidence, OEHHA has concluded that a prudent public health decision is to regard chromium VI as a carcinogen by the oral route.

OEHHA used this study as evidence to calculate a cancer potency factor for Cr(VI) by the oral route. Although, there is room for some doubt, as the number of malignant tumors was not statistically significant.

Zhang et al. 1987

Zhang et al. (1987) reported on the health effects of 155 Chinese villagers who consumed drinking water contaminated with hexavalent chromium. The area with the highest chromium concentrations (20 ppm) had lower cancer rates than the areas that had less contamination in their groundwater. It is argued that the villagers with the highest level of contamination refrained from drinking the groundwater due to its color and taste. This would explain the discrepancy in the cancer rates.

According to the report, Cr(VI) exposure in the groundwater appeared to increase the incidence of stomach cancer to a statistically significant level (1.81 CI=1.08-2.98).

Davidson et al 2004 Study

Davidson T, Kluz T, Burns F, Rossman T, Zhang Q, Uddin A, Nadas, Costa M. (2004) Exposure to chromium (VI) in the drinking water increases susceptibility to UV-induced skin tumors in hairless mice. Toxicol. Appl. Pharmacol. 19:431-437.

The Davidson Study claims to be "*the first study to show that hexavalent chromium can increase susceptibility to carcinogenesis following drinking water exposure.*" [23]

The Risk Assessment subgroup conducted linear dose response-response modeling of the Davidson et al. (2004) complete data set using the linear-from-point-of-departure (POD) approach outlined in the 1999 EPA guidelines. This analysis was carried out using the concentrations of Cr^{+6} in the drinking water as reported in the paper. The details of this analysis are reported in Appendix C of the workgroup report. Based on this analysis, the concentration-based cancer potency factor was calculated as 0.2/ppm Cr(VI) in drinking water. This cancer potency factor correlates to a Cr(VI) drinking water standard of 0.005 ppb for a one in a million cancer risk which is the basis for all carcinogens in drinking water. The potency factor appears in the Peer Review version of the Chromium Workgroup Report, it does not appear in the Public Review version which is currently on the web.

Most importantly, this cancer potency factor determined from the Davidson et al. is consistent with the State of California's determination. Dr. Froines testified to the California Senate on the cancer potency of chromium. He concluded "that of all the 200 chemicals that we've reviewed in the State of California, chromium VI is the second most potent carcinogen of all the chemicals in the state that have been reviewed at the state level. This compound is only second to dioxin. And as you can see, it is more potent than arsenic, butadiene, diesel exhaust, formaldehyde, trichloroethylene, methylene chloride, and I could go on. We're dealing with a compound that has significant cancer potency."[24]

Unlike California, the workgroup report recommends no change to its standard. The report justifies its decision by casting doubt on the study by claiming there was "*insufficient information on body weight and water consumption of the mice*" which would require the workgroup to make "*uncertain assumptions.*" Emphasizing uncertainty paralyzes NJDEP to regulate.

The Risk Assessment subgroup concluded the study to be scientifically valid and recommended the study be "*seriously considered in the context of a policy-based re-evaluation of the existing soil standard.*" [25]

However, that re-evaluation was deferred to an unspecified later date. Almost as a second thought, the workgroup report contradicts itself. The report states that the Davidson et al. (2004) study "*raises the possibility that the cancer risk posed by exposure to Cr(VI) could be larger than that used by the NJDEP in the derivation of its soil standards.*"[26]

The workgroup should have pursued additional scientific dialogue with key experts in this field. In fact, Dr. Max Costa, co-author of the study, was scheduled to meet with the workgroup to discuss details of the study to clear up any uncertainty the workgroup may have had. The invitation to Dr. Costa, however, was rescinded days before the event. NJDEP officials publicly claimed that by meeting with Dr. Costa would threatened to "bias" the workgroup members.

Dr. Costa, chairman of the NYU Department of Environmental Medicine, is considered to be one of the most highly recognized experts in this field.

Except for unspecified further study, no action was recommended based on this acknowledged possibility of heightened health risk.

Evidence of Causal Relationship for Environmental Exposure to Chromium

One well-known death of a New Jersey man exposed to chromium at a COPR site may serve as further evidence of chromium as an ingestion carcinogen. The following description of the death of Mr. Frederick Trum is taken from a 2003 news article:

> **City slipping out of poison's grasp, Jersey City, N.J**
> By JIM MORRIS
> The Dallas Morning News - Dallas Morning News
> June 16, 2003
>
> JERSEY CITY, N.J.- In October 1993, a Hudson County jury awarded $1.8 million to the widow of Frederick Trum, a dockworker who had been exposed to chromium-rich dust at a trucking terminal in Kearny at age 60. Four months before Mr. Trum's death in 1987, he had 100 times the normal amount of chromium in his body, according to a doctor's report. An autopsy showed that his bones had turned yellow. The Trum case was a stark reminder that one did not have to work in a factory to suffer from chromium poisoning. [27]

Despite its contradictory positions on this question, the workgroup report, recommends no changes in chromium soil criteria to account for the uncertainty in the carcinogenic ingestion studies for Cr(VI). The workgroup report defends this decision by claiming that the *"cancers of the gastrointestinal tract, as well as nasal and laryngeal cancers"* were not *"consistently found in all studies, and no firm conclusions are possible."*

Workgroup Report's Excessive Standard of Proof

As noted earlier, the workgroup report states that recommendations are made *"only where definitive scientific evidence was presented."* [28] This is an extremely high hurdle to justify protecting public health. Even when there is suspicion of harm, as is the case with the ingestion of Cr(VI), the burden of proof demanded by the workgroup report is unprecedented and cumbersome. Clearly demanding certainty of harm does not have the public health interest in mind.

Despite acknowledging that its conclusion was *speculative*, the subgroup recommended classifying the risk posed by ingestion of Cr(VI) as *"Suggestive Evidence of Carcinogenicity, but Not Sufficient to Assess Carcinogenic Potential"* in accordance with EPA 1999 guidelines. The effect of such a classification is significant because it falls short of requiring the establishment of a protective standard.

C) Current Criteria Fail to Protect Against Non Carcinogenic Effects Genotoxicity, Allergic Contact Dermatitis,

Chromium VI water-soluble compounds (CrO_4^{-2}) are considered extremely toxic because they structurally resemble phosphate (PO4-2) and are actively transported into all cells of the body in place of anions, such as phosphates.[29]

The evidence that Cr(VI) causes respiratory cancer is unequivocal. Inhalation of Cr(VI) also causes a variety of acute health effects, including irritation, ulceration, perforation, and necrosis of the nasal septum, asthma, dermatitis, and skin ulceration.[30] The health risk via inhalation relates primarily to inspirable particles (<100 microns), thoracic particles (<10 microns) and respirable particles (<3.5 microns) in the soil. Larger (PM-30) particles are trapped in the nasal and pharyngeal passages.

Genotoxicity

Cr(VI) has been shown to be genotoxic in many invitro studies, and among exposed workers exposed via inhalation to airborne Cr(VI) (IARC, 1990). The Workgroup noted that there are several reports in the literature of the production of genotoxic endpoints in animals following oral administration of Cr(VI) (e.g., Coogan et al., 1991; Bagchi et al., 1995; 1997; 2001; Devi et al., 2001). These studies are consistent with the hypothesis that Cr(VI) can, at some doses, be transported to tissues distant from the initial point of contact, and result in effects that may be predictive of the production of tumors.

Allergic Contact Dermatitis

Consideration of the potential for exposure to Cr(VI) to cause allergic contact dermatitis has been a factor in Cr standards and cleanup decisions for many years. The potential of Cr(III) and Cr(VI) to induce and elicit allergic contact dermatitis has been documented in many studies. Chromium dermatitis is often due to exposure in the occupational environment, with cement being one of the most common chromium sources. However, consumer products such as Cr(III)-tanned leather products are also an important source of chromium exposure. Apart from Cr(III), which is used for tanning, leather often also contains trace amounts of Cr(VI), which is formed by oxidation of Cr(III) during the tanning process. In a recent study of the Cr(VI) content of leather products bought on the Danish market, 35% of such articles had a Cr(VI) content above the detection limit of 3 ppm, ranging from 3.6 ppm to 14.7 ppm. Leachable Cr(III) was detected at levels of 430–980 ppm. An examination of available dose–response studies showed that exposure to occluded patch test concentrations of 7–45 ppm Cr(VI) elicits a reaction in 10% of the chromium-sensitive patients. When reviewing repeated open exposure studies, it is seen that either exposure to 5 ppm Cr(VI) in the presence of 1% sodium lauryl sulfate (SLS) or exposure to 10 ppm Cr(VI) alone both elicit eczema in chromium-sensitive patients. The eliciting capacity of Cr(III) has not been systematically investigated but, compared to Cr(VI), much higher concentrations are needed to elicit eczema. [31]

Until 1998, New Jersey chromium criteria for allergic contact dermatitis was derived from *Bagdon and Hazen (1991).* Based on historical studies, Bagdon (1991) estimated the 10% MET to be 10 mg Cr(VI)/l-solution. The authors further suggested that the 10 mg Cr(VI) per liter of solution would have the same potential for eliciting an allergic response as 10 mg Cr(VI) per kg of soil. Based on a previously determined site-specific Cr(VI) to total chromium ratio of 0.14, these authors estimated the total chromium soil concentration to be 75 mg/kg.

The Chromium Risk Assessment subgroup recommends adopting a cleanup value based on the Nethercott et al. (1994) study. This recommendation fails to account for weaknesses identified in the *ICO v. Honeywel decision*.

As part of a civil action suit between the Interfaith Community Organization and Honeywell International Inc., Dr. Belsito[32] reviewed and commented on several studies relevant to the Chromium Risk Assessment charge [Nethercott et al., (1994); Stern et al., (1998)].

Dr. Belsito points out that a soil-loading factor of 0.2 mg/cm^2 is too low and based on the selection of the wrong studies (by Finley and Horowitz). Further investigation of this question confirms his suspicion. Other studies of loading including EPA Rags part E and EPA Methods for Assessing Exposure to Chemical Substances put the range at from 0.5 to 3.4 mg/cm2. Belsito recommends 2 mg/cm^2. Using 2 would have the effect of lowering the NJDEP upper range for contact dermatitis from 400 to 40. The reason for the misinterpretation of the data is that for chemicals with a systemic effect the lower number is more appropriate. For contact dermatitis it is not appropriate to use the overall average because the site of action is the skin where the highest reasonable loading anywhere on the body is the correct value to use.

<u>Use of Inappropriate Statistics</u>

Dr. Belsito also found the Nethercott 1994 study to be severely flawed. Dr. Belsito reviewed two versions of the Nethercott study before publication. One version used linear regression and the other used a truncated log method to analyze the data. The linear regression method resulted in a minimal elicitation threshold of 0.076 micrograms per centimeter squared. The truncated log method resulted in a threshold of 0.089 micrograms per centimeter squared. The author's published version elected to use the 0.089 value although the correlation for the linear regression was tighter than it was for the truncated log. Dr. Belsito stated "it appeared to me that they were looking at higher numbers" for the soil standards.

It is also important to keep in mind that the Nethercott study was funded by Allied Signal ("Honeywell"). The coauthor of the study was Dr. Pastenbauch. Dr. Dennis Paustenbach, served as an expert witness for Pacific Gas and Electric in the Hinkley, California chromium case. Paustenbach has also been funded by PPG Industries Inc. and Maxus Energy Corp. to review chromium standards in New Jersey.

Ingestion of Cr(VI)

The Risk Assessment Workgroup concluded that "*ingestion of Cr(VI) can cause …allergic dermatitis*..." However, the Workgroup also concluded the studies were "*insufficient to support a quantitative*" standard. The Chromium Workgroup Report fails to disclose the relevant assumptions, limitations, and weak arguments used to justify the majority's recommendations.

Incidental ingestion is the major pathway of exposure to Cr(VI) in soil and dust.[33] According to EPA, the assumption implicit in this exposure pathway is that ingested soil and dust is best represented by the concentration in the particle size fraction that sticks to hands (and perhaps clothing and other objects that may be mouthed). EPA lead models consider this fraction to be the primary source of the ingested soil and dust. Several studies indicate that the particle size fraction of soil and dust that sticks to hands is the fine fraction and that a <u>reasonable upper-</u>

bound for this size fraction is 250 microns (Kissel *et al.*, 1996; Sheppard and Evenden, 1994; Driver *et al.*, 1989; Duggan and Inskip, 1985; Que Hee, *et al.*, 1985; Duggan, 1983). NJDEP does not distinguish between particle size and instead uses the bulk soil concentration.

California Office of Environmental Health Hazard Assessment (OEHHA) has developed a non-cancer health protective level for Cr(VI) for drinking water study in rats (MacKenzie et al., 1958). This study showed no adverse effects at a level of 2.4 mg/kg-day. The health protective level was arrived at using an overall uncertainty factor of 500, and a relative source contribution (RSC) of 40%.[34]

Ultimately the Workgroup chose not to recommend any change to the current criteria or require any changes to the remedial approach to prevent exposures to ingesting chromium dust.

Dr. Belsito testified on Stern et al (1998).[35] Stern et al was a joint study carried out by NJDOH and NJDEP to investigate potential Cr related health problems in people who worked or resided in proximity to known Cr contaminated land. This study concluded that chromium levels were elevated in urine samples in some individuals but the study provided neither conclusions nor recommendations on these results. Dr. Belsito in his testimony pointed out serious flaws and misinterpretation of health data regarding the dermatitis findings in this study. He testified that the data (if evaluated properly) had the potential to show a large increase in chrome related dermatitis in the study population and that this effect was overlooked in the DOH/DEP analysis. This testimony from a highly qualified individual was not available to the risk assessment committee.

Peer Review Comments - Failure to Account for Uncertainty

Despite the fact that epidemiological studies unequivocally demonstrate Cr(VI) causes cancer in humans when inhaled; causes non-respiratory cancers in workers when inhaled (Rosenman and Stanbury 1996; Satoh 1994)[36]; causes contact site tumors in laboratory animals (Hueper, 1955; Maltoni 1976); associated with stomach tumors in mice when ingested; and was positive in the vast number of assays for genotoxicity; the workgroup report concluded that there is “insufficient evidence… to make…an association between oral exposure to chromium and the development of stomach or gastrointestinal cancers.”

The position expressed by the Workgroup, not to account for the possibility of an increased risk of cancer in our criteria, is not consistent with the recommendations and concerns raised by the outside peer reviewers.

Peer Reviewer Dr. Gary Ginsberg, Risk Assessor and Toxicologist, Division of Environmental Epidemiology and Occupational Health, The Connecticut Department of Public Health and adjunct Professor at Yale University and University of Connecticut Health Care Center.

Dr. Ginsberg commented:

*“Since the oral genotoxicity studies and the Davidson study both point towards sufficient CrVI oral bioavailability to create some level of cancer risk, it is relevant to evaluate whether the 400 ppm CrVI proposed criteria is at or below the genotoxicity and co-carcinogenic effect levels. A minimum effect level in the genotoxicity studies in mice was 210 ug/kg (Devi, et al., 2001) while the minimum cancer effect level in the Davidson study was 0.5 ppm (approx 15 ug/kg/d). Both of these doses were lowest LOAEL for genotoxic and carcinogenic effects. Nevertheless, these effect levels can be compared to an oral dose in children from 400 ppm in soil: 400 ug/g * 0.2 g soil*

*ingested/d * 1/15kg = 5.3 ug/kg/d. Thus a residential scenario could lead to a daily child's dose of CrVI that is within 3 fold of a cancer effect level (albeit in a test system of uncertain quantitative relevance to human risk) and within 40 fold of a dose capable of inducing genotoxicity form a single exposure in mice."*

Mr. Ginsberg recommends using a safety factor *"to account for uncertainties in the oral cancer database."* Ginsberg goes on to explain that the safety factor "*could be instituted on an interim basis pending the results of the oral CrVI NTP*[37] *study. In this manner, the cleanup criteria could to some degree address a very important uncertainty, one that the NTP bioassay intends to resolve."*

The Workgroup found Dr. Ginsberg's recommendation to be *"over-reaching in an attempt to establish protectiveness."*[38] This response is not only insulting but also wrong. Dr. John Froines,[39] Environmental Health Sciences, University of California, Los Angeles, supports the concerns expressed by Dr. Ginsberg. In a personal email correspondence, Dr. Froines stated:

> *"I do consider Cr(VI) to be a risk via the oral route, and the issue is more the quantitative nature of that risk rather than a qualitative yes-no approach. That is, there has been too little attention to public health issues; some of the scientists who have reviewed the data have been too quick to assume a negative risk based on limited information rather than seeing the limited information as evidence that caution must be exercised."*[40]

It is the Department's primary responsibility to "err on the side of caution." If this primary responsibility has changed, we should inform the public.

I am not arguing NJDEP's right to determine "allowable risk", however I am arguing that the basis of that determination must be based on sound scientific reasoning.

Again, the Workgroup's recommendations reflect the presumption that the current criteria are protective.

New Jersey has not promulgated the proposed 1998 cleanup criteria used in remedial decisions, and the Chromium Workgroup has not recommended changing them to account for the uncertainty in the carcinogenic ingestion studies for Cr(VI). The Workgroup defends this decision by claiming that the *"cancers of the gastrointestinal tract, as well as nasal and laryngeal cancers"* were not *"consistently found in all studies, and no firm conclusions are possible."* This is a very weak argument. It reflects the presumption that the 1998 criteria are protective. It has become a pattern, when confronted with scientific uncertainty, the Workgroup proceeds with "business as usual" unless harm can be proven with certainty.

The Workgroup also stated that *"none of the studies individually or together provide a sufficient basis for the development of an ingestion-based soil cleanup value for allergic dermatitis."*[41]

The Workgroup cites Proctor et al. (2002)[42] to support its conclusion. The Procter et al. (2002) is a literature review that based its position partly on the Zhang et al. (1997) study, which is currently being investigated for fraud. Zhang et al. 1997 claims to be a follow-up study to the Zhang et al. 1987 study that concluded 155 Chinese villagers exposed to Cr(VI) contaminated well-water suffered from oral ulcers, diarrhea, stomach ache, indigestion, leukocytosis and increased numbers of stomach cancer. Zhang et al. 1997, claims "the results do not indicate an association of cancer" and instead claims the higher incidences in cancer "might reflect the influence of lifestyle or environmental factors not related to Cr(VI)."[43]

The Zhang et al. (1997) study was the subject of severe criticism and allegations of fraud during the 2003 California Senate hearings on chromium. The Senate declared it would follow up on these allegations. It is also interesting to note that Proctor is an employee of Exponent. She currently manages 38 chromium sites in Hudson County New Jersey for the responsible parties. I find this reference to be biased.

California recently released the peer review comments on its proposed Public Health Goal (PHG) for chromium in drinking water. The comments indicate a significant change in the risk analysis for the non-cancer effects from their previous report. The PHG for non-cancer effects has been lowered from 70 ppb to 3 ppb. Although the California report has yet to be released, a review of the peer review comments reveal that new data from the National Toxicology Program[44] was used to arrive at this new lower number.

The New Jersey Chromium Workgroup did not review the NTP data, nor many of the studies cited by OEHHA in its efforts to develop a drinking water standard for chromium. (see Appendix).

Comparison of NJDEP Chromium Cleanup Criteria to Other Agencies.

The report discusses the immense uncertainties, including regulatory uncertainties that must be addressed in setting standards. The following table illustrates the difference those uncertainties can have on standards.

Agency or State	**Residential Soil Std mg/kg**		**Soil std impact to groundwater DAF 1 (mg/kg)**	
	Cr VI	**Cr III**		
NJDEP inhalation	240	120,000		
EPA **Region 6** Human Health Screen Levels 2004-2005	230			
Maryland Interim Final Guidance 2001	30		2.1	
Oregon Acceptable	23		2.0	
Dutch Standard is based on total chromium (1/6 hex)	30	210 total Cr (1/6 ratio)		
UK Trigger for Cr(VI)	17			
	25			

D) Current Criteria and application fail to account for Accumulation of Cr(VI) on Surfaces

Due to capillary/evaporative processes, localized accumulation of highly enriched solid-phase Cr(VI) has been found to exceed the current public health criteria and average bulk concentrations in soil. Capillary action is a surface tension phenomenon that retains moisture in the pores of a soil above the water table. Capillary action causes water to move from saturated soils to drier soil against the force of gravity, much like how plants transport liquid from the roots.

NJDEP funded studies have documented this phenomena. Most noteworthy is a study conducted by New Jersey Institute of Technology and Stevens Institute of Technology on remediation of chromium contaminated soils. This technical paper describes COPR sites and illustrates how capillary action transports Cr(VI) to surfaces. It further states that risk should be based on this exposure.

> **Remediation of Chromium-Contaminated Soils: Bench-Scale Investigation Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management/ July1999**
>
> Chromate contamination has been found … on interior and exterior walls, on building floors, on the surface and subsurface of unpaved areas throughout Hudson County. These sites include residences, active work sites, public lands, commercial establishments, and other populated areas of Hudson County.
>
> Chromium concentrations were critically high at the soil surface due to the capillary rise of chromate from the slowly soluble compounds. The surface concentrations were used to determine the exposure hazard.[45]

The extent of capillary rise on a particular site depends on a number of factors, including soil composition. Chromite ore processing residue (COPR) sites located in former wetlands of Hudson County are susceptible to capillary action that, under certain conditions, can cause the transport of soluble Cr(VI) derived from COPR soils upward to form chromate salts at or near the ground surface. In a loam or silty clay loam soil (wetlands), capillary rise can rise of up to 15 feet or 4.57 meters (Knuteson et al, 1989). The groundwater table at many COPR sites is relatively shallow (0.3 – 3.3 m

A report submitted by the Responsible Party for COPR estimated the capillary rise at several sites located in Kearney (Henry, 2004).[46] Results are listed below:

Site ID	Depth to Groundwater	Soluble Cr(VI) filtered ppb	Calculated Capillary Rise (m)
42	0.3 – 1.1		10
48	1.0		>2
113	0.1 – 2.0	9,000	>10

NJDEP's current chromium cleanup criteria fail to factor in these processes. Through this omission, the current criteria leave the public vulnerable to unacceptable health risks through a variety of scenarios.

M.B. McBride, Ph.D., Department of Crop and Soil Sciences, Cornell University, submitted comments on behalf of the NJ Chapter of the Sierra Club on this issue. Dr. McBride claimed in his June 2, 2005 comments that the potential for chromate or Cr(VI), a quite mobile anion, "to concentrate to levels many times the average soil concentration" is not only "apparent in the field (on surfaces as well as basement walls), but also by the soil column experiment of T. Hayes, a NJDEP soil scientist". Dr. McBride pointed out "the residential cleanup criteria of 240 – 270 ppm chromate in soil are unlikely to be protective because much higher localized (e.g. soil surface) concentrations could result from processes of transport and evaporation."

Since soil sampling and analytical results are highly variable and dependent on weather and other conditions, "hot spots" may not always be evident. If the public health goal of NJDEP is to protect the public from exposures to Cr(VI) in excess of 240 ppm, then the Department would need to remediate using a far lower cleanup level in order to account for surface concentrations.

"The current DEP remedial approach of using capping and deed restrictions," at COPR sites was also addressed by Dr. McBride. Dr. McBride stated that it seemed to him capping and deed restrictions were "a stop-gap short-term approach that does not deal effectively to mitigate the large amount of potentially mobile chromate in soils and wastes at these sites. Depending on the hydrology of the sites, this chromate may still migrate into surface waters, basements, and other locations where human and animal exposure is possible."

This is a major concern since NJDEP has allowed extremely high subsurface levels of chromium to remain on sites. At N.J. Turnpike Kearny Site No 2, the concentration Cr (VI) left on site was 2,820 ppm. The groundwater contained 11, 800 ppb (100 ppm drinking water standard). The remedial action at the site included a soil cap and deed restriction. The site was issued an NFA on November 2003.

The final workgroup report acknowledges the preponderance of evidence that capillary action has resulted in Cr(VI) salts accumulating on surfaces at levels a thousand times the cleanup criteria, yet it recommended no action, and no modification to the current criteria to account for this phenomena. The report claims "….the complexity of the factors….determined that it is too difficult ……" to predict when capillary transport would be a concern.[47] The workgroup was "polarized" and deferred the decision for further study[48].

"Complexity" is not a justified reason to avoid action. Capillary rise is predictable and calculable.

The workgroup report concedes that capillary action may result in elevated risks to the public due to Cr(VI) accumulation. Unfortunately, the workgroup report recommends no change to NJDEP's current criteria or to its remedial approach - save for "further studies." I believe the weight of evidence shows that this is a recommendation that, if implemented, would expose the public to a further increment of unnecessary health risk.

Recommendation:

The European Union Treaty adopted the precautionary principle as the guide for environmental policy. The European Commission stated:

The precautionary principle applies where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU.

I recommend readopting the 75 ppm total chromium standard (based on 10 ppm Cr(VI)) and applying it to the entire soil column.

E) Cleanup Criteria and application Ignore Fundamental Principles of Soil Behavior – Concentration of Contaminants on Finer Particles

Background and Importance of this Issue

The evidence that Cr(VI) causes respiratory cancer is unequivocal. In addition, there is also abundant evidence that the inhalation and subsequent ingestion of Cr(VI) particles causes a variety of non carcinogenic health effects, including ulceration, perforation, and necrosis of the nasal septum, asthma, dermatitis, and skin ulceration.[49] The cancer risk via inhalation relates primarily to inspirable particles (<100 microns), thoracic particles (<10 microns) and respirable particles (<3.5 microns) in the soil. Larger particles (>30 microns) are trapped in the nasal and pharyngeal passages. Therefore, it is crucial to determine the contaminant concentration in inspirable particles for any inhalation-based risk assessment.

NJDEP current soil sampling practices for chromium – the use of site-average bulk soil concentration – does not differentiate between concentration and particle size. Average bulk soil sampling assumes contaminant concentrations are uniform across all particle sizes. Conversely, if contaminants are concentrated disproportionately in smaller particles – the particles that become airborne and are most respirable – then risk analyses based on bulk soil concentrations will underestimate actual exposures. In addition, the air model used by NJDEP to estimate air risk greatly under predicted measured air concentrations at the site. This finding is very disturbing because NJDEP has already approved numerous cleanups based on averaging a sites bulk soil concentration. It made sense for the workgroup to examine the "weight of evidence" supporting this practice.

Evidence Confirming Particle Size Enrichment

It is an undisputed fact among soil scientists that smaller soil particles carry a higher percentage of contamination than larger particles. The weight of evidence confirms that this phenomenon would apply to chromium. Among the noteworthy studies are Que Hee et al. 1985; TRW Cercla site review; Loyaux-Lawniczak, 2001; Kitsa, 1992).

1. Que Hee et al. (1985) measured the lead content in samples of house dust categorized into fractions by particle size collected in Cincinnati, Ohio. Sampling results determined that 77% of the lead was present in particles smaller than 149 microns. This distribution of lead in small particles would maximize intestinal absorption.[50]

2. A TRW review of data from CERCLA sites demonstrated that the lead concentration in the fine fraction often differs from the lead concentration in the total soil sample. The fraction less than 250 um is most often measured, but data are available on smaller size fractions as well. This difference in lead concentration between the fine fraction and the total soil sample is confirmed by a number of investigators (Fergusson and Ryan, 1984; Fergusson and Schroeder, 1985; Kitsa *et al.*, 1992), and enrichment of lead and other metal contaminants in the fine fraction is suggested. In the development of his *de minimis* model for lead exposure to children, Stern (1994) recommended a generic correction for enrichment of lead in the exposure fraction.[51]

3. Loyaux-Lawniczak, 2001 (*Behavior of hexavalent chromium in a polluted groundwater: redox processes and immobilization in soils*): This paper was reviewed by Julia Barringer, Ph.D. in a July 13, 2004 memorandum (*Evidence Supporting Enrichment of Respirable Particles*). Dr. Barringer concluded the particle analysis performed in the study supported the enrichment theory.

> "Evidence Supporting Enrichment of Respirable Particles" A memo dated July 13th, 2004 by Julia Barringer, Ph.D.
>
> Loyaux-Lawniczak, 2001 *Behavior of hexavalent chromium in a polluted groundwater: redox processes and immobilization in soils.*
>
> Grain size fractionation of four soil samples was performed, and fraction analyses show that chromium is preferentially accumulated in the clay fraction (<2 micron). The article also indicates that "the two coarsest fractions mainly derive from waste grains of chromite, residues of the old ore processing activities" and "Cr is mainly found on the two coarse (>500 um) and the finest fractions (<2 um)…" So the smallest fractions of the soil—excluding the chunks of slag that they identified as comprising the coarse fraction—contained the largest Cr concentrations measured in the soil.[52]

4. Kitsa et al., 1992 *Particle-Size Distribution of Chromium: Total and Hexavalent Chromium in Inspirable, Thoracic, and Respirable Soil Particles from Contaminated Sites in New Jersey*.

Kitsa et al., 1992 is a study funded by NJDEP which focused primarily on the inspirable, thoracic, and respirable soil particles (<30 microns) from COPR contaminated sites.

Julia Barringer, Ph.D., (geochemist, USGS), provided an in-depth analysis of the Kitsa et al. 1992 study, and stated her conclusions in a memo to workgroup members dated July 13th, 2004: ("Evidence Supporting Enrichment of Respirable Particles"), "Evidence Supporting Enrichment of Respirable Particles" A memo dated July 13th, 2004 by Julia Barringer, Ph.D.

Summary of Barringer's analysis of Kitsa et al. (1992):

Table 1 - the bulk sample had a Cr concentration of 2480 mg/kg. For all the subsequent fractions (between 500 and 250   m; between 250 and 150   m, etc.) down to d< 38   m (the smallest fraction achievable with sieving), Cr concentrations increase from 1920 to 3420 mg/kg. Barringer states this supports "The potential for hexavalent chromium enrichment…..".

Inspirable particles are defined in the article as d<100, consequently, particles with d<38 (which contained 3420 mg/kg of Cr) are inspirable, and the data clearly indicate that the inspirable particles carry most of the Cr present in the soil sample. Also in Table 2 are results for the Cr (VI) blooms (this is why the water extraction was used, I presume). In those fractions, from 75<d<150 down to d<38, Cr (VI) increased from 883 to 1133 mg/kg. I also mention that, "for fractions of smaller particles (d <30 um to d<2.5 um) on filters from a re-suspension chamber, total Cr concentrations were largest in the fraction 10<d<30 um…than in the smallest size fractions." This refers to the data shown in Table 3, and is an accurate representation of those data.

So I have pointed out that the data show that the bulk of the chromium concentration is on the smaller particles, both in soil and in the blooms. Only within the inspirable fractions do total Cr concentrations decrease, and, as per data in Table 7, Cr (VI) concentrations in blooms also decrease within the inspirable fractions. But, as in Table 2, the data indicate that concentrations increase as particle size decreases down to d<38. What should concern the SRWMP, since this is a human health issue we are discussing, is that inspirable fractions of soils and blooms contain the bulk of the Cr concentrations. And increasing enrichment of small particles is demonstrated by the data, down to about d=30 um. As for the fractions <30 um, the data clearly show that they carry a very large portion of the total Cr, AND the Cr (VI), present in the sample. The data presented by SRWMP on the top of page 5, which I presume is for COPR-affected soils, indicates that the fraction d<75 um contains about 76% of all the chromium present. This indicates to me that smaller particles carry the bulk of the Cr that is present, and the data do not support the argument that there is no enrichment of smaller particles. [53]

Interpretation of the results in Kitsa *et al.*, 1992 "polarized the Workgroup. The workgroup members representing the Site Remediation program maintained that the study did not offer enough evidence to warrant a change in NJDEP's bulk sampling practices. This faction of the workgroup emphasized that particle sizes less than 30 microns tend to reduce in chromium concentrations. Emphasizing this point ignores the fact that the fraction d<75 microns contains about 76% of all the chromium present. Others in the workgroup argued that the overwhelming weight of evidence including Kitsa et al., (1992) on this issue as it relates to a range of contaminants, provide sufficient information that enrichment on finer particles occurs and that the soil sampling procedures must be changed to reflect it. Regrettably, the workgroup report presents only the opinion of the members who were committed to protecting the status quo. No mention was made of Dr. Barringer's conflicting analysis.

Site Remediation Program's Reliance on Questionable PPG Study

A study prepared on behalf of PPG was offered to counter the claim that fine particles carry higher concentrations of Cr(VI) than coarser particles. PPG physically separated many samples of soil into particle size fractions, d<75 um and d<10 um. The bulk samples, the d<75 um fractions and the d<10 um fractions were analyzed for Cr(VI) concentrations (termed HCbulk, HCL75 and HCL10, respectively).

A consultant to PPG attempted to show with the fractionation results that physical separation of fines for Cr(VI) analysis is unnecessary. The consultant calculated the difference of each bulk concentration from its corresponding fraction concentration, that is, HCbulk-HCL75 and HCbulk-HCL10. Negative differences indicate that HCbulk underestimates the concentration in the fines (except when one concentration number or both actually represent the detection limit of a non-detection result). The consultant applied a standard nonparametric statistical sign test (Conover 1980) to the calculated differences. When all non-detections are included, more positive differences are present than negative ones. That statistical test shows "better (more than 97.5%) than 95% confidence that the bulk confidence that the bulk concentration is larger than the concentration in the <10u fraction." Alternatively, with the majority of the non-detections excluded, more nearly equal numbers of positive and negative differences can be counted so the statistical tests "support the common conclusion that the bulk concentration is no worse than equivalent to the <10u fraction concentration." In either case, the consultant states a similar conclusion for the <75u fraction.

According to Dr. Page, the particular statistical test results offered by the consultant give a limited view. Graphs of the measured Cr(VI) concentrations show tremendous scatter and limited evidence of correlation. Linear regression analysis shows HCbulk to be a weak predictor of HCL10 with squared correlation coefficient r^2 of 0.14 or less. The squared correlation coefficient is 0.14 when all 97 pairs of HCL10 and HCbulk are part of the regression analysis. (The squared correlation coefficient was lower, only 0.10, for the 36 pairs that appeared in another PPG document; that document omitted most of the samples where HCL10 and HCbulk were both non-detections.) In the 19 cases where both HCL10 and HCbulk are detectable, the HCL10/HCbulk ratios range from 0.14 to 38. Five samples with HCL10 > 20 mg/Kg (1470B76001, 1470B54002, 112AB53004, 0040B93002, 1120B42001) show no detection in the bulk sample. One sample with HCL10 of 770 mg/Kg (112AB43003) shows only 20.3 mg/Kg in the bulk sample, a HCL10/HCbulk ratio of 38.

Despite these weaknesses, the PPG report[54] claims that "bulk hexavalent chromium concentrations are conservative when used to estimate the hexavalent chromium concentrations in <75 microns and <10 microns size fractions." [55]

Workgroup's Discussion and Findings on this Issue

Many Chromium Workgroup members did not agree with PPG's findings and presented compelling evidence to support their position.

Chromium Workgroup member Roger Page, Ph.D.[56] performed a series of graphical and statistical analysis on PPG's data. His analyses led to a contrary conclusion: "...the bulk concentration is a poor predictor of the concentration in the fine fraction of particles." [57] His analyses pointed out that while the average bulk concentration in several soil samples would be considered protective, analyses of the fine particles revealed much higher concentrations requiring remediation. One of PPG's soil samples had a bulk concentration of 20.3 ppm and an estimated Cr(VI) concentration of 770 ppm in the thoracic particles (<10 microns). Although the workgroup acknowledged his expertise in this area, the report did not include the results of his analysis.[58]

Another workgroup member, Theodore Hayes, presented a sample calculation to the workgroup showing how the concentration in a soil sample could understate the concentration in the fine particles (<2.5 microns) by a factor of 9. Dr. Page reproduced that calculation and tested a few other hypothetical distributions of spherical particles, which illustrated how the factor could be somewhat larger or smaller. A soil consisting entirely of respirable-sized particles would have a factor of 1. At the other extreme, respirable particles that contribute only a small percentage of the soil mass could contribute the majority of the soil's particle surface area.[59]

Julia Barringer, Ph.D., (geochemist, USGS), reviewed wrote a memo dated July 13, 2004 ("Evidence Supporting Enrichment of Respirable Particles"), providing a detailed analysis of the data. She concluded that the weight of evidence showed that fine particles (<75 microns) carried 76% of the chromium present.

Dr. Barringer observation coincides with the testimony of Dr. Froines. Dr. Froines determined that almost 60% of Cr(VI) is found in the particles greater than 10 microns and less than 100 microns in diameter. This determination was based on data collected by OSHA in the spray paint industry.

The workgroup report dismisses these findings, and to dismiss the phenomenon of fine particle concentration as theoretical, claiming there is "no published literature" that unequivocally finds that higher *chromium* concentrations exist on finer particles. The workgroup members who disagreed with the application of this principle to chromium failed to offer any coherent argument for why chromium would behave differently than other contaminants in this respect.

The Workgroup's Irresponsible Recommendations to Maintain the Status Quo

Although it is an undisputed among soil scientist that the smaller soil particles carry a higher percentage of contamination than larger particles. The workgroup report dismisses the phenomena as theoretical by claiming there was "no published literature" that unequivocally finds that higher chromium concentrations exist on smaller particles[60].

The workgroup report chose to diverge sharply from conventional practices and theories on the issue of particle size and contaminant concentration by recommending **no change** to its current soil criteria or sampling procedures (bulk soil sampling). Scientific ethics require a much higher "burden of proof" to support such a divergence. The evidence presented for such a finding must "rise above subjective belief or unsupported speculation." The workgroup report only cited an undocumented and non-peer reviewed study prepared on behalf of PPG Industries, Inc. to defend the practice of averaging soil bulk samples. Obviously, the burden of proof was not met by this report.

If the workgroup had accepted this fundamental principle of soil behavior – contaminant enrichment on smaller particles – it would have required either lowering the chromium soil criteria or changing the soil sampling procedures from bulk sampling to particle distribution analysis. The workgroup, again consistent with its pattern of lending validation to the status quo, deferred the issue for future research.

No changes to the soil criteria or bulk sampling procedures were recommended, either on a permanent or an interim basis. No alternative explanations were offered as to why the Department's air modeling underpredicted actually-measured ambient chromium levels by 70,000 times, resulting in an excess cancer risk of 1 in 10 at the Arden Chemical site. No particle size analyses were conducted at New Jersey chromium sites.

The calculations presented by Theodore Hayes and Dr. Roger Page, establishing a numerical basis for which NJDEP's cleanup criteria could be modified to reflect particle size distribution, were rejected. No mention was made of these proposals in the final workgroup report.

McBride (Cornell University), in his public comments submitted on behalf of the New Jersey Sierra Club, criticizes NJDEP's bulk soil sampling approach because it “fails to recognize the importance of measuring chromium in those particles most likely to be respired, that is, the clay and silt fraction.” McBride further emphasizes that “the important concentration for human exposure is not the average in the bulk soil, but the concentration that can accumulate at surfaces accessible to humans, particularly in the fine respirable particles likely to be found in air-borne dust.”[61]

NJDEP Sampling Procedures Underestimates Concentration in Soils

Dr. McBride, Cornell University (on behalf on NJ Sierra Club), commented on NJDEP bulk soil sampling method. Dr. McBride stated, “*it is possible that the finer soil particles at the soil surface could contain even higher concentrations of chromium and chromate than the average measured in a bulk soil sample taken from the to 6 inches. Thus, the NJDEP method of measuring chromium in a bulk surface soil fails to recognize the importance of measuring chromium in those particles most likely to be respired, that is, the clay and silt fraction.”* McBride further emphasizes that *“the important concentration for human exposure is not the average in the bulk soil, but the concentration that can accumulate at surfaces accessible to humans, particularly in the fine respirable particles likely to be found in air-borne dust.”*[62]

Perhaps no other issue considered by the workgroup better illustrates the extent to which Site Remediation Program managers and DEP's authors avoided scientific rigor, disregarded well-established science, and ignored well-founded alternative points of view within the Department in order to preserve DEP's irresponsible approach to chromium sites.

The workgroup report recommendation to continue to use bulk-sampling techniques for averaging the soil chromium concentration, is completely groundless and contrary to established science. The impact of this recommendation, if implemented, could be potentially great. Maintaining such a sampling practices expose the public to a host of health risks. The current criteria do not account for the physical mechanism by which chromium-laden dust gets into the air and becomes available to humans via inhalation. Bulk sampling averages will continue to be used in the air model; no air model can be expected to produce accurate results if the input data is wrong.

Alternative Remedial Standards

NJDEP currently allows for site-specific development of cleanup standards (Alternative Remediation Standard or “ARS”) derived from an air model based on EPA’s ISC model. ARSs allow for a wide range of Cr(VI) levels to remain onsite. To validate the air model, Hazen et al., compared air-modeling results at a COPR contaminated site to observed indoor air sampling results. Hazen et al. found that the model greatly underestimated the ambient concentrations; thus underestimating the risk posed by the soils.

According to Hazen et al., the site (Arden Chemical) had indoor air measurements as high as 300 ng/m^3 *(Remedial Investigation 2001).* The mean soil concentration was 434 mg Cr(VI)*/Kg (ppm) at the site. Therefore, a site with an average soil hexavalent chromium concentration of 434ppm there is an association of air levels of 8,800ng/cu m (8.8ug/cu m), 300ng/cu m, and 32ng/cu m; representing excess cancer risks (if lifetime exposure) of 0.1, 0.003 and 0.0004 respectively.*

The air model proposed by ChemRisk as part of the 1996 ARS procedures and accepted by NJDEP was run for this site and predicted a risk of 1 x 10-6 for a target Cr(VI)cleanup level of 302ppm Cr(VI). This underpredicts the measured air levels and corresponding risk by factors of ranging from 270 to 76,000 depending upon which of the three air levels is chosen to be appropriate for future site use.

The actual excess cancer risk based on the air monitoring data was as high as 1 out of 10. The air model had underestimated actual airborne levels and corresponding risk by as much 76,000 times. This finding is very disturbing because NJDEP has already approved numerous cleanups based on this model.

There may be several reasons for this discrepancy. For example: 1) Model assumptions do not reflect the conditions of an urban environment, such as the model assumes rural dispersion coefficients and 50% vegetative cover. Urban areas commonly have no vegetation due to pedestrian traffic. This makes wind erosion a significant exposure pathway; 2) The model also does not differentiate among particle sizes in predicting particulate impacts. The input concentration is based on the bulk soil concentrations. 3) An additional underlying assumption of the air model is that soil contaminants levels are homogeneous throughout the soil column. This assumption does not apply to COPR contaminated sites since extremely high concentrations Cr(VI) remain on site at different depths within the soil column. Capillary transport can bring these concentrations to the surface.

The air model used to develop ARS for COPR sites was developed by ChemRisk (now Exponent) in 1996. Modifications of the air model were based on several studies conducted at COPR sites. These studies concluded that wind erosion did not significantly contribute to the airborne concentration of Cr(VI) at these sites (Scott et al. 1997; Finley et al. 1993). It is important in this case to identify the source of funding for this research because studies have shown that research findings are strongly influenced by the source of this funding. Both studies, Scott et al. 1997 and Finley et al. 1993, were performed at COPR sites while working for the responsible party.

In light of the data presented in the Hazen Report indicating that the air model greatly under-predicted the impacts from ground-level fugitive dust sources, NJDEP should cease issuing ARS until further studies are conducted. In addition, the results from the Hazen Report demand that the NJDEP revisit past remedial decisions where offsite residents may be impacted

This question became an urgent public health matter with the findings of the Hazen et al. 2004 report – in particular, one alarming finding regarding extreme inaccuracies in the Department's air modeling, a key component of an inhalation-based risk assessment. When

Hazen et al examined the Site Remediation Program's Quality Assurance/Quality Control air monitoring data for one randomly selected chromium site – the Arden Chemical site in Kearny – they found that the actually measured levels of airborne chromium at the site were as many as 76,000 times higher than predicted by NJDEP's theoretical model. The resulting excess cancer risk for the site was 1 in 10, of 1 in 1,000,000.

This finding signaled that there is something badly amiss with NJDEP's air model (see the separate section on "Alternate Remedial Standards"), and that use of this model may be leading to public health risks far beyond acceptable levels. The model itself was developed by ChemRisk, a consulting firm working for the chromium responsible parties, and adopted by DEP (a decision which warrants further investigation in and of itself). Clearly an examination of this model and of particle-size distribution in particular should have been an important focus of the workgroup.

The impact of this decision is potentially great. NJDEP currently uses bulk-sampling techniques for averaging the soil chromium concentration. It is this concentration that is used in the air model. No air model can be expected to produce accurate results if the input data is wrong. The implications of this decision is documented in Hazen et al.

The Air Transport subgroup found that it was very difficult to compile the history of how an ARS was developed and the final decision-making process that led to the selection of a remedy.

F) Current Criteria Neglect to Provide Protection of Groundwater and Surface Water

The Court found that *"contaminated groundwater from the site seeps to the surface of sites, presenting a risk of allergic contact dermatitis to trespassers, utility and construction workers, future commercial workers, future residents, and others who come on the site."* The Court concluded *"failure to delineate the deep groundwater may pose a risk to human health since human ingestion of contaminated groundwater from the site is possible."* To date, NJDEP does not have a groundwater impact standard for chromium.

NJDEP argues that *"due to highly variable soil conditions throughout the State, it is not possible at this time to develop a generic soil impact to ground water cleanup criterion for Cr(VI)."*[63]

This argument is irresponsible. For one, COPR sites are not located throughout the state – they are located primarily in Hudson and Essex County. Secondly, both EPA Region III and RegionVI have developed groundwater impact numbers for chromium (see Table 1).

Table 1 – EPA Groundwater Impact Standard for Chromium

Agency	**Soil std impact to groundwater DAF 1**
EPA Region III RBC April 7,2005	2.1

EPA Region 6 Human Health Screen Levels 2004-2005	2.0

It is obvious that a groundwater impact standard would drive the cleanup. The workgroup report, consistent with its pattern to maintain the *status q*uo throughout this review process, rejected the option of adopting EPA's standard and instead chose to define COPR by a term that has yet to be defined in the Technical Regulations, "continuous source". The report claims that by *"treating the COPR material as a continuous source, it falls outside the scope of the impact to groundwater soil clean-up standards,…"*

The term *"continuing source"* has no remedial significance and thus no remedial action would be required. It is very deceiving to coin a term to avoid remedial action. The implications of such deception could have negative impacts to public health.

Risk of Chromium Intrusion into Public Water Distribution System

Past remedial decisions on COPR sites have left extremely high concentrations of Cr(VI) in the groundwater. This is problematic because it increases the chance that chromium may find its way into Hudson County's public water supply distribution system.

LeChevallier et al 2003, identifies in his paper a number of criteria that have actually been found to encourage the intrusion of contaminants into public water supply systems. The paper also includes several epidemiology studies that concluded the water distribution systems were at least partially responsible for increased levels of gastrointestinal illnesses among the exposed population (contaminant in these cases was bacteria from sewage lines).

According to LeChevallier et al, intrusion of contaminants into water distribution systems commonly occur when there is an abrupt change in water pressure (also referred to as "surge" or "water hammer"). The frequency and magnitude of intrusion depends on several factors, all of which apply to Hudson County. Hudson County's water supply system is old (pipes are cracked, leaky valves…), the distribution system located miles from the reservoir, and many of its water lines lay either below the water table or close to it. Relative to the suburbs, it is not uncommon for local officials to warn residents in Hoboken, Jersey City and Weehawken to boil their drinking water due to detection of bacteria. Hudson County's water supply lines are located within feet of the sewage lines.

The impact of not protecting groundwater from contamination in urban areas is potentially great. To ensure the public is not being exposed to contaminants in the groundwater, NJDEP should revisit past remedial decision as soon as possible

Maximum Groundwater Cr(VI) Concentration for Air Risk in Interior Spaces

Re-suspension of dust inside dwellings can lead to human exposure to chromium associated with respirable particulates. Groundwater is a pathway for hexavalent chromium to be transported to areas more susceptible to public exposure. Leachate evaporation at interfaces results in localized accumulations of highly enriched solid-phase hexavalent chromium at soil and/or building surfaces.

This is a major concern since NJDEP has allowed for widely differing concentrations of residual chromium contamination to be left at sites. At N.J. Turnpike Kearny Site No 2, the concentration Cr (VI) left on site was 2,820 ppm (criteria varies between 20 – 270 ppm) . The groundwater contained 11, 800 ppb (100 ppm drinking water standard). The remedial action at the site included a soil cap and deed restriction. The site was issued an NFA on November 2003.

Robert Hazen, member of the workgroup, calculated that the water concentration to produce a 1E-6 risk caused by inhalation of dust in interior spaces would require a groundwater cleanup standard of 1.7 ppb.[64]

G) Current Criteria Neglects to Account for the Oxidation of Cr(III) to the much more Toxic Cr(VI)

The current 1998 criteria allow high concentrations of Cr(III) to remain in the soils (120,000 ppm). Oxidation of only a very small fraction of Cr(III) to Cr(VI) could present a health risk to the public. The Environmental Chemistry subgroup concluded that there was "*not a preponderance of evidence in the published literature to warrant a change*"[65] in the Cr(III) soil criteria. The application of the weight of evidence in this decision is very difficult for anyone outside the workgroup to judge.

This decision was later clarified further by stating the workgroup "*believed*" the cleanup standard for Cr(III) to be protective however it recommends "*that oxidation rates of Cr(III) in COPR be further investigated.*"[66]

Weight of Evidence does not support Chromium III Standard

Published literature documenting oxidation of Cr(III) to Cr(VI) includes studies in soils containing manganese oxides. The following studies indicate that oxidation of Cr(III) may occur in COPR contaminated soils.

Oxidation Studies in Soils

Fantoni et al. (2002) in Italy. The pH of the groundwater in the area was reported to be 7.6.

Oze et al. (2004) New Caledonia, Oregon and California.

Cooper (2002) in Zimbabwean. Ultramafic soils (pH about 6).

Laboratory Studies of Oxidation of Cr(III)

Eary & Rai (1987) show that oxidation to Cr(VI) is rapid in the presence of manganese oxides at pH 3-4.7.

Schroeder and Lee, 1975 - oxidation of Cr(III)-bearing slag from stainless steel production oxidation was rapid in alkaline conditions.

Pillay et al. (2003) found that oxidation proceeded faster in weathered slag samples, and also in powdered samples rather than balls. Smaller particle size also promoted oxidation.

Fendorf et al. (1992) found oxidation by Mn-oxides decreased with increasing pH (>4) due to formation of a Cr $(OH)_3$ precipitate on MnO_2 surfaces.

Johnson and Xyla (1991), showed that the oxidation rate for Cr(III) was faster using manganite than using Mn-oxides, and that the rate was "largely independent of pH and ionic strength…"

Kozuh et al. (2000) observed oxidation of Cr(III) in soils low in organic-matter content and rich in Mn (VI) oxide.

Dr. McBride[67] expressed his concern that *"since the criteria allows for huge concentrations of Cr(III) to remain in soils on the assumption that this chromium is chemically stable, even a very small fraction of this total Cr oxidizing to chromate would be problematic."* Based on his review of the Moermann (1996)[68] thesis he concluded that *"chromate is the thermodynamically stable form of Cr in COPR."* Thus, McBride believes that there is a real possibility of oxidation of Cr(III) by molecular oxygen (or Mn oxides from soils over time). The factor limiting the rate of formation is probably the very low solubility of Cr(III) in COPR and COPR-contaminated soils.

Dr. McBride also supports his position by pointing out "*that in soils containing serpentine, a mineral containing high levels of Cr(III) which normally assumed stable, significant and potentially phytotoxic levels of chromate have been found in soil solution* (Oze et al., 2004; Becquer et al., 2003; Copper, 2002)." McBride concludes that "a similar oxidation of mineral Cr(III) to soluble chromate could occur in COPR contaminated soils."

McBride cited Chung et al. (2001) that found in a *"serpentinitic aquifer material in Davis, California, chromate was being generated continuously, and well water in the area was contaminated with chromate at concentrations as high as 200 ppb Cr."* McBride concludes that "*this proves that at a slightly alkaline pH (about 8) in a subsoil with low organic carbon, problematic amounts of chromate can be formed from stable Cr(III) in mineral and released into groundwater. The mean total Cr concentration in these subsoils was only 216 ppm, much lower than concentrations than concentrations that will be permitted in the COPR-contaminated soils under the NJDEP proposed criteria*."

There are several other studies that investigate oxidation of Cr(III) in waste materials with mixed results.

Pillay et al. (2003) - weathered slag - "trivalent chromium in alkaline slag is amenable to atmospheric oxidation."

Chuan and Liu (1996) observed that oxidation of Cr(III) species from tannery sludge amendments (high in organic matter) was slower than when pure Cr(III) species are added to soil.

James (1994) - found that at pH 8 to 10, neither oxidation nor reduction occurred when soluble Cr(VI) was added to a high-Cr(VI) soil and to a low-Cr(VI) soil.

James (2002) points out that "aged, less soluble, and more crystalline forms of Cr(III) (e.g. Cr_2O_3) are much less prone to oxidation."

Geelhoed et al. (1999) - at low pH (below pH 5) and low Cr(III) concentration, oxidation is fairly rapid - but at pH above 5, Cr(III) precipitates on the Mn-oxide surface, thus restricting the reaction.

Approximately 12 studies out of 16 document confirm oxidation of Cr(III). Two studies found unequivocal results, both of which were conducted by Bruce R. James[69]. Therefore, the weight of scientific evidence clearly suggests that the current criteria for Cr(III) is problematic. According to Court's recent Decision in ICO V. Honeywell : "If an error is to be made……., the error must be made in favor of protecting public health, welfare and the environment."[70]

H. As applied, the Current Chromium Criteria do not provide long term protection

Degradation rates of chromate waste suggest that it will take decades, if not centuries, for chromium concentrations to reach levels that pose no risk to public health and the environment. NJDEP's increasing reliance on engineered barriers and institutional controls of persistent chemical constituents is reported to be "problematic".

Regulatory Decisions are Reactionary vs. Precautionary

Discussions and deliberations were constrained, dominated and largely shaped by Site Remediation Workgroup members. Although the scope of our review was intended to be strictly scientific – at several key junctures – Site Remediation managers cited law to trump science claiming that the law tied NJDEP hands. (For the record, several members of the Workgroup disagreed with these interpretations of state law)

NJDEP's regulatory decisions on chromium are based on a reactionary approach requiring "*definitive scientific evidence"* before taking action or making recommendations. According to the Site Remediation Workgroup members this reactive approach is supported in the state's Brownfield Act. The Act encourages the use of institutional controls (capping and deed restrictions) and long term management.[71] The Act allows NJDEP to take additional remedial steps only after the institutional controls fail to be protective.[72] This approach rejects precaution and has proven not to serve the public health interest well.

The National Academy of Science (NAS) has examined the capabilities and limitations of long term management of institutional controls at DOE hazardous waste sites. NAS has concluded this remedial approach is inherently prone to failure[73].

Examples of Failed Institutional Controls:

- Love Canal – Occidental Chemical (Hooker) deeded land previously used for chemical disposal in 1953 to the town School Board; in 1954, a school built over landfill

- In the 1990s, DOE transferred land at Oak Ridge site to local government with deed restriction prohibiting groundwater wells; within 10 years, wells were installed to irrigate the golf course. Contaminated groundwater was pumped out onto the course and exposed the public to the contaminants.[74]

- Oregon homes built on landfill in 1990s, despite requirement to submit local land use plans to state; domestic wells contaminated.

- Anderson Island, Louisanna, deed restriction failure. The site had been a former refinery and deed restrictions were placed on the site. The developers were well aware of the restrictions but chose to ignore them. A housing development was built on the site in violation of the deed restriction. The homeowners are now suing the former refinery owner.[75]

- Two landfill caps at Wright-Paterson AFB in Ohio have already been breached, in violation of IC's within 5 years of ROD.

- Grand Junction UMTRCA mill site—city did not follow deed restriction requiring submittal of construction plans to state for review

Recent Reports expressing concerns with Institutional Controls (ICs):

- "ICs have weaknesses in terms of long-term reliability" (EPA, 1998)

- "there is little or no evidence demonstrating the effectiveness of …. IC's" (DOE 1997)

- "the working assumption… must be that many stewardship measures… will eventually fail" (National Academy of Sciences 2000)

- "In Colorado, we have everything we need to implement institutional controls, except institutions and controls." (D. Miller, 1998)

Capping at best can only provide short-term protection by temporarily preventing moisture from entering the waste area. Over time, liners fail through physical and chemical weathering processes in addition to changes in the pH and redox characterization of the soil, ultimately leading to metal remobilization. HDPE geomembranes are particularly susceptible to degradation in the presence of transition metals such as Cu, Mn, Cr and Fe. Transition metals may significantly enhance the oxidation rate of a geomembrane by breaking down the hydroperoxides present in the geomembrane and creating additional free radicals. The transition metals in the presence of moisture or liquid have also been found to diffuse into the geomembrane and accelerate degradation (Rowe and Sangam, 2002). Laboratory results have found that the oxidation rate of a geomembrane increased by a factor of 10 or more depending on the metal.

Evaluation of the Effectiveness using Institutional Controls on COPR sites

Chromite ore processing residue (COPR) sites are primarily located adjacent to and, in many instances, over former wetlands that were once inundated with water. Geotechnical conditions and the soil characteristics at these sites present particular challenges that require special considerations and extra precaution when evaluating risk and remedial decisions.

Associated Problems

Numerous problems have been observed due to a lack of understanding of the physical properties of the subsurface conditions at sites very similar to the conditions at COPR sites. They include:

Excessive Settlement

Excessive settlement is a primary concern at COPR sites located on or near the meadow mat. These areas are commonly highly susceptible to compression and have a low bearing capacity due to the high water content in the soils. Some studies have shown that these soils (marshy) may compress from 25% to 50% of their original thickness (Jack McCormick and Assoc., 1974). Settlement of this magnitude would be detrimental to caps or foundations supported by the soils because cracks would develop.[76]

Differential settling is more problematic. Differential settlement is commonly the result of varying subsurface conditions or nonuniform weight distribution. Differential settlement may cause utility pipes (gas, water and sanitary) to break.

Frost Heave

Frost heave cause significant damage by cracking pavements and roads in Hudson County each year. The principal factors that contribute to the frost heave of soils are: the capillary (pore structure) characteristics; shallow groundwater table; presence of dissolved salts (tends to increase the surface tension of the water and thereby attracts more capillary water).

It is well recognized that roads and buildings are subjected to rapid deterioration due to precipitation of salts and minerals in the water-soluble phase.[77] Thus, this would also apply to the capping materials used at COPR sites.

Solutions

Excessive settlement and frost can be prevented by excavation of the susceptible soils and replacing them with clean granular material such as sand or gravel. This obviously would cause a problem if the soils are contaminated with chromium.

Comment

The weight of evidence does not support the long-term effectiveness of NJDEP's current remedial approach (capping and deed restrictions) for COPR contaminated sites. Dr. McBride corroborates this position. He states: *"The current DEP remedial approach of using capping and deed restrictions of COPR sites seems to me to be a stop-gap short-term approach that does not deal effectively to mitigate the large amount of potentially mobile chromate in soils and wastes at these sites. Depending on the hydrology of the sites, this chromate in soils and wastes at these sites. Depending on the hydrology of the sites, this chromate may still migrate into surface waters, basements, and other locations where human and animal exposure is possible."*

VI. Examination of Chromium Review Process

The integrity of science depends on consistently applied rules and procedures to protect against conflicts of interest. In the Workgroup's case, such protections were inadequate. Many of the proposed recommendations are based on non-peer reviewed data, internal NJDEP studies, and personal correspondence.

In light of major litigation cases, the process by which the report was produced must be examined. Recent reports by preeminent scientists have claimed widespread and unprecedented "manipulation" of science in government. In November 2003, a panel commissioned to review California's chromium drinking water standard, was accused of being biased and having conflict of interests with industry. One member, Dr. Dennis Paustenbach, served as an expert witness for Pacific Gas and Electric in the chromium case in Hinkley, California. In the 1990s, Paustenbach and his company (ChemRisk and later Exponent) published numerous studies on hexavalent chromium. California has since shelved the report.

Weaknesses in the Workgroup Review Process

Many of the Workgroup members from the Site Remediation & Waste Management Program and technical studies they reviewed were directly responsible for past remedial decisions. This was problematic because the subject of our review was their Program's policies and procedures. Conclusions and recommendations were influenced by personal experience and observations rather than on newly published studies or data.

In the 1990s, New Jersey's chromium soil cleanup criteria for Cr (VI) increased from 10 ppm to levels that range as high as 6100 ppm and Cr (III) increased from 500 ppm to 120,000 ppm. Studies funded primarily by a responsible party (Maxus Energy) contributed to these increases. According to testimony by Dr. Paustenbach, consultant, in the Aguayo vs. PG&E lawsuit, he testified that his firm was paid approximately $7.1 million dollars by Maxus Energy for his work on the New Jersey chromium criteria.[78] The Workgroup's evaluation of chromium risk via inhalation, ingestion and contact dermatitis are based on many of these same studies.

The Workgroup neglected to review the documents in the appropriate context. The basis for the Workgroup and the public's renewed interest in chromium criteria is a result of a series of memoranda, newspaper articles, and a major federal litigation suit both in New Jersey and California. A thorough review of these documents was critical. The expert testimony in the Federal District Court's Decision would have provided a better understanding of the relevance of the scientific issues. Regrettably, the process did not accommodate analysis of these types of issues.

To prevent undue influence from special interests, rules should have been established to deal with uncertainty, technical disagreements, and to disqualify data or research papers that may give the appearance of a conflict of interest.

Lack of Policies and Procedures

The review lacked the proper policies and procedures, resulting in applying scientific principles incorrectly and arbitrarily. The following statements contained in the report are of primary concern:

- "*recommendations were made only for issues where definitive scientific evidence was presented*"

- The workgroup was "*polarized in their professional judgment about some of the issues.*"

- Recommendations are not to result in "*retroactive application.*"

The report does not provide the references or citations on many of the recommendations. Nor does it provide the rationale used to determine whether there is definitive scientific evidence. The report also should have identified the "polarizing" issues because it would have given an opportunity for experts in soil chemistry and engineering to respond to some of these controversial issues.

The statement that the recommendations will not be applied retroactively is also of particular concern because we are knowingly condoning past mistakes. Since the majority of Workgroup members were from the program responsible for past remedial decisions on chromium sites, it is not surprising that the report concluded that the 1998 chromium cleanup criteria are "based on the science currently available." Under the circumstances, it is inconceivable that a genuine and fair review of any controversial issue could be conducted without allowing for scientists with differing views to present and discuss their findings.

Failure to Account for Uncertainty and Weight of Evidence in Recommendations

Many of the recommendations in the Chromium Workgroup Report reveal a high degree of uncertainty. Scientific uncertainty is unavoidable. The report should have explained how "scientific uncertainty" would be incorporated into environmental management decisions. Unfortunately, the report recommends deferring scientific uncertainty to a long list of research projects. Although, I endorse the need for more research, I also recognize that research dollars are finite and would most likely have limited value in accelerating cleanups. The report did not make any recommendations on how to proceed in the absence of this research.

The weight of scientific evidence is a standard requiring a qualitative examination of the quality of the studies, the consistency of results, the nature and severity of effects and the degree of statistical significance. Documenting how the weight of evidence is evaluated is an indispensable part of the scientific method. Since the Workgroup did not document how weight of evidence was applied, it is very difficult for anyone outside the Workgroup to judge whether the decision was biased or not.

Weaknesses in the Peer Review Process

Full disclosure of information and reports to peer reviewers is critical for assessing the report's accuracy and intent. These documents were vital for the peer reviewers to fully understand the context of their review. Instead the panel, as reflected in their comments, reviewed the report as a literature review. In spite of incomplete information, the panel's comments raised concerns regarding safety factors, which went largely, ignored. Although the reviewers agreed with the report's primary recommendation that more research is required, they did not appreciate the regulatory significance their review would have on future remedial decisions. In the meantime, the report fails to address how the Department should proceed.

Appendix

The New Jersey Chromium Workgroup did not review the NTP data, nor many of the studies cited by OEHHA in its efforts to develop a drinking water standard for chromium. These studies include:

MacKenzie, RD, Byerrum, RU, Decker, CF, Hoppert, CA, Langham, RF (1958). Chronic toxicity studies, II. Hexavalent and trivalent chromium administered in drinking water to rats. *Am. Med. Assoc. Arch. Ind. Health* **18**, 232-234. This study showed no adverse effects at a level of 2.4 mg/kg-day.

Costa, M (1997). Toxicity and carcinogenicity of Cr(VI) in animal models and humans. *Critical Reviews in Toxicology* **27**, 431-442. This study reviewed evidence that Cr(VI) is taken up by the GI tract and transported to all tissues of the body.

Hueper, WC (1955). Experimental studies in metal carcinogenesis. VII. Tissue reactions to parenterally introduced powered metallic chromium and chromite ore. *J. National Cancer Institute* **16**, 447-462.

Maltoni, C (1976). Predictive value of carcinogenesis bioassays. *Ann. Science* **271**, 431-443.

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1 Memorandum from Eileen Murphy to Commissioner Campbell – March 24, 2004
2 Memorandum from Eileen Murphy to Commissioner Campbell – March 24, 2004

3 Email correspondence June 22, 2004 from Eilleen Murphy, Director; Email transmitted response from Dr. Robson, supervising chair of workgroup; and Assistant Commissioner Jeanne Herb – They directed workgroup to start the review with the 1998 proposed standards, thus assume current criteria are protective. Workgroup was instructed not to revisit past remedial decisions . Robson's email also directed Murphy to "remind" the Workgroup that "it is not their place to challenge" the final word of the Commissioner. The workgroup "HAVE TO ACCEPT" the decision.

4 NJ Chapter of Sierra Club, June 2, 2005 –Review of NJ Department of Environmental Protection cleanup criteria for COPR - M.B. McBride, Dept. of Crop and Soil Sciences, Cornell University

5 Bagdon and Hazen (1991)

6 NJ Chromium Workgroup Report, Chapter 1; page 6 3rd paragraph: "the NJDEP Chromium Workgroup has determined that the cleanup criteria for C(III) and Cr(VI), initially proposed in 1998 (Table 1.1), are based on the science currently available."

7 "Heaving" is responsible for millions of dollars of damage to roads and building foundations. In general, heaving occurs under the following conditions: freezing temperatures, frost susceptible soils (fine sand and silts are very susceptible to heaving) and a relatively shallow groundwater table.

8 Robert Hazen Ph.D in Biology, New Jersey Department of Environmental Protection Division of Science and Research.

[9] Bagdon, R.E., and Hazen, R.E. (1991). Skin Permeation and cutaneous hypersensitivity as a basis for making risk assessments of chromium as a soil contaminant. Environ. Health Perspect. 92:111-119.

10 United States Court of Appeals for the Third Circuit Interfaith Community Organization v. Honeywell International, Inc.1. Legal Standard - Conservation Chemical, 619 F. Supp. at 1994

11 Chromium Workgroup Report, Chapter 1, paragraph 1, sentence 10 –"However, recommendations have been made only for issues where definitive scientific evidence was presented."

12 Julia Barringer, Ph.D. Geology; specializing in geochemistry; University of Pennsylavania

13 Response by Julia Barringer to SRWMP Draft Comments on Small Particle Size Enrichment and Unsaturated Flow Concentration Effects Drafts of Theodore Hayes, Roger Page, and Julia Barringer – Dated July 13,2004

14 NJ Chromium Workgroup Report, Chapter 6, page , paragraph 5, "By treating the COPR material as a continuing contaminant source, it falls outside the scope of the impact to groundwater soil clean-up standards, which pertains to calculation of clean-up standards for contaminated soil."

15 Dr. Kirk Brown, professor emeritus at Texas A&M University, testified in great detail that the "only appropriate remediation.." is to " remove it, treat it, and bring in new clean fill."

16 "Evaluation of the Medium to Long-Term Effectiveness of Capping at COPR Sites", by Zoe Kelman, August 9, 2004 revised November 24, 2004

[17] New Jersey Chromium Report, Chapter 3, page 33, first paragraph:" *there is insufficient evidence from any individual occupational epidemiological study to conclude that* Cr^6 *is carcinogenic by ingestion. The group also concluded that it did not seem likely that a meta-analysis across these studies would provide a clear qualitative determination of ingestion carcinogenicity or provide a useful cancer potency estimate. The group recognizes that this conclusion is speculative, and that a firm determination of the usefulness of a meta-analysis requires a close examination and quantitative analysis of the individual and aggregate studies. However, the committee also recognizes that such an examination and analysis could not be completed within the allotted time frame."*

[18] Joint Information Hearing of the Senate Committee on Health & Human Services; Senator Deborah Ortiz, Chair Senate Committee on Natural Resources & Wildlife; Senator Tom Hayden, Chair and the Assembly Enviornmental Safety & Toxic Materials Committee; Assemblymember Hannah-Beth Jackson, Chair "Health Effects of Chromium VI Contamination of Drinking Water" October 24, 2000, Burbank, California

19 Cielo Fernandez-Ortega, Zhang Z, Froines J.Department of Epidemiology, School of Public Health Chromium Exposure and Gastric Cancer. A Combined Analysis

[20] Findings of the Scientific Review Panel on **THE REPORT ON DIESEL EXHAUST**
as adopted at the Panel's April 22, 1998, Meeting – page 6, bullet 17: "Over 30 human epidemiological studies have investigated the potential carcinogenicity of diesel exhaust. These studies, on average, found that long-term occupational exposures to diesel exhaust were associated with a 40 percent increase in the relative risk of lung cancer. The lung cancer findings are consistent and the association is unlikely to be due to chance. These epidemiological studies strongly suggest a causal relationship between occupational diesel exhaust exposure and lung cancer."

21 February 1999, Office of Environmental Health Hazard Assessment California Environmental Protection Agency, "Public Health Goal for Chromium in Drinking Water".

[22] The National Toxicology Program (NTP) is currently conducting a chronic cancer bioassay (ingestion exposure) for Cr(VI) .

23 Davidson, Kluz, Burns, Rossman, Zhang, Uddin, Nadas, Costa, 2004, Exposure to chromium (VI) in the drinking water increases susceptibility to UV-induced skin tumors in hairless mice; Toxicololgy and Applied Pharmacology 196 (2004) 431-437

[24] Dr. John Froines Testimony to Senate Hearing of the Senate Health and Human Services Committee "Possible Interference in the Scientific Review of Chromium VI Toxicity", February 28, 2003 Los Angeles, California

25 NJDEP Chromium Workgroup Report, Chapter 3, Risk Assessment, page 37, 2nd bullet

[26] NJDEP Chromium Workgroup Report, Chapter 3, Risk Assessment, Page 37, 3rd bullet

27 06/16/2003 By JIM MORRIS / The Dallas Morning News

28 Chromium Workgroup Report, Chapter 1, paragraph 1, sentence 10 –"However, recommendations have been made only for issues where definitive scientific evidence was presented."

[29] Cohen, M.D., Kargacin, B., Klein, C.B., and Costa, M., Mechanisms of chromium carcinogenicity, Crit. Rev. Toxicol., 23, 255, 1993.

[30] The carcinogenicity of Hexavalent chromium is based on 50 years of epidemiological studies of workers. Environmental Protection Agency, *Toxicological Review of Hexavalent Chromium* (1998)

[31] Hansen M.B.; Rydin S.; Menne T.; Duus Johansen J; "Quantitative aspects of contact allergy to chromium and exposure to chrome-tanned leather"; Contact Dermatitus, Volume 47, Number 3, September 2002, pp. 127-138(8); Blackwell Publishing

[32] Dr. Belsito is board certified in three areas – internal medicine, general dermatology and dermatological immunology. Dr. Belsito testified as an "expert witness" on behalf of W.R. Grace in ICO v Honeywell.

[33] It is known that some children exhibit pica for soil (deliberate ingestion of soil and that these children have soil ingestion rates well in excess of the typical ingestion levels used in the IEUBK model or EPA risk assessments.

[34] Office of Environmental Health Hazard Assessment California Environmental Protection Agency; February 1999; Public Health Goal for Chromium in Drinking Water

[35] Alan H. Stern, Jerald A. Fagliano, Jonathan E. Savrin, Natalie C.G. Freeman, and Paul J. Lioy The Association of Chromium in Household Dust with Urinary Chromium in Residences Adjacent to Chromate Production Waste Sites - 1998

[36] Rosenmand and Stanbury 1996; found that workers employed in industries producing chromium compounds had significantly increased nasal and sinus cavity cancers. Satoh 1994; reported four cases of nasal carcinoma in workers employed for greater than 19 years in a chromate factory in Japan.

[37] The NTP (National Toxicology Program) study is a bioassay of Cr^{+6} ingestion. Results from this study are expected to provide qualitative and/or quantitative information to develop a standard for toxicity and carcinogenicity from ingestion. Results are not expected for at least two years and possibly longer.

[38] Response to Peer Review Comments, Chapter 3, page 6 – Risk Assessment Subgroup -"Based on the reviewer's assessment of the data (with which we are in agreement), we believe that this analysis is over-reaching in an attempt to establish protectiveness. Given the many uncertainties in both datasets, we do not believe that even this relatively simple calculation is supportable."

[39] Dr. Froines is Associate Director of the Southern California Environmental Health Sciences Center and the Director of the UCLA Fogarty Program in Occupational and Environmental Health. Dr. Froines chairs the State of California's Scientific Review Panel; the central review panel at the State level for identifying toxic air contaminants.

[40] Personal email correspondence with J. Froines, 9-10-05.

41 Executive Summary, page 7, 2nd sentence.

42 Proctor, D.M., Otani, J.A., Paustenbach, D.J., et al. 2002. Is Hexavalent Chromium Carcinogenic via Ingestion? A Weight-of-Evidence Review. Journal of Toxicology and Environmental Health, Part A, 65: 701-746.

[43] Cancer Mortality in a Chinese Population Exposed to Hexavalent Chromium in Water. Journal of Occupational & Environmental Medicine. 39(4)315-319, April 1007. Zhang, Jin Dong MD; Li ShuKun MD

[44] The National Toxicology Program (NTP) is currently conducting a chronic cancer bioassay (ingestion exposure) for Cr(VI) .

[45] Meegoda, Kamolpornwijit, Vaccari, Exeldin, Noval, Mueller, Santora, Remediation of Chromium-Contaminated Soils: Bench-Scale Investigation Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management/ July1999

[46] Henry, K.S. (2004) Evaporative Deposition of Chromate Salt in Northern New Jersey and Means to prevent it, Tierra Solutions, Inc.

[47] page 113, 1st paragraph, 9th sentence: "Given the complexity of the factors involved, it is determined that it is too difficult ……" to predict when capillary transport would be a concern."

[48] Page 124, Research 2nd bullet: "….. it is recommended that a study be conducted to investigate the potential occurrence of surface enrichment due to capillary transport of hexavalent chromium."

[49] The carcinogenicity of Hexavalent chromium is based on 50 years of epidemiological studies of workers. Environmental Protection Agency, *Toxicological Review of Hexavalent Chromium* (1998)

[50] Analysis Paper: Impact of Lead-Contaminated Soil on Public Health: Agency for Toxic Substances and Disease Registry, Atlanta, Georgia 30333 May 1992

[51] EPA #540-F-00-010; OSWER #9285.7-38; April 2000; Short Sheet: TRW Recommendations for Sampling and Analysis of Soil at Lead (Pb) Sites; Office of Solid Waste and Emergency Response U.S.E. P.A. Washington, DC 20460

[52] Response by Julia Barringer to SRWMP Draft Comments on Small Particle Size Enrichment and Unsaturated Flow Concentration Effects Drafts of Theodore Hayes, Roger Page, and Julia Barringer – Dated July 13,2004

[53] Response by Julia Barringer to SRWMP Draft Comments on Small Particle Size Enrichment and Unsaturated Flow Concentration Effects Drafts of Theodore Hayes, Roger Page, and Julia Barringer – Dated July 13,2004

[54] November 22, 1995 – Response to NJDEP Comments on Particle Fractionation - Sites 112A and 016

[55] PPG Industries, Chrome Fractionation Information, March 17, 1997 -

[56] Roger Page, Civil Engineer PhD., New Jersey Department of Environmental Protection, Site Remediation Program

[57] Roger Page July 21, 2004 Reasons for Presenting PPG Data for HCL75, HCL10 and HCBULK in Chromium Committee Report.

[58] Email from Eileen Murphy acknowledges that Roger Page's technical background ….

[59] Draft White Paper; Charges Relevant to Concentration on Thoracic and Respirable Particles

[60] Chromium Workgroup Report Executive Summary page 3, paragragh 3, first sentence

[61] NJ Chapter of Sierra Club, June 2, 2005 –Review of NJ Department of Environmental Protection cleanup criteria for COPR - M.B. McBride, Dept. of Crop and Soil Sciences, Cornell University

[62] NJ Chapter of Sierra Club, June 2, 2005 –Review of NJ Department of Environmental Protection cleanup criteria for COPR - M.B. McBride, Dept. of Crop and Soil Sciences, Cornell University

[63] New Jersey Chromium Workgroup Report, Chapter 2 , page 23, last sentence.

[64] Robert Hazen, NJDEP Division of Science and Research, Preliminary Estimate of Cr(VI) Groundwater Concentration for Production of Critical Cr(VI) Air Risk in Interior Spaces.

[65] NJDEP Chromium Report, Chapter 1, page 8: "After much discussion within the subgroup, it appears that there is not a preponderance of evidence in the published literature to warrant a change in the determination of soil clean-up levels based on oxidation reactions."

[66] NJDEP Chromium Report Chapter 6, page 123: " It is believed that proposed clean-up standards for chromium will be protective of human health; however it is recommended that oxidation rates of Cr(III) in COPR be further investigated…"

[67] M.B. McBride, Ph.D., submitted comments on behalf of the NJ Sierra Club. McBride - Dept of Crop and Soil Sciences, Cornell University

[68] Moerman (1996) Advanced Characterization and Leaching Behavior of Hexavalent and Trivalent Chromium from Waste Material

[69] Bruce R. James, Professor of Soil Chemistry, University of Maryland – submitted public comments on behalf of Tierra Solutions, Inc., Chromium Responsible Party.

[70] Conservation Chemical, 619 F. Supp. at 1994.

[71] The Act at NJSA 58:10B-12g(2) states "Contamination may, upon the department's approval, be left onsite at levels or concentrations that exceed the minimum soil remediation standards for residential use if the implementation of institutional or engineering controls at that site will result in the protection of public health, safety and the environment

[72] The Act at NJSA 58:10B-13f states "Whenever the department approves or has approved the use of engineering controls for the remediation of soil, groundwater, or surface water, to protect public health, safety or the environment, the department may require additional remediation of that site only if the engineering controls no longer are protective of public health, safety, or the environment."

[73] The National Academies' National Research Council reported in 2000 that "due to inadequate funding, and lack of any convincing evidence that institutional controls -- such as surveillance hazardous wastes left at sites,

security fences, and deeds restricting land use -- will prove reliable over the long term."

[74] Transcript of Trial Proceedings Volume 8; ICO v Honeywell; January 28, 2003; Testimony of Kirk Wye Brown Ph.D Pages 1596 - 1598

[75] Transcript of Trial Proceedings Volume 8; ICO v Honeywell; January 28, 2003; Testimony of Kirk Wye Brown pages 1596-1598

[76] Whitlock, Moosa, Foundation Design Considerations for Construction on Marshlands; Journal of Performance of Construction Facilities/ February 1996

[77] French, Poole, Ravenscroft, Khiabani, Results of prelininary experiments on the influence fabrics on the migrationof groundwater and water-soluble minerals in the capillary fringe. Department of Geological Science, Queen Mary College, London, The Geological Society 1982

78 February 28, 2003 California Senate Hearing of the Senate Health and Human Services Committee, "Possible Interference in the Scientific Review of Chromium VI Toxicity" Deposition of Dr. Dennis Paustenbach, August 29th, 2002.