
INTEROFFICE MEMORANDUM

TO: COMMISSIONER CAMPBELL

FROM: ZOE KELMAN, SITE REMEDIATION AND WASTE MANAGEMENT PROGRAM

SUBJECT: NEW JERSEY CHROMIUM WORKGROUP REPORT

DATE: 11/14/2005

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Text in red and in 12 pt font reflects responses from the workgroup chair, with assistance from the subgroup chairs. Not every point was commented upon, as there were time constraints. Many of the criticisms of the chromium workgroup raised in this memo seem to represent criticism of the risk based paradigm in general. The chromium cleanup criteria are based on the current risk based paradigm and not on a precautionary paradigm, although the two are not necessarily mutually exclusive. It is the tool that both the federal and state government uses for determining “acceptable” risk. Other paradigms have been addressed in recent years and include the precautionary approach. This is a valid approach and deserving of attention. However, it is beyond the purview of this workgroup to change the paradigm.

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. **The 1998 criteria formed the framework and starting point for the workgroup deliberations and critical examination of the soundness of these criteria was the crux of the workgroup charge. As the charge of the workgroup was to examine the current science underlying the cleanup criteria and not to evaluate remedial decisions, reviewing remedial decisions, whether they were current or past, was not conducted.**

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. **In fact, the report was authored in chapters, with each subgroup chair authoring the chapter for that subgroup. There were four such chapters, and four such authors. None of the chapter authors were from the site remediation program. Further, an outside panel of experts was convened and asked to review the document. The comments from the peer review did not result in substantive changes to the recommendations of the workgroup.**

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
Zoe Kelman
Hazardous Site Mitigation Engineer
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**

It is customary to put the acknowledgments section after the front page. Also it is typical to specify the type of assistance provided (advice, proofreading, technical assistance, or help with preparation of the paper).

It was discovered inadvertently that one of the individuals listed on the front page was unaware that this was being done. The person was concerned that having his name on the front page implied concurrence where it did not necessarily exist.

Therefore, NJDEP correspondence was initiated with each of the individuals acknowledged in the acknowledgements to determine their levels of concurrence.

- Dr. Hazen, from DEP, reiterates that while he has issues with the workgroup report, he does not formally endorse this memo.
- Dr. Page, from DEP, feels that the factual information provided is reflected truthfully.
- Mr. McKee, retired from NJDEP in July 2004, continues to not respond to any emails from the chair of the workgroup. Despite repeated solicitations from the workgroup chair, Mr. McKee did not participate in workgroup deliberations after his retirement.
- Mr. Posey, from DEP, admits that he proofread the memo.
- In an email to Zoe Kelman, Dr. Barringer, from USGS, states, “My role was strictly to give advice on scientific issues. Therefore, I cannot take any stance on policy issues in the final Workgroup Report. Nor can I take any stance on policy issues in any minority reports that might arise, including your report. My only stance regarding any reports is supporting accurate descriptions of relevant scientific findings--this describes my role as a member of the Chromium Workgroup, and my role as a scientist.”
- Dr. Froines from UCLA wrote, “I am not a co-author and my name should not appear on a cover page.” In a subsequent email, he wrote, “I have reviewed the chromium document and found references to me on pages 15-17 [*refer to pages 26-28 in this response to the memorandum*], 20 [*refer to page 30 in this response to the memorandum*] and 25 [*refer to page 38 in this response to the memorandum*]. The work described on pages 15-17 should be deleted and I have recently communicated that to Ms. Kelman. While we conducted an initial study that resulted in the findings described, we did not go further and complete the study for submission to a peer reviewed journal. The work has not been peer reviewed and published and therefore I don't consider it appropriate for inclusion in your report. The references to me on pages 20 [*refer to page 30 in this response to the memorandum*] and 25 [*refer to page 38 in this response to the memorandum*] are fine with me.”

REPORT TO THE NJDEP COMMISSIONER 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. **The workgroup examined the scientific validity of the cleanup numbers. It was beyond the purview of the scientists on the workgroup to investigate remediation controls.** 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. **The workgroup report pertained to the cleanup numbers and did not make any recommendations on remediation engineering controls such as capping.**

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 COMMISSIONER 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, (Court decisions, while informative, are not scientific studies and therefore cannot be used as scientific evidence) a series of in-depth newspaper articles, (newspaper articles, while interesting, are not scientific evidence) and an internal review by New Jersey Department of Environmental Protection (“NJDEP”) scientists (the original Hazen et al. (2004) report formed the starting point for the workgroup deliberations) 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. The author confuses the workgroup’s task with broader policy decisions that are made by upper management at NJDEP. The task of arriving at consensus on the weight of evidence is not the same as the task of deciding how to act under uncertainty. The current paradigm for doing this is to use the risk management approach. It is the tool that both the federal government uses and all states in the US use for determining “acceptable” risk. Other paradigms have been introduced and discussed in recent years and include the precautionary approach. This is a valid approach and deserving of attention. However, it is beyond the purview of this workgroup to change the paradigm.

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*. While not everyone on the workgroup completely agreed with every aspect of the report, they agreed that the report reflected the weight of evidence. There continues to be disagreement among participants.

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. While a formal peer review has not been conducted on the 1998 criteria, the criteria are based on extensive public comments received from the 1995 interested party review. The 1998 criteria take into consideration the comments generated from the interested party review of the 1995 effort. (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. While responsible party funding serves as a red flag, the funding itself is not, in and of itself, a reason to reject a study. The studies used to provide the basis of the 1998 criteria have been peer reviewed, published in a refereed journal, or reviewed and accepted by the NJDEP.

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. **Workgroup members were uncertain what to use as the “starting point”.** The starting point was always assumed to be the 1998 criteria, which are the most recent standards. But one member asked if we should use an earlier number and discount the 1998 criteria altogether. The resulting June 22, 2004 email to the Env. Chem. Subgroup states:

“An issue came up at our last meeting regarding the "starting point" for the charges. I explained that the group determined during its first meeting that the starting point was the proposed soil standards (which, at the time, were undergoing internal NJDEP review). Tom McKee expressed concern and thought we should start with what the Dept. has been using historically.

I brought the issue to the attention of the supervising chair, Dr. Mark Robson and to Asst. Commissioner Jeanne Herb. Both felt that we should start with the proposed soil standards. Attached are Dr. Robson's comments.

When writing pieces to address our charges and when discussing issues, keep in mind that our starting point will be the proposed soil standards (with whatever modifications we make for chromium).”

This does not presume the validity of the criteria. In fact, it questions them, as was appropriate for the task at hand.

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 **As indicated in the above response, upon Mr. McKee’s request, the chair posed the question to Dr. Robson and Ms. Herb and received guidance, which is different from “sought and obtained concurrence for this decision”.** 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. **All the studies that were reviewed were done so with the 1998 criteria in mind.** It is difficult to understand how after directing the Chromium Workgroup to not review the 1998 chromium criteria (again, the group did review the 1998 criteria and any subsequent pertinent information that had been published since that evaluation), that the main

conclusion of the Workgroup's report is that the 1998 chromium criteria are based on the science currently available. **All evidence supported the numbers in the 1998 criteria.**

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. **This is perplexing. The currently used criteria were those proposed in 1998. Of course that was the starting point. As no additional evidence was presented to contradict these criteria and because published information available after 1998 in fact support the criteria, they were determined to be based on the available science. The report stipulates that as new information becomes available (i.e., final results from the National Toxicology Program study), the criteria should be revisited with the new information in mind. It is not clear where the author feels the group should have begun its deliberations.**

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. **There are substantive recommendations in the report, such as the addition of a formalized process for developing and reviewing Alternative Remediation** 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. **Any and all scientific evidence was reviewed and considered. There was no presumption. The 1998 criteria were critically examined against the recent science. Had any evidence been presented or any proposals submitted to alter the numbers developed in 1998, they were acknowledged and reviewed. There was no information presented indicating different numbers.**
- 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. During the window when stakeholders were invited to submit articles and material for consideration by the workgroup, over 300 pieces were received from responsible parties or their consultants. Each of these pieces were reviewed against the criteria established by the workgroup (description of the criteria is attached). Most of the articles submitted by responsible parties were rejected. Only work that met the criteria developed and accepted by the workgroup was used in the formation of recommendations. Throughout the workgroup deliberations, all members were encouraged to bring forward all pertinent information for evaluation. Many did. The only restriction was that the information meets the standards developed and accepted during the first workgroup meeting. Funding information was evaluated more stringently during this effort. Scientific studies funded by responsible parties were considered with greater skepticism than government-funded studies. However, funding source alone was not reason enough to reject a study outright. It served as a red flag.

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). Members of the workgroup agreed unanimously that chromate blooms occur. The disagreement among the members pertained to the capacity of soils having lower chromium levels to develop blooms; that is, to what extent does enrichment occur at relatively low levels of hexavalent chromium in the soil. To date, blooms have only been observed in areas having very high levels of chromium. Unfortunately, there was no evidence presented to quantify this process at low levels and no proposal for producing a model was submitted.
- 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 ingestion effects were reviewed by the Risk Assessment Subcommittee and found not to be sufficient to justify the development of a standard at this time. The subcommittee further lists the studies that are known to be on-going with the caveat that these studies be reviewed and used to update the criteria, as appropriate.
- 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/cm². The soil loading value was **not** taken from studies by Finley and Horowitz. It was taken from the value recommended in EPA's

Risk Assessment Guidance for Superfund (RAGS)-Part E. 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 risk assessment subgroup agreed that, given the uncertainty inherent in the range of possible soil adherence/loading values, the use of a reasonable maximum exposure value was appropriate. The group therefore concluded that a soil adherence factor of 0.2 mg/cm² should be used. This value is surface area-weighted for a child resident up to 6 years of age wearing a short-sleeved shirt and shorts with no shoes. The recommended weighted adherence factor is based on the 95th percentile (upper end) adherence factor for children playing at a day care center (typical soil contact activity) or the 50th percentile (central tendency) adherence factor for children playing in wet soil (high end soil contact activity). This value is also protective of the adult in a residential setting because the corresponding adherence factor for an adult is given as 0.07 mg/cm². For a nonresidential exposure under a reasonable maximum exposure scenario, a soil adherence of 0.2 mg/cm² is applicable. This is surface weighted for an adult since children in the work place are considered to be atypical.**

- 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 direct that site-specific criteria be established to protect ground and surface water because of the difficulties and complexities of doing so in a generic fashion. This is very different from saying there is no standard.**
- 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. **The evidence in the scientific literature does not show that oxidation occurs to a significant extent in the conditions known to occur in Hudson County. However, workgroup members presented several convincing scenarios whereby oxidation may occur. As a result of these discussions, it was acknowledged in the report that oxidation probably does occur in some areas in Hudson County but that the rate is so slow as to be insignificant.**

- 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. **The task of the workgroup was to evaluate the science behind the chromium cleanup criteria and not on engineering controls used for remediation efforts.**
- DEP's practice of approving remedies that leave high concentrations and large volumes of hexavalent 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. **The 1998 cleanup criteria are effective for any land use area, taking into account both residential and nonresidential land uses.**
- 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. **A telephone conversation between Dr. Murray McBride and the workgroup chair in June indicated that Dr. McBride had not reviewed the workgroup report but, instead, reviewed the Hazen et al. (2004) report. Upon his request, the workgroup chair mailed him the draft Chromium Workgroup Report and background material. Dr. McBride did not submit any comments.** 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

Members of the Environmental Chemistry subgroup discussed this at length. Because there are no routine methods available for fractionating the soil by particle size at these very low particle size fractions, all agreed that the recommendation to do so on a routine basis could not be completed. However, the workgroup stipulates that responsible parties desiring to calculate an alternative remediation standard conduct the fractionation analysis – see recommendation from Chapter 6 below. Further, the workgroup recommends the development of these methods for potential future routine use.

“As described, the sampling and analytical capabilities for determining Cr(VI) concentration on very small particles (PM_{2.5}) are not fully developed or available commercially. These methods are still being developed. But there are steps that can be taken to ensure that alternative remediation standards are developed accurately: when a responsible party seeks to develop an alternate remediation standard for inhalation, a complete analysis of Cr(VI) by particle size should be developed, submitted and formally approved by the NJDEP. Such an analysis should include experiments in a

resuspension chamber and use analytical methods consistent with those described in Chapter 3 of this report.”

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. **The workgroup report goes to great lengths to address all of these issues. The author disagrees with them. That is different from not addressing them. There was no evidence presented during the workgroup discussions to invalidate the 1998 criteria. However, it is acknowledged that the information generated from on-going studies at the national level should be watched carefully and reviewed thoroughly for possible updating of the New Jersey criteria.**

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 chromium⁵ as clearly in 2005 as it did in 1991, when it was adopted. **The 75 ppm total chromium concentration recommended is based on contact dermatitis and does not take into consideration the numerous recent studies on analytical methods or toxicology.**

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. **New Jersey is proposing site-specific criteria to address the impact-to-groundwater scenario.**

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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

Table 1 omits the fact that there is a 20 milligram Cr(VI) per kilogram dry weight soil (nonresidential inhalation exposure scenario) in the 1998 criteria and that allergic contact dermatitis, and impacts to ground and surface water need to be determined on a site-specific basis when appropriate.

The correct information for the 1998 criteria appears in the workgroup report and is reproduced below:

Table 1.1. Soil Cleanup Criteria for Trivalent and Hexavalent Chromium (proposed 1998)

Exposure Pathway	Trivalent Chromium (ppm)		Hexavalent Chromium (ppm)	
	Residential	Nonresidential	Residential	Nonresidential
Allergic contact dermatitis	None ¹	None ¹	Site specific, but not to exceed 400 ⁴	Site specific, but not to exceed 400 ⁴
Inhalation	None ²	NR ²	270 ⁵	20 ⁵
Ingestion	120,000 ³	NR ³	240	6,100
Impact to Groundwater	None ¹	None ¹	Site specific ⁶	Site specific ⁶

1 – Under normal environmental conditions, trivalent chromium is insoluble in water.

2- Noncancer toxicological data for trivalent chromium does not exist for this exposure pathway.

- 3- For the nonresidential scenario, ingestion of trivalent chromium does not pose an unacceptable risk.
- 4- The 400 ppm maximum is a new criterion being recommended in this report.
- 5- Due to the effects of vehicular traffic, the nonresidential scenario soil cleanup criterion will be lower than the residential criterion.
- 6- The model used to develop a generic impact to ground water remediation criterion for Cr(VI) is not appropriate for COPR, which will require remediation in accordance with N.J.A.C. 7:26E requirements. A site-specific criterion for Cr(VI) in COPR-soil mixtures can be developed with NJDEP review and approval.

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. **The workgroup was charged with examining the cleanup criteria and not remedial strategies. The cleanup criteria were found to be based on the current science.**

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. **While a formal peer review has not been conducted on the 1998 criteria, the criteria are based on extensive public comments received from the 1995 interested party review. The 1998 criteria take into consideration the comments generated from the interested party review of the 1995 effort.** (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. **Studies used to provide the basis of the 1998 criteria have been peer reviewed, published in a refereed journal, or reviewed and accepted by the NJDEP, in keeping with what the Brownfield legislation requires of the NJDEP in establishing standards. While responsible party funding serves as a red flag, the funding itself is not, in and of itself, a reason to reject a study.** 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. **There was no information presented during workgroup deliberations to validate this statement. Indeed, health studies conducted by the New Jersey Department of Health (now New Jersey Department of Health and Senior Services) in the vicinity of COPR sites in the early 1990's showed no elevated levels of these health effects.**

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.

The court case was of interest but does not form a scientific basis on which to develop soil cleanup criteria. In a recent development, the expert witness that the judge relied upon regarding the topic of capping has reversed his position. The appropriateness of this reversal needs to be questioned, but it illustrates the importance of relying on evidence, rather than court testimony in reviewing scientific decisions. It validates the decision of the workgroup to rely upon certain fundamental scientific criteria for its recommendations.

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.

Newspaper articles are of interest but do not form a scientific basis on which to develop soil cleanup criteria.

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 based on the model is 1 out of a million. The recommendations in the air transport section (better documentation) will not correct this problem. Hazen et al. (2004) in part used erroneous data (a typographical error appeared on a table generated by the site remediation program). Hazen et al. (2004) examined the inhalation pathway alone without considering the other analyses that were conducted at the site and that ultimately drove the cleanup at the site. Dr. Hazen acknowledged this himself during workgroup discussions.

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. In fact, the recommendation of 10 ppm Cr(VI) for the inhalation route is very close to the 1998 criteria, which is 20 ppm for the inhalation route at nonresidential areas. The 20 ppm is based on sound and citable current science, while the 10 ppm is not.

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., (In fact, the workgroup spent many hours reviewing material and discussing the issues outlined in the Hazen et al., 2004 report) never reviewed the expert testimony (expert testimony was not used in the formation of any recommendations) and reports of the "exceptionally qualified" expert witnesses in *ICO v. Honeywell*, (The exceptionally qualified witness has changed his testimony and now supports capping as a remedial action. The workgroup did not use this expert's testimony as scientific evidence and would not do so now.) and never examined the extent to which science consultants working for the responsible parties might have unduly influenced the Department's cleanup criteria (It is uncertain what is being said here. Responsible parties and workgroup members share an antagonistic relationship, and there was no responsible party representation on the workgroup, so it is not understood how the responsible parties or their consultants "unduly influenced" the process.) and overall approach to remediation of chromium sites. In short, the Workgroup failed to examine the central questions, (The workgroup scrutinized and vigorously debated the issues repeated in this memorandum) failed to evaluate the most useful data, (The workgroup reviewed all scientific evidence for data on the issues of concern) and failed to draw upon the most qualified experts (The workgroup membership was comprised of all authors on the original Hazen et al. (2004) report, regardless of their qualifications, plus qualified scientists from the NJDEP Division of Science and Research, the NJDEP Site Remediation Program, the US Geological Survey and the New Jersey Department of Health and Senior Services. The workgroup report was subjected to an external peer review using the National Academy of Sciences peer review guidelines.).

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. **The chromium cleanup criteria are based on the current risk based paradigm and not on a precautionary paradigm, although the two are not necessarily mutually exclusive. Currently, all hazardous waste sites are regulated using the risk based paradigm. The author's criticisms of the chromium workgroup seem to represent criticism of the risk based paradigm in general on which the federal and state governments manage environmental risk.**

- B) Ignore the compelling evidence that Cr(VI) is a carcinogen by ingestion **There is no "compelling evidence". However, the workgroup makes the following recommendation: *"The results of the Davidson et al. (2004) study of the co-carcinogenicity of UV radiation and Cr(VI) ingestion should not form the basis of a revised soil cleanup value for Cr(VI). Nonetheless, this study raises the possibility that the cancer risk posed by exposure to Cr(VI) could be larger than that currently used by the NJDEP in the derivation of its soil standards. Therefore, additional research on the oral carcinogenicity of Cr(VI) would be valuable and any additional data should be rapidly evaluated to determine whether they provide sufficient additional evidence of oral carcinogenicity for Cr(VI)."*** The workgroup fairly evaluated the weight of evidence on oral carcinogenicity and indicated important scientific sources on the horizon that may add to the body of knowledge. There was consensus that there is suggestive evidence of oral carcinogenicity, but that quantitative risk assessment based on existing studies was not warranted by the study data quality. The workgroup recognizes that additional information may become available in the future and acknowledges the significance of this in the report.

- C) Fail to protect against non carcinogenic health effects **In fact, the numbers protect against the most conservative health endpoint, which is cancer resulting from inhalation of hexavalent chromium. In the case of direct contact of skin with hexavalent chromium in soil, the most conservative health effect is contact dermatitis, and the workgroup recommends a new standard be developed specific to this end point: *"The NJDEP should consider adopting a cleanup value based on the Nethercott et al. (1994) study and USEPA's current guidance on reasonable maximum soil adherence on skin as developed in this document.***

Based on the assessment of this group, a value of 400 ppm Cr(VI) is recommended for direct contact with soil. This value should be applied under the assumption of 100% bioavailability.” The ultimate cleanup number selected for a site is the most conservative one. That is, the exposure route resulting in the lowest number is the number used for cleanup.

Application of the current criteria:

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

In fact , the workgroup spent a great deal of time reviewing this phenomenon and the application of the cleanup criteria attempt to account for this phenomenon. From Chapter 6 (Environmental Chemistry) chapter of the workgroup report:

“Visible blooms in areas of significant surface enrichment are typically associated with high hexavalent chromium concentrations. Initially observed in areas known to be disposal sites for pure waste, this surface enrichment on the waste was transient and appeared related to periods of dryness following precipitation events, but it has not been observed at all COPR sites. While these latter sites without blooms contain elevated soil chromium levels, the levels are not as high as those recorded at the sites where large amounts of pure waste have been deposited. Salts observed at COPR slag and adjacent sites have been confirmed as chromate. These evaporate-like deposits are transient, being readily dissolved by rainfall. When surveyed, elevated chromium concentrations in runoff, ground water, and river sediments have been detected proximate to these sites. Field data have confirmed the presence of chromate but have not fully characterized its distribution within the soil profile. The chromate blooms observed at many of the COPR sites occur when hexavalent chromium salts precipitate on the surface of poorly drained soils where shallow ground water and a capillary fringe permit upward movement and evaporation of soil water containing these soluble chromate salts (James 1994). This phenomenon has been observed on the ground surface directly above COPR, and in basement walls directly adjacent to COPR deposits (SRWMP, written communication about IT Corp., 1992 and 1995). The chromate blooms have not been observed at every site where COPR is found at the surface. Nor have blooms been seen across the entirety of those COPR sites where blooms have been occasionally observed. The blooms can appear during dry periods, when evaporation of soil water occurs at the soil surface, and the blooms disappear when rainwater dissolves the salts again (James 1994). Despite the recurrent nature of the blooms in some locations, knowledge of Cr(VI) levels in soils might not be sufficient to predict blooms at COPR sites, except at highly contaminated sites where visible blooms have been recorded regularly. A variety of physical and chemical conditions contribute to bloom formation, such as total Cr(VI) and water soluble Cr(VI) concentrations, pH, and wetting/drying cycles. Data show that blooms occur on land surfaces where gross contamination of Cr(VI) is dominated by the presence of pure COPR waste. However, in areas of COPR-soil mixtures, the actual blooms have not been observed. 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.”

The workgroup recognizes the formation of salts on basement walls as well: “During remedial investigations by the Department at COPR sites, the presence of chromate salts on the interior wall surfaces was observed as green or yellow precipitates. This led to a conscious effort to visually inspect all interior building surfaces constructed on or near COPR sites for the presence of more blooms or for conditions that would favor their development of blooms. After inspection of structures at numerous sites, it was determined that the occurrence of chromate salts on interior wall surfaces was associated with very high hexavalent chromium concentrations in surrounding soil in direct contact with the structures. Blooms were not observed in areas where these conditions were not met. The most probable mechanism was determined to be hexavalent chromium contaminated water seeping horizontally or “wicking” upward through the concrete or cinder block or mortar joints. Evaporation promoted the seepage through the concrete. Subsequent evaporation and crystallization then resulted in the observed salt formation. Review of a subset of the Hudson County Chromium Sites (those of Tierra Solutions, Inc.) illustrates the observations (SRWMP, written communication, 2004). Of the 40 sites being addressed by Tierra, 4 sites (Sites 41, 47, 58, and 209) exhibit chromate salt formation on interior walls. Interim remedial measures have been taken at these sites, which include the use of epoxy coverings to isolate salts from human contact, as well as mandated routine inspection and testing. The experience has been that, extant physical damage to the epoxy coverings, these measures have been protective. However, despite years of inspection, new areas of chromate salt formation have not been observed and the known areas show neither significant migration nor expansion nor any change in location of chromate salt formation. This indicates a certain stability in the occurrence of these visible salt formations that perhaps an equilibrium is reached over time.”

B) 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

It is acknowledged in the report that enrichment on small particles occurs. As stated in the workgroup report, “The presence of Cr(VI) on small, respirable particles suspended due to vehicular traffic, construction traffic or other activity that can suspend particles from unpaved surfaces warrants further investigation. Currently, the development of alternative remediation standards is allowable by law. These standards can be developed by responsible parties to more accurately model the distribution of chromium on particles specific to their sites. The generic cleanup numbers are based on conservative estimates of a hypothetical site. However, the actual numbers generated by this process have been difficult to replicate. It is established in the literature that chromium adsorbs more to smaller particles than to coarser particles in general. This mechanism is expected to occur at COPR sites and should be accounted for in the development of both generic standards (which it is) and alternative remediation standards (which is unclear).”

In an attempt to incorporate this phenomenon into the criteria, two recommendations were made one by the Environmental Chemistry subgroup:

- *The approval of an alternative remediation standard should be contingent upon the responsible party conducting site-specific studies in accordance with departmental guidelines. Submissions that do not follow the guidelines should be rejected. Those that do should undergo a rigorous review with a transparent and formal approval process. Any alternative remediation standard developed to address the inhalation exposure route needs to be formally incorporated in to the case records and made available for replication. As described, the sampling and analytical capabilities for determining Cr(VI) concentration on very small particles (PM_{2.5}) are not fully developed or available commercially. These methods are still being developed. But there are steps that can be taken to ensure that alternative remediation standards are developed accurately:*
 - *when a responsible party seeks to develop an alternate remediation standard for inhalation, a complete analysis of Cr(VI) by particle size should be developed, submitted and formally approved by the Department. Such an analysis should include experiments in a resuspension chamber and use analytical methods consistent with those described in Chapter 3 of this report.*
 - *when investigating and describing a site in relation to the inhalation exposure route, the responsible party should include analysis of the following when determining the presence of particles at the site:*
 - *wind direction relative to the location of any air samplers and relative to vehicular activity. Samples should be collected downwind of vehicle traffic.*
 - *time of day of sample collection. Samples should be collected during the normal 8-hour work day.*
 - *soil sample averaging.*

and the other by the Air Transport subgroup: “It is recommended that future soil remediation standards and of alternative remediation standards (ARS) include both traffic-generated dust and wind-blown dust in the calculation. In cases where no traffic is anticipated, an ARS should be based on exposure to windblown dust at a hypothetical residence located at property fence line (the default being 270 mg/kg at the moment).”

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

Site-specific criteria for the impact-to-groundwater scenario has been recommended. Site-specific criteria allow the site conditions specifically at the COPR waste sites to be used in the development of site-specific impact-to-groundwater numbers.

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

While it was acknowledged that oxidation probably occurs at COPR sites (despite lack of evidence measuring that oxidation occurs), it was determined that the rate of oxidation is so slow as to be insignificant.

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

There was only one recommendation from the Environmental Chemistry subgroup that could be considered unanimous, and it directly addresses this concern, “*Recommend that the Department consider defining COPR waste material and soil with larger amounts of COPR waste material as a continuing source of contamination to ground water that will require remediation in accordance with the Department’s Technical Requirements for Site Remediation (N.J.A.C. 7:26E).*”

The Chromium Workgroup Report fails to point out that many of these issues polarized the Workgroup. It is stated throughout the report that the members were polarized. In the first paragraph of the executive summary, it states that, “*For some aspects of the report, consensus was not possible, as the individuals serving on the workgroup were polarized in their professional judgment about some of the issues. This report has attempted to outline those issues for which evidence was presented that demonstrate the theoretical possibility of a phenomenon occurring*” The Workgroup should have resolved these controversial issues by either contacting experts in soil chemistry and engineering or chosen to adopt a precautionary position. This was done in the form of an external peer review, conducted by a professor outside the NJDEP and using experts outside the state. The guidelines and materials developed by the National Academy of Sciences was used for the peer review to ensure impartiality. 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. It is true that the author continues to disagree with the recommendations of the workgroup. However, an external panel of unbiased experts agrees that the report reflects the current science on the issues.

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. Lack of evidence is not the same as negative information. A good example here is the body of work looking at possible cancers (other than lung cancer) associated with exposure to chromium. There are existing studies showing no association. In other words, the evidence indicates no causal link. The author suggests that this evidence be rejected outright as though the studies were never conducted. We continue to evaluate new studies that examine this association, but the current evidence suggests no such association. Many studies were interpreted as theoretical possibilities rather than in terms of potential risk. There continues to be a theoretical possibility that chromium

causes cancer other than lung cancer. The available evidence thus far, however, indicates that it does not.

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

This is a true statement. It is not known what the relevance of this statement is.

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. These 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. **In fact, site-specific criteria are recommended for the impact-to-groundwater scenario. In addition to this, the workgroup classified COPR as a continuous source. The recommendation to classify the chrome waste as a continuous source was unanimous at the time. This term does have regulatory significance. Under the Technical Requirements for Site Remediation (1997 Response to Comment document) and the Water Pollution Control Act (N.J.A.C. 7:9-6.1(a)), remediation of continuing sources that adversely impact ground water are required. This would preclude exceedance of the current total chromium ground water standard of 70 micrograms per liter. The term “continuing” or “ongoing” source is used frequently in the 1997 Response to Comments Document for the Technical Requirements for Site Remediation (TRSR). This document does have remedial significance. For example, in the response to Comment 704, the Department stated “Source areas represent a continuing discharge of contaminants to ground**

water, and their removal, containment, or control to the extent practicable, is critical in order to prevent or reduce further degradation of ground water resources....”.

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.

It is acknowledged in the report that capillary movement does occur, and the reality of this phenomenon was never disputed. Available evidence suggests that surface chromium concentrations become problematic primarily in close proximity to very high concentrations of Cr(VI) provided sufficient moisture is present and the media is porous in nature. Modifying factors include the presence of organic material, sulfides, manganese, and other soil constituents. Since remediation efforts have been underway, problematic surface concentrations have not been observed in the area. However, because of the variability of conditions, site-specific evaluation of the potential for movement seems to be the only logical course of action in the absence of a model that can predict such movement and concentration. This is how the site remediation program has addressed this issue in the past and will likely do so until a suitable predictive model is developed. Capillary movement is also why capillary breaks are a component in many remedial decisions and why this phenomenon is considered anything but “theoretical.”

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 **The workgroup report pertained to the cleanup numbers and did not make any recommendations on remediation engineering controls such as capping.**

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.

Epidemiological studies have focused on lung cancer because its causal connection to occupation chromium exposure was suspected and confirmed. Other cancers were not and still are not clearly linked to chromium exposure. They were, therefore, not the focus of these studies.

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 *insufficient* 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

The workgroup report also contained the following text immediately following the quoted material: "It is recommended that California's efforts toward such a meta-analysis be followed and evaluated when it becomes available for review and comment." Thus, the workgroup did not ignore the possibility that a meta-analysis might provide useful information on chromium ingestion carcinogenicity, but chose to review the California study already in progress when it becomes available rather than undertake a study on its own that would necessarily be inadequate given the time available.

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). **In an e-mail reply to Mary Kearns-Kaplan responding to her request for information on the conference abstract, Fernandez-Ortega C, Zhang Z, Froines J. (2000). Chromium Exposure and Gastric Cancer. A Combined Analysis. Epidemiology;11(4):S101, Dr. Froines states: “I am sorry to say that the work you cite was never completed, and there is no paper at this point.”**

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

From an email correspondence with Dr. Froines: “I have reviewed the chromium document and found references to me on pages 15-17, 20 and 25. The work described on pages 15-17 should be deleted and I have recently communicated that to Ms. Kelman. While we conducted an initial study that resulted in the findings described, we did not go further and complete the study for submission to a peer reviewed journal. The work has not been peer reviewed and published and therefore I don't consider it appropriate for inclusion in your report.”

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.”

Again, Dr. Froines himself has asked that this section be removed from this memorandum.

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-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.

The history of these deliberations is checkered. However, the bottom line is that the standard based on the assumption of ingestion carcinogenicity has been withdrawn, and California currently has no such standard that can be reviewed or adopted. Once material from California is published, it should be reviewed by NJDEP promptly.

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 Program²² was used to arrive at this new lower number.

The Office of Environmental Health Hazard Assessment peer reviewers uniformly criticize Office of Environmental Health Hazard Assessment for basing the risk assessment on Borneff, and are critical of Zhang as supporting evidence. The occupational meta-analysis is also criticized. Although the memorandum says that Office of Environmental Health Hazard Assessment appears to have used National Toxicology Program data in their risk assessment, this was not apparent in the peer review comments. It would seem that had National Toxicology Program data been used, there would be no need to rely upon the less adequate data of Borneff. In any event, the workgroup recommended close examination of the forthcoming National Toxicology Program data when available. This is the most appropriate path.

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 recommendations in the workgroup report are based solely on scientific and public health considerations without regard to economic cost considerations. Economics was not a factor for any of the subgroups.** 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 OEHHA acknowledges that there is some evidence that weighs against considering chromium VI an oral carcinogen, OEHHA 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.

The workgroup did not base any conclusions on any single epidemiological study, or even on multiple epidemiological studies. Because of California's ongoing review and New Jersey's commitment to consider that review when it becomes available, and the preliminary finding that there is no immediately obvious causal link between GI cancer and chromium exposure in the literature, epidemiological studies did not form a major part of the risk assessment subgroup's determination.

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.

The peer-review comments for the California draft assessment were generally strongly negative toward the use of the Borneff study, consistent with the workgroup's conclusions.

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).

There are two Zhang papers dealing with this population. The first of these was published in 1987; the second of these, published in 1997, is of disputed authorship and is widely acknowledged to be tainted by the consultants for the defendants in the California court case. The workgroup did not discuss the 1987 Zhang paper. This was a conscious decision based on the knowledge that consideration of this paper was unlikely to lead to a definitive finding and that review of the 1987 paper would necessitate review of the later contested paper that purports to support the opposite findings.

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.

This was not the Workgroup's rationale for its decision not to utilize this study in the derivation of an ingestion carcinogenicity standard. Rather the Workgroup's rationale was stated as: "*Given that the Davidson et al. (2004) study was conducted in a single species, and a single sex, and that the findings were confined to a single study, the study is not sufficient by itself to support the development of an ingestion-based soil cleanup standard for Cr(VI).*" Additionally, and supporting this conclusion, the Workgroup concluded that: "*The group also noted that the hairless mouse model for UV-Cr⁺⁶ has not been characterized with respect to the mechanism involved in tumor initiation or promotion. This includes lack of characterization of this strain of mouse with respect to its potential for specific sensitivity to either UV or Cr⁺⁶. In the absence of such characterization, it is difficult to predict to what extent this model may be relevant to humans. While a similar system has been shown to produce skin tumors in this strain of mouse with co-exposure to UV and arsenic, the group notes that arsenic is a known human skin carcinogen. There are no reports of skin cancer in humans associated with Cr.*"

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 full context of this quote is: "*However, given that this study was conducted in a single species and a single sex, and that the findings were confined to a single study, the study is not sufficient by itself to support the development of an ingestion-based soil cleanup value for Cr(VI). Nonetheless, this study raises the possibility that the cancer risk posed by exposure to Cr(VI) could be larger than that currently used by the NJDEP in the derivation of its soil standards. Therefore, additional research on the oral carcinogenicity of Cr(VI) would be valuable and any additional data should be rapidly evaluated to determine whether they provide sufficient additional evidence of oral carcinogenicity for Cr(VI).*"

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. **The Risk Assessment subgroup had telephone discussion with one of the authors of this study (Fred Burns) in an attempt to clarify questions about the study. The workgroup report reflects the information obtained in these discussions. The uncertainties referenced in the report remain after these clarifications. The reason that Dr. Costa’s presentation was canceled reflected the overall policy of the workgroup, which was to decline presentations from anyone (including responsible parties and academics) outside the New Jersey government agencies conducting the review.**

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.*”

The relevancy of this newspaper article to the cancers described is not clear.

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 quote does not appear in Chapter 3, which is the subject of the current discussion.

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. The full context of this quote is: “*Based on this analysis, the group concluded that there is insufficient evidence from any individual occupational epidemiological study to conclude that Cr(VI) 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. It is recommended that California’s efforts toward such a meta-analysis be followed and evaluated when it becomes available for review and comment.*”

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 (PO_4^{-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.

Genotoxicity tests, in general, are useful in highlighting substances appropriate for in-vivo chronic carcinogenicity evaluation, and sometimes for elucidating the mechanism of that carcinogenicity. However, genotoxicity tests, by themselves, are not always considered equivocal evidence of carcinogenicity because they do not address the processes operating in the whole organism over time. In the absence of evidence from properly constructed in-vivo tests, genotoxicity test results cannot form the basis for a risk assessment.

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 **These observations are consistent with the basis and background developed to support DEP’s existing allergic contact dermatitis cleanup criterion.**

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. **This does not reflect the current allergic contact dermatitis cleanup criterion.**

The Chromium Risk Assessment subgroup recommends adopting a cleanup value based on the Nethercott et al. (1994) study. **This reflects a misunderstanding of the workgroup’s recommendation. The recommendation proposed an alternative approach to be used in concert with the existing approach. The existing approach is based on the concentration**

of Cr(VI) in solution given a specific extraction procedure from soil. The recommendation proposed an additional approach that is based on the concentration of Cr(VI) in solid material (e.g., soil). The workgroup recommended that both approaches be adopted and that whichever approach yielded the lower concentration at a given site be used. The alternative approach recommended by the workgroup identifies a fixed value of 400 ppm Cr(VI) in soil. Depending on the specific soil types and conditions, the existing extraction procedure could yield a value larger than 400 ppm. The workgroup's recommendation thus, serves as a ceiling on the allergic contact dermatitis cleanup criteria. This recommendation fails to account for weaknesses identified in the *ICO v. Honeywell decision*.

As part of a civil action suit between the Interfaith Community Organization and Honeywell International Inc., Dr. Belsito³² 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/cm² is too low and based on the selection of the wrong studies (by Finley and Horowitz). **The soil loading value was not taken from studies by Finley and Horowitz. It was taken from the value recommended in EPA's Risk Assessment Guidance for Superfund (RAGS)-Part E.** 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. **It is not known where these values come from. The recommended value of 0.2 mg/cm² is the default value specified by EPA in RAGS Part E. The workgroup report acknowledges that this value was derived for consideration of dermal absorption with respect to systemic toxic endpoints rather than specifically with respect to localized dermal phenomena such as allergic contact dermatitis. The workgroup report also acknowledges that this value is likely to underestimate the loading on local areas of skin in direct contact with soil, and that the value was chosen for consistency with the default soil loading values used in the proposed NJDEP soil cleanup regulations. Nonetheless, the workgroup report also notes that this value is an upper 95th percentile estimate of soil loading on children playing in soil at a day care facility and further notes is also equivalent to the 50th percentile of soil loading on children playing in wet soil. Therefore, while not specifically chosen with respect to soil loading on localized areas of skin, it still appears to be a reasonable value for that purpose. These other suggested values have no unique provenance. Belsito recommends 2 mg/cm² – based on what criteria?. 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.**

Use of Inappropriate Statistics

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. **The workgroup report did not follow either approach of Nethercott et al. (1994). The workgroup report conducted independent benchmark dose modeling to arrive at a value of 0.08 µg/cm². These calculations are provided in detail in Appendix C to Chapter 3 of the report. That this value is close to the value derived by Nethercott et al. is largely a function of the data, and not of a common bias.**

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. Pastenbach. 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. **These were not majority recommendations, but unanimous recommendations of the risk assessment subgroup.**

Incidental ingestion is the major pathway of exposure to Cr(VI) in soil and dust.³³ **There is no available evidence that specifically supports this conclusion for the Hudson County contamination. However, even if we accept this assumption, it does not mean that ingestion is the major pathway leading to allergic contact dermatitis. This depends on the dose-response for allergic contact dermatitis by the ingestion versus the dermal contact route. Since the dose-response relationship for allergic contact dermatitis by ingestion is not known, there is no way to judge the relative contribution of ingestion and dermal contact to allergic contact dermatitis potential.** 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 reasonable upper-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.

The current cleanup criterion for Cr(VI) is the lower of the allergic contact dermatitis or non-cancer (RfD) based ingestion value, based on the current IRIS value.

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. Stern et al. (1998) did not address health effects. That study investigated associations between total chromium exposure as reflected in urine total chromium concentration and total chromium concentration in household dust. There was no direct indication of health effects. 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. Conclusions were, indeed, reached. Those conclusions speak to the relationship between chromium in household dust in homes adjacent to known waste sites (at the time of the study) and internal exposure – particularly in children. The conclusion was that there was exposure to total chromium in these areas, and a presumptive exposure to the Cr(VI) that was contained in the total chromium. 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. There was no dermatitis finding in that study. These comments are confusing the DHSS Hudson County Chromium Medical Screening Study with Stern et al., 1998. This testimony from a highly qualified individual was not available to the risk assessment committee. The testimony appears to confuse the various studies conducted in New Jersey.

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; (As discussed previously, this is an equivocal conclusion at best, and does not lead to a quantitative cleanup number) 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 Cr(VI) oral bioavailability to create some level of cancer risk, it is relevant to evaluate whether the 400 ppm Cr(VI) 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: $400 \text{ ug/g} * 0.2 \text{ g soil ingested/d} * 1/15\text{kg} = 5.3 \text{ ug/kg/d}$. Thus a residential scenario could lead to a daily child's dose of Cr(VI) 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 from 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 Cr(VI) NTP³⁷ 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.

These comments take the workgroup's response to Dr. Ginsburg's comments out of context. The full reply to this comment follows:

"We appreciate the reviewer's concern that whatever value is applied to protect against ACD not result in a significant ingestion cancer risk. However, given that the reviewer, having previously made the point that the available data do not permit the use of either the genotoxicity data or the Davidson et al. data in quantitative risk assessment, it is difficult to justify these calculations. 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. Furthermore, we note that even given the uncertainties in this calculation, the effect levels taken at face value, do not exceed the exposure at the 400 ppm ACD concentration. In the absence of a dose response relationship, and a determination of hazard identification for human exposure for either dataset, we do not believe that any conclusions, even semi-quantitative are warranted from these data. We also note that the as per the group's recommendations in the draft report, the 400 ppm value if adopted would be used in conjunction with the solution-based ACD cleanup value as well as in conjunction with the other cleanup endpoints. Therefore, the 400 ppm value would function as a ceiling, and would only constitute the cleanup value in limited number of cases, if at all. Nonetheless, we recognize the basis for concern in the reviewer's comment, and agree that such considerations should add to the overall recommendation of prudence in considering the overall Cr⁺⁶ cleanup policy."

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 Proctor 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.

There are two Zhang papers. The first of these was published in 1987; the second of these, published in 1997, is of disputed authorship and is widely acknowledged to be tainted by the consultants for the defendants in the California court case. The overall suspect nature of both Zhang papers is exactly why the workgroup decided not to investigate the use of the Zhang data in its considerations. The Proctor et al.(2002) study was only cited incidentally in the workgroup report. The totality of the reference to the Proctor et al. (2002) paper is as follows:

"The most recent analysis of the literature by Proctor et al. (2002) arrives at a similar conclusion." Obviously the workgroup's conclusions were not influenced by this work regardless of its provenance.

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 Program⁴⁴ 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). **The National Toxicology Program data were not peer-reviewed, are not available, and the draft version was recently withdrawn. When it becomes available, New Jersey should review it immediately.**

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		

A cursory review of standards shows the numerous errors in the above table. A thorough validation was not conducted, but known errors are corrected below.

The criteria labeled as “NJDEP inhalation” are actually for the ingestion pathway. The residential exposure scenario number for the inhalation pathway is 270 milligrams Cr(VI) per kilogram of soil. For the nonresidential exposure scenario, the inhalation pathway criterion is 20 milligrams Cr(VI) per kilogram of soil. The Department was the first and one of the few that has chosen to regulate on the basis of allergic contact dermatitis and to do so as an acute exposure. For sake of comparison, the USEPA Region III risk based concentrations for the ingestion pathway under a residential scenario are comparable to those in the table attributed to the NJDEP, 230 milligrams Cr(VI) per kilogram of soil and 120,000 milligrams Cr(III) per kilogram of soil. Corrections are shown below. Time precluded a more comprehensive correction of the errors.

Agency or State	Cr III	Cr VI	Total Cr
NJDEP			
Residential, inhalation	120,000	270	
Residential, ingestion	None	240	
Nonresidential, inhalation	None	20	
Nonresidential, ingestion	None	6,100	
Impact to groundwater	None	Site Specific	
USEPA, Region 6			
Residential	100,000	30	210
Industrial, indoor worker	100,000	64	450
Industrial, outdoor worker	100,000	71	500
Ambient Air, ug/m3		230,000	16,000
Maryland			
Residential	12,000	23	
Nonresidential	310,000	61	
Impact to groundwater	None	None	
Dutch intervention value			380

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/ July 1999

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.

It is true that NJDEP has not calculated a specific cleanup criteria to account for accumulation of Cr(VI) on soil surfaces due to capillary rise, because many factors are involved that are only qualitatively understood at this time. At least four possible scenarios may be described:

- 1) Where the water table depth is deeper than the capillary rise, New Jersey climate conditions result in a net annual groundwater recharge, indicating that long-term movement for Cr(VI) is down . This is why chromium “blooms” are only observed in some locations at chromium waste sites.

- 2) In areas where the capillary zone reaches the soil surface, annual groundwater recharge may be reduced or eliminated and surface water evaporation may result in a net long-term accumulation of Cr(VI) at the soil surface.
- 3) In areas where there is overland runoff of Cr(VI) in solution to lower areas with poor infiltration, the infiltrating water itself represents a source of Cr(VI), which is not true in 1) and 2) above. In this case, the addition of Cr(VI) to the soil surface could sometimes exceed its potential to be transported downward through infiltration. Evaporation of surface water would then result in accumulation of Cr(VI) at the soil surface.
- 4) When evaporation of Cr(VI)-containing water occurs from interior surfaces, chromium may accumulate on these surfaces. In this case, there is no removal mechanism for Cr(VI), and unless the walls are cleaned periodically, Cr(VI) may accumulate indefinitely.

The four mechanisms above (and there are likely others) would each require separate, distinct modeling approaches in order to determine appropriate cleanup criteria. No models have been identified that quantitatively address these mechanisms.

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”. The document authored by Theodore Hayes of NJDEP was included as an appendix to the original Hazen et al. (2004) report and therefore was considered initially for workgroup deliberations. As it was learned that the document was unpublished, undated and uncitable and there were no plans for it to be published, it was determined that it did not meet the criteria established by the workgroup and was rejected. In the same way that unpublished material submitted from responsible parties during the course of the workgroup proceedings were rejected, this unpublished work was rejected. 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.” The author quotes Dr. McBride’s comments. Neither the author nor Dr. McBride have offered any data to support this opinion.

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 author states 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 study⁴⁸.

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

There was no information presented by which calculations of capillary rise would be predicted. The phenomenon of capillary rise is acknowledged in the report. The author assumes an infinite capacity for this route of travel, but there was no data showing the actual distances that chromium could travel via capillary action. Therefore, studies designed specifically to quantify this route were recommended.

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.

The European Commission further defines the precautionary principle in recognition of the fact that this concept can be misused or abused. The Commission stresses the need for "reliable scientific data and logical reasoning." Before "triggering" the use of the principle, it recommends a thorough evaluation of scientific evidence. The analysis must also include an assessment of the uncertainties in the scientific data. It stresses the wide range of actions that may be taken under the principle, including no action at all. The precautionary principle should not be used in an arbitrary way but is itself based on a thorough review and interpretation of scientific evidence.

The author's criticisms of the chromium workgroup are actually criticisms of the risk paradigm. Some, though not all, are valid criticisms deserving of discussion at both the state and federal levels. The risk based and precautionary approaches are not necessarily incompatible, as the author suggests. However, this is a discussion to be held at the policy level and not within the chromium workgroup. Until the state changes its paradigm for managing risk, the chromium cleanup criteria will be developed using the risk paradigm.

I recommend readopting the 75 ppm total chromium standard (based on 10 ppm Cr(VI)) and applying it to the entire soil column. **There needs to be some scientific evidence on which to base this number.**

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. **The Bureau of Air Quality Evaluation has stated that the current criteria are protective of potentially higher Cr(VI) concentrations in the smaller soil size fractions because the models are not affected by the particle size.**

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 **It is agreed that methods for fractionating soils by particle size should be developed for possible routine use and this is stated in the workgroup report. However, until such methods become available, the Department must use bulk soil sampling and averaging for routine evaluation of the inhalation exposure pathway, as there is no alternative available at this time. The report does recommend fractionation studies in instances where alternative remediation standards are proposed by responsible parties (see recommendation from Chapter 6 on page 11 of this response document). Bulk soil sampling and averaging of the data for determining compliance with the inhalation criteria is the accepted practice for determining compliance with remediation standards or criteria for soil as used by the USEPA (EPA/540/1-89-002).**

This issue would affect all the proposed inhalation-based soil remediation standards as it is not specific to just Cr(VI).

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 generic physical mechanism of contaminant enrichment on smaller particle sizes was not disputed by members of the chromium workgroup. The phenomenon is not unique to chromium or even just Cr(VI), but can occur with many contaminants, which is the basis for the soil washing remediation technology.**

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

This article appears to pertain to lead rather than chromium. The chemistry and toxicity of lead are very different from chromium.

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. **This article appears to pertain to lead rather than chromium. The chemistry and toxicity of lead are very different from chromium.** 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*): **In this paper, the researchers observed limited migration potential of hexavalent chromium in groundwater contaminated by COPR material in France due to likely reduction by ferrous iron (Loyaux-Lawniczak et al. 2001). The paper does not concern particle size but rather reduction of chromium.** 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.

Loyaux-Lawniczak, S., Refait, Ph., Ehrhardt, J-J, Lecomte, P., and Genin, J-M. R. (2000), "Trapping of Cr by Formation of Ferrihydrite During the Reduction of Chromate Ions by Fe(I)-Fe(III) Hydroxysalt Green Rusts," *Environmental Science and Technology* 32: 438-443.

These researchers actually demonstrated the "...rapid and complete reduction of Cr(VI) into Cr(III)." They prove the reduction of Cr(VI) in the green rusts studied.

“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

As stated, the workgroup does not dispute this.

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 μ m; between 250 and 150 μ m, etc.) down to $d < 38 \mu$ 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 $d < 100 \mu$ m, consequently, particles with $d < 38 \mu$ m (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 $75 < d < 150 \mu$ m down to $d < 38 \mu$ m, Cr (VI) increased from 883 to 1133 mg/kg. I also mention that, “for fractions of smaller particles ($d < 30 \mu$ m to $d < 2.5 \mu$ m) on filters from a re-suspension chamber, total Cr concentrations were largest in the fraction $10 < d < 30 \mu$ m...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 $d < 38 \mu$ m. 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 $d = 30 \mu$ m. As for the fractions $< 30 \mu$ m, 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 $d < 75 \mu$ m 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

The Kitsa study is described in Chapter 6 of the workgroup report, and the raw data from the report are presented in Figure 3 of the report. It is not in disagreement with Dr. Barringer’s assessment. *“While chromium levels in areas of visible blooms showed increasing chromium concentrations with decreasing particle size (to $PM_{2.5}$), soils from contaminated sites but not in visible bloom areas and soils from background sites demonstrated an opposite trend. That is, enrichment of chromium on small particles seemed to occur when chromium levels were very high (above 11,000 ppm in bloom areas) but was not observed when chromium levels were lower. Mean total chromium concentrations of 12,885; 8,591; and 7,941 mg/kg were measured on particle size fractions of between 10 and 30 microns, between 2.5 and 10 microns, and less than 2.5 microns, respectively using x-ray fluorescence analysis of filters obtained from resuspension chamber experiments. Data taken from the study tables showing samples collected in 1991 are shown in Figure 3. It would appear that in a soil system inundated with chromium, adsorption sites on the smaller particles become filled with chromium;*

whereas in less contaminated soils, a more homogeneous distribution among particle sizes occurs. The researchers conclude that: “Thus it appears that exposure to high concentrations of contaminated dust occurs primarily during resuspension conditions at sites with visible hexavalent chromium crystals.” Interestingly, the percentage of hexavalent chromium decreased with particle size: hexavalent chromium was 60%, 50% and 20% of the total extractable chromium found in the PM₃₀, PM₁₀ and PM_{2.5} size fractions, respectively. If the particles of all sizes are composed of chromium bearing minerals, it might be expected that concentrations would be much the same from one size class to another. Examples of non-uniform concentrations could include fine, unattached crystals of evaporite from chromate solutions or chromium distributed somewhat uniformly over the surface area of the particles. Enrichment factors were calculated as part of the study. They show that the enrichment in total chromium at COPR sites are high when compared to rural soil. However, the enrichment factors are lowest for PM_{2.5} particles (65) than for the PM₁₀ particles (352) or for the PM₃₀ particles (452). One of the conclusions of the report is: “Thus, it appears that exposure to high concentrations of contaminated dust occurs primarily during resuspension conditions at sites with visible hexavalent chromium crystals.” Later, they add, “...hexavalent chromium in crystal or ‘bloom’-laden soil is bioavailable in size fractions that are of concern for deposition in the respiratory system.”

In fact, the workgroup makes several significant recommendations concerning particle size.

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 is true. The workgroup report does not reflect the Site Remediation program's position particle size.** 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.

Much discussion ensued on this issue. Much analysis plus correspondence with the authors on the Kitsa *et al.* (1992) paper validate the position of the workgroup, which is in opposition to several of the workgroup members. Despite the opposition of several members of the workgroup, the report makes the following recommendation based on particle size fractionation: *“As described, the sampling and analytical capabilities for determining Cr(VI) concentration on very small particles (PM_{2.5}) are not fully developed or available commercially. These methods are still being developed. But there are steps that can be taken to ensure that alternative remediation standards are developed accurately: when a responsible party seeks to develop an alternate remediation standard for inhalation, a complete analysis of Cr(VI) by particle size should be developed, submitted and formally approved by the NJDEP. Such an analysis should include experiments in a resuspension chamber and use analytical methods consistent with those described in Chapter 3 of this report.”*

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. **The PPG data was requested by Dr. Page, Mr. Hayes and Ms. Kelman. Ultimately, the workgroup determined that this data was not useable due to the statistical evaluation conducted by Dr. Leo Korn at the request of the workgroup chair.** PPG physically separated many samples of soil into particle size fractions, $d < 75 \mu\text{m}$ and $d < 10 \mu\text{m}$. The bulk samples, the $d < 75 \mu\text{m}$ fractions and the $d < 10 \mu\text{m}$ 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 concentration is larger than the concentration in the $< 10 \mu\text{m}$ 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 $< 10 \mu\text{m}$ fraction concentration." In either case, the consultant states a similar conclusion for the $< 75 \mu\text{m}$ 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 $> 20 \text{ mg/Kg}$ (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 report⁵⁴ claims that "bulk hexavalent chromium concentrations are conservative when used to estimate the hexavalent chromium concentrations in $< 75 \text{ microns}$ and $< 10 \text{ microns}$ size fractions."⁵⁵

At the request of the workgroup chair, Dr. Leo Korn (the Department's only statistician) evaluated the PPG report. His review is attached (Attachment II). The PPG data was requested by Dr. Page, Mr. Hayes and Ms. Kelman. Ultimately, the workgroup determined that this data was not useable due to the statistical evaluation conducted by Dr. Leo Korn at the request of the workgroup chair.

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.

The PPG report was not used in the determination of any recommendations by the workgroup, as it was determined that the statistics used did not support the conclusions reached in that report.

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

Dr. Page wanted the information from the PPG report to be included in the workgroup report. However, information from the PPG report ultimately was not used in the determination of any recommendations by the workgroup, as it was determined that the statistics used did not support the conclusions reached in that report.

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.

In fact, the workgroup report points out that particle size is indeed a factor in chromium adsorption to soil particles. From page 117 of Chapter 6 of the Chromium Workgroup Report:

"For the purposes of this report, particle enrichment has been defined as the preferential adsorption of hexavalent chromium on smaller particle sizes such as clay-

sized particles. This can occur at the surface of the soil, which is of concern here, or at depth through the soil column, which is a factor in chromium transport to groundwater. The issue of concern here is that vehicular activity on unpaved surfaces of COPR sites will result in the suspension of airborne particulates (small particles with sorbed hexavalent chromium) from the surface of the soil. If the chromium is associated with the surface particles, it will also be associated with the airborne particulates suspended from that surface.

“The phenomenon when it occurs on the land surface is important because the inhalation risk-based soil clean-up criterion for chromium is determined by modeling the risk from respirable particles less than 10 microns in size. There are two types of models used to calculate soil cleanup levels. The first model predicts emission rates of particulates from truck traffic and wind-blown dust. The second is used to describe the movement of this particulate through the air and predict air concentrations at designated points at and around the site. These predicted concentrations are then used to back-calculate to the soil concentration that would result in the one in a million cancer risk level for a specific contaminant, Cr(VI), and is compared against the soil chromium concentration in bulk soil samples collected at the top 0-6 inches. Thus, there is concern that the current methodology by which bulk sampling techniques are compared to the inhalation risk level may underestimate the risk because the sampling method does not distinguish among the different sized particles. Adsorption and other mechanisms that distribute mass on particle surfaces raise concerns that small particles may contain more chromium per mass of particles than the coarser soil particles. Techniques for separating the smaller particles are not fully developed for routine uses.” Page 117, Chapter 6 of the Chromium Workgroup Report

Further, the report presents methodologies to address the issue of particle size in the model used. From pages 82-85 of Chapter 5 of the Chromium Workgroup Report:

“How do particle size assumptions affect the inhalation soil remediation standards?”

“Review of the methodology for developing the SCCs indicates that we were able to calculate emission estimates for Inhalable Particulate (PM-10) using the USEPA (1995a) emission factor guidance in AP-42. A smaller portion of the particulate matter emissions would be 2.5 um or less in diameter, and therefore able to penetrate to the lowest portion of the respiratory tract. Basing the SCC (and subsequent ARS) on the PM-10 fraction is consistent with general guidance from USEPA which recommends that analysis of ambient air concentrations of toxic metals be based on speciation of PM-10 samples, since all of the PM-10 is available to the respiratory system (although PM-2.5 will penetrate the farthest), and may therefore be of toxicological significance.

“The question of how fugitive dust is apportioned among the various particle size categories has been explored by a number of authors. Watson, Chow and Pace (2000) report that about 52.3% of the particulate from road and soil dust is less than 10 micrometers in diameter; of this particulate 10.7% has been found to be smaller than 2.5 micrometers in diameter; and the remaining 41.6% falls between 10 and 2.5 micrometers (sometimes referred to as coarse particulate). Another way of stating these findings is that

PM2.5 mass emissions account for about 20% (i.e. 10.7% divided by 52.3%) of the PM10 mass emissions.

“Kitsa, et al. (1992) found a similar particle size distribution when resuspending soil taken from a COPR site in a sealed chamber. In their experiment, the large particles (greater than 30 micrometers in diameter) accounted for 50% of the mass, while the coarse fraction was 30% and the fine (PM2.5) fraction was 7%.

“Finally, the latest version of AP-42 guidance for Unpaved Roads and Industrial Wind Erosion (USEPA 2003) now provides factors that can be used to estimate fugitive dust emissions of various sizes. Using the same assumptions regarding truck traffic and pile size that were used in the derivation of the SCCs, the emission estimates shown in Table 5.2 can be calculated using this new guidance.

Table 5.2. Particulate Emission Rate Estimates (grams/second) from Various Revisions to AP-42

	PM30	PM10	PM2.5
Emissions from Truck Traffic (USEPA, 1995a)*	1.54	0.23	0.061
Emissions from Truck Traffic (USEPA, 1998)	0.70	0.15	0.022
Emissions from Truck Traffic (USEPA, 2003)	0.48	0.14	0.022
Emissions from Wind Blown Dust (USEPA, 1995a)	0.015	0.008	0.003

* Input values initially used for silt content and vehicle speed differ from current values that are used.

“In the Truck Traffic scenario (USEPA 2003), the PM10 fraction is 29% of the PM30 emission rate and the PM2.5 fraction is 5%. For the Wind Blown Dust scenario, the PM10 and PM2.5 fractions are 53% and 20%, respectively.

“If the SCC’s or ARS’s were based on the mass of PM2.5 (instead of PM10) that is likely to get into the air due to activities at the COPR sites or from wind-blown dust, the allowable hexavalent chromium concentrations would be somewhat higher in soil. However, if it were assumed that the smaller particles had higher concentrations of hexavalent chromium than what can be observed by standard soil testing methods, then a weighted average method could be used to account for this concentration and a somewhat lower allowable soil concentration of hexavalent chromium would be derived. How much lower depends on the degree of hexavalent chromium concentration on the particle, but one sample calculation suggests that assuming an order of magnitude increase in hexavalent chromium on the small particles would lower the allowable soil concentration (SCC or ARS) by about 25%. Compared to the general conservative nature of the ISC model (sometimes over predicting by as much as a factor of 2) and other conservative assumptions that have been made, this difference of 25% is negligible.”

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 particles⁶⁰. **This statement is incorrect, as evidenced by the quotes from the workgroup report above.**

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). **In fact, the workgroup recommended three major changes to the way the model is used for air transport, pertaining to particle size. From Page 87 of Chapter 5 of the Chromium Workgroup Report:**

“It is recommended that future ARS calculations be limited in the number of parameters that can be varied for the inhalation pathway. The Inhalation SRS that are currently available for interested party review would allow only the silt content of the soil or the fraction of vegetative cover to be changed. We recommend that facility-generated ARS vary silt content only while the SRS are being reviewed. Limiting ARS changes to site-specific silt content is advisable for a number of reasons. One is that the silt-content is an existing parameter that can be measured and is unlikely to change, in contrast to truck traffic (which is projected) and site size (which could change if a lot is subdivided or if adjacent lots are annexed).”

“It is also recommended that future SRS and ARS include both traffic generated dust and wind-blown dust in the calculation. In cases where no traffic is anticipated, an ARS should be based on exposure to windblown dust at a hypothetical residence located at property fenceline (the default being 270 mg/kg at the moment).”

“In USEPA (2003), the soil moisture content was removed from the equation for traffic-generated dust, because “unpaved roads have a hard, generally nonporous surface that usually dries quickly after rainfall or watering, because of traffic-enhanced natural evaporation.” Removing this factor results in higher estimate of particulate emissions from truck traffic. This new equation should be used in the development of the Inhalable SRS and any interim ARS.”

The report also recommends thorough particle size fractionation studies for responsible parties seeking alternative remediation standards based on the inhalation exposure route:

“As described, the sampling and analytical capabilities for determining Cr(VI) concentration on very small particles (PM_{2.5}) are not fully developed or available commercially. These methods are still being developed. But there are steps that can be taken to ensure that alternative remediation standards are developed accurately: when a responsible party seeks to develop an alternate remediation standard for inhalation, a complete analysis of Cr(VI) by particle size should be developed, submitted and formally approved by the NJDEP. Such an analysis should include experiments in a resuspension chamber and use analytical methods consistent with those described in Chapter 3 of this report.”

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.” **This quote appears nowhere in the workgroup report.** 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.

The PPG report was not used in the determination of any recommendations by the workgroup, as it was determined that the statistics used did not support the conclusions reached in that report. These comments on PPG are perplexing, as the workgroup report agrees with the author: From Chapter 6 of the workgroup report:

“A report describing chrome fractionation studies was submitted by PPG Industries to the Department in 1995 as part of the Remedial Investigation phase of a site in Hudson County (ICF Kaiser Engineers, 1993). The final report addresses NJDEP concerns about whether hexavalent chromium concentrations differed between the bulk samples and the fractions. While the authors report that “...bulk hexavalent chromium concentrations are conservative when used to estimate the hexavalent chromium concentrations in <75u and <10u size fractions,” a statistical evaluation of the data indicates that this statement may not be complete. The authors cite this report as justification to discontinue soil fractionation and particle size analysis for hexavalent chromium. However, the data seem to be equivocal, at best. In the report, the argument is made that even though there is no evidence that bulk Cr(VI) is greater than Cr(VI) on smaller fractions, the concentrations are equivalent. This kind of testing has low power, so it should not be considered as strong evidence of equivalence. In summary, the report does not present evidence that Cr(VI) concentrations in bulk soil samples is higher or equal to Cr(VI) concentrations on smaller particles.”

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. **There are three recommendations in the air transport chapter of the report and one in the environmental chemistry chapter directly addressing the issue of particle size.** From Chapter 6 (environmental chemistry): *“As described, the sampling and analytical capabilities for determining Cr(VI) concentration on very small particles (PM_{2.5}) are not fully developed or available commercially. These methods are still being developed. But there are steps that can be taken to ensure that alternative remediation standards are developed accurately: when a responsible party seeks to develop an alternate remediation standard for inhalation, a complete analysis of Cr(VI) by particle size should be developed, submitted and formally approved by the NJDEP. Such an analysis should include experiments in a resuspension chamber and use analytical methods consistent with those described in Chapter 3 of this report.”* From Chapter 5 (air transport): *“It is recommended that future ARS calculations be limited in the number of parameters that can be varied for the inhalation pathway. The Inhalation SRS that are currently available for interested party review would allow only the silt content of the soil or the fraction of vegetative cover to be changed. We recommend that facility-generated ARS vary silt content only while the SRS are being reviewed. Limiting ARS changes to site-specific silt content is advisable for a number of*

reasons. One is that the silt-content is an existing parameter that can be measured and is unlikely to change, in contrast to truck traffic (which is projected) and site size (which could change if a lot is subdivided or if adjacent lots are annexed).

It is also recommended that future SRS and ARS include both traffic generated dust and wind-blown dust in the calculation. In cases where no traffic is anticipated, an ARS should be based on exposure to windblown dust at a hypothetical residence located at property fenceline (the default being 270 mg/kg at the moment).

In USEPA (2003), the soil moisture content was removed from the equation for traffic-generated dust, because “unpaved roads have a hard, generally nonporous surface that usually dries quickly after rainfall or watering, because of traffic-enhanced natural evaporation.” Removing this factor results in higher estimate of particulate emissions from truck traffic. This new equation should be used in the development of the Inhalable SRS and any interim ARS.”

No changes to the soil criteria or bulk sampling procedures were recommended, either on a permanent or an interim basis. **See recommendations from workgroup above.**

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. **Criteria for acceptance of evidence were established at the beginning of workgroup deliberation.**

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 author is referred to the recommendations of the workgroup that directly speak to this issue.

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. **In fact, there is no alternative, given that methods for fractionating soil particles at these very low particle sizes are not routinely available at this time. However, for the development of alternative remediation standards, the workgroup recommends the use of research methods to conduct the analyses.** 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/m³ (*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. **Rural dispersion coefficients result in greater**

pollutant concentrations near the source; the instability that is associated to urban coefficients disperse and carry pollutants from the source quicker. 50% vegetative cover This is an USEPA default used for calculating generic standards; Alternative Remedial Standards would use site-specific data. 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. Unfortunately, while particle size distribution may make a difference on health impacts, the Bureau of Air Quality Evaluation is currently constrained by the tools and science it uses to predict ambient particulate concentrations. The ISC3 model (version 02035) does not differentiate its prediction of ambient concentrations based on particle size. The ambient concentration of particulates predicted by ISC3 will be the same whether assuming all of particles are 75 microns or less, all of the particles are 2.5 microns or less, or some other reasonable distribution of particle size measured in the environment. When predicting ambient or inhalable concentrations, ISC3 evaluates any pollutant, whether gaseous or particulate, as a gas. Particle size distribution is important only when calculating deposition impacts. And, furthermore, when calculating deposition impacts, ISC3 does not subtract any of the deposited material from the ambient impact concentration. In other words, the ISC3 provides an estimate of what would normally fall out based on particle size, and the maximum ambient concentration assuming nothing is deposited. 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. The air model developed by ChemRisk was modified by the Bureau of Air Quality Evaluation to include conservative inputs. For example, the Bureau of Air Quality Evaluation changed the dispersion factor component in the ChemRisk model from FDM to ISC3. In addition, conservative inputs were included for silt content, inhalation rate, and exposure duration. 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. **The impact to groundwater procedure is site specific, which is different than having no standard.**

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 Region VI have developed groundwater impact numbers for chromium (see Table 1). The NJDEP has not developed a generic soil impact to groundwater cleanup criterion for Cr(VI) due to highly variable soil conditions throughout the State. In the revised soil standards proposal, all sites containing inorganic chemicals and low mobility organic chemicals are now to be tested using the Synthetic Precipitation Leaching Procedure (SPLP), an EPA SW-846 analytical method (Method 1312) that can be used to determine the concentration of contaminant that will leach from soils and wastes (USEPA, 1998). The SPLP results are compared to generic Leachate Standards (LS), which are determined by multiplying the health-based Ground Water Quality Criteria (GWQC) by a default dilution-attenuation factor (DAF). New Jersey's proposed default DAF has a value of 13, and represents dilution of the contaminant when it enters

the groundwater. If the SPLP results indicate that leachate concentrations are below the LS, existing concentrations of contaminants on site do not represent a threat to groundwater quality and no further action is needed for the impact-to-groundwater pathway. If SPLP results indicate that leachate concentrations are above the LS, then the site must be remediated or the responsible party may do a site-specific determination of an alternate remediation standard.

Chromium was removed from the soil standards contaminant list because COPR waste sites were being considered separately by the chromium task force. However, a Leachate Standard for chromium is appropriate and may be proposed at this time. The health-based Ground Water Quality Criterion for chromium is 70 µg/L (applied to total chromium, but based on hexavalent chromium toxicity). When multiplied by the generic dilution-attenuation factor (13), this yields a proposed Leachate Standard of 910 µg/L.

While a leachate standard value for chromium has been proposed, the applicability of the SPLP test for determining leachate concentrations from actual site samples is still under evaluation.

The leachate concentration determined using the SPLP test may underestimate concentrations that would be observed under natural conditions because the large amount of extracting solution used may dilute the contaminant concentration below that which would be observed in the field. For this reason, the SPLP leachate concentration (determined at a 20:1 liquid-solid ratio) should be adjusted to normal field saturation conditions (0.41:1.5 liquid-solid ratio). To determine the proper adjustment procedure, existing site investigation data relating to the contact dermatitis exposure pathway is being evaluated. In its evaluations of the dermatitis pathway for various sites, the Site Remediation Program has accumulated data regarding the effect of the solid-to-solution ratio on the observed leachate concentration. The compilation and examination of this data may provide insights as to adjustments that should be made to SPLP test results when evaluating the impact-to-groundwater pathway. If the data suggests that a generic adjustment procedure is not defensible, then a site-specific adjustment to the SPLP procedure may be utilized. Specifically, a procedure similar to that employed for the contact dermatitis pathway, where multiple solid-to-solution ratios are run for each site, may be suitable.

While chromium is not included in NJDEP's draft Soil Standards regulations, the procedures contained in those draft regulations were reviewed for potential applicability to chromium waste sites. This assessment was included in the Chromium Workgroup report. Since the completion of the workgroup report, modifications have been made to the draft Soil Standards regulations that affect this assessment. A newly proposed procedure in the proposed regulations is partially applicable to chromium-contaminated waste sites, and an evaluation of modifications necessary to fully apply the procedure will be conducted.

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 quo* 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,...*” This quote appears no where in the workgroup report. In fact, site-specific impact-to-groundwater standards are proposed. Defining the COPR material as a continuous source strengthens the Department’s ability to require clean-up based on potential groundwater contamination, not lessen it.

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. The term “continuing” or “ongoing” source is used frequently in the Response to Comments Document for the 1977 TRSR. This document does have remedial significance:

In the response to Comment 454, the Department stated “residual contamination may be present below the water table, thus presenting an ongoing source of ground water contamination.”

In the response to Comment 483, the Department stated “contaminated soil could be present below the water table, that could act as a continuous source of ground water contamination, or cause a direct contact threat.”

In the response to Comment 698, the Department stated “Ground water contaminant sources provide an uncontrolled reservoir of contaminants which will continue discharge of contaminants to ground water. It is critical, therefore, that the sources be removed, contained, or controlled whenever feasible in order to maximize the effectiveness of dissolved plume remediation....”

In the response to Comment 704, the Department stated “Source areas represent a continuing discharge of contaminants to ground water, and their removal, containment, or control to the extent practicable, is critical in order to prevent or reduce further degradation of ground water resources...”.

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 author discusses the potential for chromium to leak into the city's potable water system, comparing the situation to the events where bacteria leak into the lines, requiring boiling of water. Such events, where positive pressure lines experience an abrupt change in water pressure and allow infiltration, are known to occur in cities having old infrastructure. Instances of actual contamination are rare. However, even one sip of bacteria-laden water can cause an acute reaction, so it is prudent to issue boil water advisories when this change in pressure occurs. A similar exposure to chromium would not be expected to have a similar reaction. The toxicity values for chromium are based on long-term exposure. Nevertheless, this is a valid concern that was not address by the workgroup and is deserving of some attention.**

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

The Environmental Chemistry subgroup concluded that there was not adequate evidence indicating that significant oxidation of trivalent chromium to hexavalent chromium is occurring at COPR sites. Specifically, oxidation that occurs appears to be occurring slowly, apparently slowly enough that removal mechanisms for hexavalent chromium (rainfall, flushing by surface runoff) prevent hexavalent chromium concentrations from increasing to a significant extent. Evidence available from chrome waste sites does not suggest that hexavalent chromium concentrations have been increasing over time.

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.

The workgroup report acknowledges the literature on oxidation and reduction. From Chapter 3 (Environmental Chemistry chapter): “*Overall, studies in the literature report a wide range of results regarding oxidation of trivalent chromium, Cr(III), to hexavalent chromium, Cr(VI). Research has shown that oxidation can occur in soils, particularly those containing manganese oxides, so it is possible that oxidation takes place in areas where soil has been mixed with the COPR material. Some studies show that the oxidation reaction is so slow as to be insignificant, while others indicate the oxidation can occur over a period of less than a decade. There is not enough evidence in the published literature to warrant a change in the determination of soil clean-up levels based on oxidation reactions.*”

All of the studies cited below were accepted and reviewed by the workgroup. In fact, much of the descriptions appearing after the study citation appear verbatim in the report. A complete citation and a more complete assessment of each study is provided.

Oxidation Studies in Soils

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

Fantoni, D., Brozzo, G., Canepa, M. and Cipolli, F. (2002), "Natural Hexavalent Chromium in Groundwaters Interacting with Ophiolitic Rocks," *Environmental Geology* 42: 871-882.

The authors state that while trivalent chromium dissolves from ophiolites, especially serpentinites and ultramafites, which are Cr-rich, and subsequently oxidizes to hexavalent under oxidizing conditions of shallow aquifers having magnesium and calcium, it is subsequently reduced at greater groundwater depths, in the presence of Fe(II) and organic matter.

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

Oze, C., Fendorf, S., Bird, B.D., and Coleman, R.B. (2004), "Chromium Geochemistry of Serpentine Soils," *International Geology Review* 4: 97-126.

Serpentine soils from New Caledonia, Oregon and California (slightly acidic, pH approximately 6, containing Fe(III) oxides and clays and trivalent concentrations of 827 to 9,528 mg/kg), oxidation of trivalent chromium spinels occurs by high valence manganese oxides to hexavalent chromium. After oxidation, hexavalent chromium is "...subsequently reduced by reacting with organic matter or Fe(II)-bearing minerals such as magnetite, which are present in serpentine soils.", page 23.

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

Cooper, G.R.C. (2002), "Oxidation and Toxicity of Chromium in Ultramafic Soils in Zimbabwe," *Applied Geochemistry* 17: 981-986.

The researchers found that, in a laboratory experiment, added trivalent chromium exerted a toxic effect on maize. The soils contained appreciable easily reducible manganese. The authors attribute the toxicity to a slow oxidation of trivalent chromium to hexavalent after slow hydrolysis to chromium hydroxide. The authors conclude: "The small amounts of Cr(VI) produced would probably not be enough to be toxic to annual crops and, furthermore, would probably be removed by natural leaching." Although they conceded that oxidation could occur in poorly drained soils with fluctuating water tables.

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.

Eary, L.E. and Rai, D. (1987), "Kinetics of Chromium(III) Oxidation to Chromium(VI) by Reaction with Manganese Dioxide," *Environmental Science and Technology* 21(12) 1187-1193.

The authors state in their abstract that, "In slightly acidic to basic solutions, the oxidation of aqueous Cr(III) is very slow and is limited by the low solubility of Cr(OH)₃. Of note in this experiment is the discovery that "...oxidation of aqueous Cr(III) does not occur by surface-catalyzed reactions with dissolved oxygen but by direct reaction with β-MnO₂(s)..." The authors further state (and the workgroup report agrees) that, "The ready oxidation of Cr(III) to Cr(VI) by manganese oxides indicates the need to examine the mineralogy and oxidation potential of both the waste materials and the underlying soils at sites where Cr-bearing wastes may be

deposited.... in the absence of manganese oxides, the oxidation of aqueous Cr(III) is unlikely to occur.” Page 1193.

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

Schroeder, D.C. and Lee, G.F. (1975), “Potential Transformations of Chromium in Natural Waters,” *Water, Air, and Soil Pollution* 4: 355-365.

This study agrees with earlier cited studies, as stated in its abstract, “The results of this study indicate that Cr(VI) is reduced by Fe(II), dissolved sulfides, and certain organic compounds with sulfhydryl groups, while Cr(III) is oxidized by a large excess of MnO₂ and at a slow rate by O₂ under conditions approximating those in natural waters.” In the results section of this study, the authors state, “...it appears that the rate of this reaction [oxidation] is sufficiently slow in natural waters that Cr(III) may be involved in other reactions, particularly sorptions, before it can be oxidized by O₂.” Page 357. The researchers state that over the pH range of 5.9 to 9.9, pH itself does not appear to be significant. “In all cases, less than 2% of the added Cr(II) was oxidized in two weeks.” Page 358. In sum, the authors conclude that “Cr(III) is oxidized by O₂, but at a slow rate, and by MnO₂, although this reaction is inhibited by substances in natural waters. Cr(VI) is reduced by Fe(II), dissolved sulfides, and certain organic compounds with sulfhydryl groups...” Page 364.

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.

Pillay, K., von Blottnitz, H. and Peterson, J. (2003), “Ageing of Chromium(III)-bearing Slag and its Relation to the Atmospheric Oxidation of Solid Chromium(III)-oxide in the Presence of Calcium Oxide,” *Chemosphere* 52: 1771-1779.

The researchers found “very gradual oxidation” when slag is exposed to atmospheric oxygen. Oxidation ceased to occur after 12 months. Further, the authors state that “...the quantities of hexavalent chromium that may thus be formed appear to be limited to about 0.1 to 1% of the total chromium present...”, with no oxidation occurring after 12 months regardless of the form of the chromium (weathered slag, powdered or balls).

Fendorf et al. (1992) found oxidation by Mn-oxides decreased with increasing pH (>4) due to formation of a Cr (OH)₃ precipitate on MnO₂ surfaces.

Fendorf, S.C. and Zasoski, R.J. (1992), “Chromium(III) Oxidation by Manganese Oxide. 1. Characterization,” *Environmental Science and Technology* 26(1): 79-85.

These authors found that as manganese oxide levels decreased, the rate of oxidation decreased: “As the MnO₂ is consumed, the rate decreases, with the reaction continuing until the surface is diminished – the reaction rate was dependent on the level of MnO₂. Very rapid initial rates of oxidation at pH = 5 are followed by a “shut down” in oxidation.” Page 82. The conclusions reached by these researchers validate those in the workgroup report: “It appears that Cr(III) concentration, pH, and the amount of initial available surface are the parameters controlling the degree of oxidation.” Page 84.

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...”

Johnson, C.A. and Xyla, A.G. (1991), “The Oxidation of Chromium(III) to Chromium(VI) on the Surface of Manganite”, *Geochimica et Cosmochimica Acta* 55: 2861-2866.

These researchers state that “The rate of oxidation is very slow...” The experiments, however, were designed to examine oxidation rates of various manganese oxides. They found that MnOOH is more effective at promoting oxidation than other manganese oxides. The presence of manganese oxides in natural waters can cause Cr(III) to oxidize. However, “...there is evidence from this and other investigations that inorganic and organic dissolved components can significantly decrease the rate of this reaction.” Page 2865. This article indicates that oxidation can occur but that other components of natural waters can interfere with it.

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

Kožuh, N., Stupar, J., and Gorenc, B (2000), “Reduction and Oxidation Processes of Chromium in Soils”, *Environmental Science and Technology* 34: 112-119.

The researchers here state in their abstract that, “Reduction of soluble chromium was observed in all the soils examined. It depends mostly on the content of organic matter, on the concentration of the added chromium, and on the pH of the soil... Oxidation of soluble chromium was observed especially in soils high in manganese(IV) oxides and low in organic matter.” Page 112.

Dr. McBride⁶⁷ 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 “*serpentinic 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.*”

Chung, J-B and Sa, T-M. (2001), Chromium Oxidation Potential and Related Soil Characteristics in Arable Upland Soils”, *Communications in Soil Science and Plant Analysis* 32(11&12): 1719-1733.

Chung & Sa find that in Korean soils “as the pH was higher and the organic matter content lower, the chromium oxidation potential was higher.” The presence of manganese and organic matter are known to enhance reduction, and the lack of manganese and organic matter are known to enhance oxidation. The authors state further that, “manganese-oxides are the only known oxidants of chromium in natural environments, and the soil humic substances, which constitute the majority of the organic fraction in most soils, represent a significant reservoir of electron donors for Cr(VI) reduction.” Pages 1725-1726. In the Korean soils studied, manganese and organic matter were abundant.

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.*”

Dr. McBride’s comments on page 39 concern the oxidation of Cr(III) in soils containing the Cr(III)-bearing mineral serpentine. McBride points out that serpentine was previously thought to be a stable mineral, but now shows the potential for oxidation. This is not directly relevant to chromium waste sites because chromium slag waste does not contain serpentine, but it does imply that further investigation of COPR waste may be warranted. This is recommended in the report.

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.” This article was cited in the previous section on oxidation studies.

Pillay, K., von Blottnitz, H. and Peterson, J. (2003), “Ageing of Chromium(III)-bearing Slag and its Relation to the Atmospheric Oxidation of Solid Chromium(III)-oxide in the Presence of Calcium Oxide,” *Chemosphere* 52: 1771-1779.

The researchers found “very gradual oxidation” when slag is exposed to atmospheric oxygen. Oxidation ceased to occur after 12 months. Further, the authors state that “...the quantities of hexavalent chromium that may thus be formed appear to be limited to about 0.1 to 1% of the total chromium present...”, with no oxidation occurring after 12 months regardless of the form of the chromium (weathered slag, powdered or balls).

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.

Like the others, this is a direct quote from the Chromium Workgroup Report. Most of the research agrees that oxidation occurs in the presence of organic matter and manganese.

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, B. (1994) "Hexavalent Chromium Solubility and Reduction in Alkaline Soils Enriched with Chromite Ore Processing Residue," *Journal of Environmental Quality* 23(2): 227-233.

This researcher noted no oxidation of Cr(III) and no reduction of Cr(VI). An unusual discovery in this study was that added manganese reduced more than 50% of soluble Cr(VI) to Cr(III) in soils with more being reduced in the high Cr(VI), pH 10 soil. Ferrous iron was more effective than manganese as a reducing agent. Most studies have shown that manganese enhances oxidation rather than reduction, but this study demonstrated that reduction occurred with added manganese.

James (2002) points out that "aged, less soluble, and more crystalline forms of Cr(III) (e.g. Cr₂O₃) are much less prone to oxidation."

James, B.R. (2002), "Redox Phenomena," *Encyclopedia of Soil Science*, pages 1098 -1100.

There is no mention of oxidation of chromium in this general article.

James, B.R. (2002), "The Chromium File," By the International Chromium Development Association, Paris, France, Volume 8(February, 2002).

James proposes that several parameters are significant in determining whether oxidation or reduction is predominant in soils. They are presence and amount of organic matter, pH, form and amount of chromium, and presence of manganese (hydr)oxides. The dominant reaction depends upon these parameters. This is a general article summarizing these parameters and is not a laboratory or field study.

James et al. (1977), James (1975), and James (2002) present a visual model of the relationship between organic matter and manganese (Mn[III,IV] [hydro]oxides) on chromium oxidation, depicted in Figure 6.1 of the chromium report. In effect, this seesaw depiction describes the phenomenon described by Böhm & Fischer (2003). The James' papers indicate that pH is a "master variable" for both oxidation and reduction reactions. The point of this illustration is to show that many variables control the interconversion of the chromium species and that a change in any of them can alter which reaction dominates.

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.

Geelhoed, J.S., Meeussen, J.C.L., Lumsdon, D.G., Roe, M.J., Thomas, R.P., Farmer, J.G. and Paterson, E. (1999), "Processes Determining the Behavior of Chromium in Chromite Ore Processing Residue Used as Landfill", *Land Contamination and Reclamation*, 7(4) 1999, 9 pages.

These researchers state that oxidation will be strongly restricted by pH conditions above 5 and that any "oxidation of Cr(III) by oxygen is extremely slow." In their conclusions, they state, "... oxidation of Cr(III) to Cr(VI) in COPR is highly unlikely, because the reactivity of the possible oxidant, manganese oxide, will be restricted due to surface precipitation of Cr(III) hydroxide on the oxide at the high pH found in COPR."

Approximately 12 studies out of 16 document confirm oxidation of Cr(III). **None of the studies confirm oxidation of Cr(III) to Cr(VI) at the conditions known to occur at COPR sites. Many of these studies show the potential for oxidation as well as the potential for reduction. None of the studies described above are evidence that oxidation occurs at COPR sites in New Jersey.** Two studies found unequivocal results, both of which were conducted by Bruce R. James⁶⁹. **The footnote here indicates that James submitted unpublished material showing unequivocal results. None of the work of James that is published or citable in accordance with the workgroup criteria show this.** Therefore, the weight of scientific evidence clearly suggests that the current criteria for Cr(III) is problematic. **The weight of evidence shows that oxidation is favorable under conditions of high manganese and high organic matter levels and that reduction is favorable under conditions of low manganese and low organic matter levels.** 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

Most of these studies are not applicable to chromium waste site conditions. Many of the studies were under pH conditions that are not relevant (<pH 8-10) and/or were studies in soils, rather than slag waste material. Further, in order for hexavalent chromium concentrations in waste material to increase, the kinetics of oxidation would need to be sufficiently rapid so that hexavalent chromium would be formed faster than it is being removed via environmental processes. This is the reason that the workgroup recommended that "oxidation rates of Cr(III) in COPR be further investigated".

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. **The author is herself a staff member in the site remediation program.** 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) **There were no legal restrictions to the workgroup review of the clean-up criteria. Legal issues dealt with the allowability of alternative remediation standards development and remedial controls, both of which were beyond the purview of this report.**

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 failure⁷³.

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, Louisiana, 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-Patterson 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.

The workgroup examined the scientific validity of the cleanup numbers. It was beyond the purview of the scientists on the workgroup to investigate remediation controls.

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.

Attachment I provides the criteria with which all material was evaluated. Over 300 articles were submitted to the chromium workgroup from external groups. Each one was evaluated by subgroup chairs to determine whether or not it met the criteria. The author suggests that items such as newspaper articles, unpublished work, and non-peer reviewed studies, such as the Hayes report, be used to make recommendations. These materials would not pass the review criteria.

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.

There were no industry members or industry representatives on the workgroup. The workgroup was comprised of 1) all authors on the original Hazen et al. (2004) report, regardless of their credentials; and 2) scientists from the Division of Science, Research and Technology, the Office of Quality Assurance, and Site Remediation Program with specific expertise in the areas under examination. Dr. Paustenbach had no input whatsoever in this process and the implication here that he did is in serious and imprudent error. In fact, none of the studies authored by Dr. Paustenbach were used in the development of recommendations in the workgroup report. A review of the references listed in each subchapter shows that the authors of the scientific papers used to evaluate the cleanup criteria were not on the workgroup. An exception is Dr. Alan Stern (NJDEP-DSRT) and Dr. Jerry Fagliano (NJDEP-DHSS) who have co-authored human exposure studies and Dr. Paul Sanders (NJDEP-DSRT) who co-authored soil studies. Scientists who have worked on the development of the 1998 criteria, including those just listed, were included in the workgroup, as they had the expertise necessary to interpret the technical material.

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.

It was evident at the beginning of the workgroup discussions that the authors of the Hazen et al. (2004) document did not have a thorough understanding of the cleanup

regulations for chromium. This, despite the fact that some of them, including the author of this memorandum, work in the site remediation program. In order to examine the scientific validity of the criteria, it was necessary to understand the regulatory context. Staff from the Site Remediation program who have been working on the issue of chromium remediation were asked to serve on the workgroup in order to provide this expertise as well as to provide information on sites upon request.

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.

Attachment I provides the scientific criteria for acceptance of scientific evidence. Newspaper articles and court cases do not meet this criteria. Indeed, the primary expert witness for the federal case cited here has since changed his mind. The defense is now appealing the decision in light of this change of expert testimony. Had the workgroup relied upon this testimony as "evidence", there would now be no basis for recommendations. It is important to use scientific evidence in formulating scientifically-based recommendations.

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.

Attachment I was distributed several times throughout the process. It describes the criteria for acceptance of articles.

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"

It was established that, as this was a scientific review to determine whether or not the soil cleanup criteria were based on the science available, it was appropriate to examine scientific evidence.

- The workgroup was “*polarized in their professional judgment about some of the issues.*” This is not being refuted. The fact that members disagreed does not mean there were no policies and procedures. There were. The process was open in order to provide all points of view with a voice. That is appropriate.
- 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. This is incorrect. References appear at the end of each chapter. 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. Many pages of the report discuss the issues surrounding the “polarizing” topics. Out-of-state experts in soil chemistry reviewed the report as part of the peer review process.

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.

All points of view were discussed at length. There were polarized factions within the workgroup and neither side would budge from their established set of opinions. Therefore, the weight of evidence approach was used whereby opinions and professional judgement was required to be based upon evidence. The weight of the evidence presented reflects the information in the workgroup report.

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 report recommends use of the 1998 criteria until and unless new data are provided that warrant a change.

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.

Weight of evidence is used to examine issues where some uncertainty exists. Uncertainty is not the same as improbability nor is it the same as probability. As with most things in the natural world, chromium behavior can rarely be predicted with absolute mathematical

certainty (and even the current science may someday be disproven). But, again, for some things in science there is a large body of evidence that supports a particular hypothesis — this refers to the “weight of evidence.” The references provided at the end of each chapter provide the backbone for the weight of evidence conclusions reached by each of the subgroups. Professional judgement is an important factor in this. The workgroup was limited to those players within state government for its professional judgement. The peer review provided an avenue for the workgroup to hear from external, unbiased experts in the field.

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. **In fact, peer reviewers were supplied with the workgroup report plus copies of all the articles referenced in the report.** 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. **The peer reviewers were not asked to comment on remedial decisions. This would be beyond their expertise.** In the meantime, the report fails to address how the Department should proceed.

The external peer review followed the guidelines published by the National Academy of Sciences. The procedures and instructions for conflicts-of-interest outlined in this document, especially the Policy On Committee Composition And Balance And Conflicts of Interest for Committees Used In The Development of Reports, was used for the chromium peer review. The NAS gave New Jersey written permission to use their documents for free for the peer review process.

The peer reviewers were:

Peer Reviews who attended the January 10, 2005 discussion meeting:

Dr. Paul Brandt-Rauf, Department Chair, Environmental Health Sciences, Columbia School of Public Health

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. Gregory Turk, Group Leader, Spectrochemical Methods, Analytical Chemistry Division, National Institute for Standards and Technology

Readers:

Dr. Jonathan Chorover, Associate Professor of Environmental Chemistry, Soil, Water, & Environmental Science, University of Arizona

Dr. Herbert Gibb, Epidemiologist and Risk Assessor, Sciences International, Inc (recently retired from Office of Research)

Dr. C.P. Huang, Civil & Environmental Engineering, University of Delaware
Dr. Robert W. Puls, Laboratory Director, National Risk Management Research
Laboratory, Office of Research and Development
(Dr. Puls gave the report to his staffer, Dr. Chunming Sua soil scientist)
Dr. Ken Stollenwerk, Hydrologist, US Geological Survey, Denver Federal Center

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:

The National Toxicology Program study is not finished. Only preliminary data was available on the web. The data has since been removed from the web for unknown reasons. California, likewise, has withdrawn its information on chromium and removed it from their website. Once these documents become finalized and available, they will be reviewed, and appropriate changes will be made to the chromium cleanup criteria, if warranted.

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 powdered 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.

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 Eileen 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) **This is an incomplete reference.**

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 Pennsylvania

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.” **Dr. Brown has recently accepted a position with Honeywell and has altered his view on this issue. He accepts capping as a viable option.**

16 “Evaluation of the Medium to Long-Term Effectiveness of Capping at COPR Sites”, by Zoe Kelman, August 9, 2004 revised November 24, 2004 **There is an implication that this is a published document. If this has been published in a peer-reviewed journal or was published by any agency, please provide the citation.**

¹⁷ New Jersey Chromium Report, Chapter 3, page 33, first paragraph: “ *there is insufficient evidence from any individual occupational epidemiological study to conclude that Cr⁶ 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 Environmental 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 **This is not published work, as per e-mail correspondence with Dr. Froines.**

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.” **The relevance of this to chromium is unexplained.**

²¹ February 1999, Office of Environmental Health Hazard Assessment California Environmental Protection Agency, “Public Health Goal for Chromium in Drinking Water”. **This was recently withdrawn by Office of Environmental Health Hazard Assessment**

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; *Toxicology 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) **This is an incomplete reference.**

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 Dermatitis*, 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 **This is an incomplete reference.**

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

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/ July 1999 **This is an incomplete reference.**

⁴⁶ Henry, K.S. (2004) Evaporative Deposition of Chromate Salt in Northern New Jersey and Means to prevent it, Tierra Solutions, Inc. **This is an incomplete reference.**

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) **This is an incomplete reference.**

⁵⁰ Analysis Paper: Impact of Lead-Contaminated Soil on Public Health: Agency for Toxic Substances and

Disease Registry, Atlanta, Georgia 30333 May 1992 **This is an incomplete reference.**

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 **This is an incomplete reference.**

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 - **This is an incomplete reference. Please provide full citation.**

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 **This is an incomplete reference. Please provide full citation.**

⁶⁰ Chromium Workgroup Report Executive Summary page 3, paragraph 3, first sentence

⁶¹ NJ Chapter of Sierra Club, June 2, 2005 –Review of NJ Department of Environmental Protection cleanup criteria for COPR **Incorrect title** - 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 **Incorrect title** - 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. **This is an incomplete reference. Please provide full citation.**

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 **This is an incomplete reference. Please provide full citation.**

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. **This is an incomplete reference. Please provide full citation.**

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.” **This is an incomplete reference.**

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 **This is an incomplete reference.**

⁷⁷ French, Poole, Ravenscroft, Khiabani, Results of preliminary experiments on the influence fabrics on the migration of groundwater and water-soluble minerals in the capillary fringe. Department of Geological Science, Queen Mary College, London, The Geological Society 1982 **This is an incomplete reference.**

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.

ATTACHMENT I:

NJDEP Chromium Workgroup

Supervising Chair: Mark Robson⁷⁸

NJDEP Chairs: Tom Cozzi and Eileen Murphy

The overall charge to the workgroup, as identified by Commissioner Campbell:

- **The workgroup will review the application of the current chromium standards and any revised standards.**

Toward this end, the workgroup will prepare and submit a concise report to the Commissioner outlining the science of the issues identified with recommendations concerning the application of the chromium standards as they apply to chromium processing ore residue sites.

The calendar for report-writing is:

April – July, 2004: Subgroup meetings and discussion

July 6, 2004: Report-writing from subgroups. Consensus on issues reached.

August 6, 2004: All subgroup summaries sent to workgroup chairs for incorporation into main report

September 1, 2004: Draft report sent to academic peer review

October 15, 2004: Report available to the public

Material that may be considered (*this material may be used to validate decisions made by the group*):

- Articles that have appeared in peer-reviewed journals whose source of funding is identified
 - Studies will be evaluated on a case-by-case basis.
- Government-sponsored or government-issued reports or documents in final form (not draft)
- Final, signed masters or doctoral theses
- Case studies submitted to or prepared by government organizations that have passed a quality assurance review

Material excluded from consideration (*the group may read and present this material but may not use it to validate a decision*):

- Documents that have not been published or peer-reviewed in some capacity
- Presentations (i.e., Powerpoint presentations of unpublished work)
- Opinion articles
- Newspaper articles or other mainstream media material
- Anecdotal information or accounts

The chair of each subgroup will sum up the findings and recommendations of his/her group for adaptation into the full report. The subgroups are:

1. Analytical Chemistry
2. Chromium Environmental Chemistry
3. Risk Assessment
4. Air and Dust Transport

- Analytical Chemistry Subgroup (Lead: Joe Aiello)
NJDEP: Stu Nagourney, Lee Lippincott, Greg Toffoli, Joe Sanguiliano
NJDHSS: Nick Tumillo
USEPA: Michael Sivak, John Bourbon

- Chromium Environmental Chemistry Subgroup (Lead: Eileen Murphy and Becky Jones)

NJDEP: Paul Sanders, Teruo Sugihara, Ted Hayes, Tom McKee, Zoe Kelmen, Roger Page,
Bob Hazen, Dave Barskey, Maryanne Kuserk, Dave Van Eck
USGS: Julia Barringer

- Risk Assessment Subgroup (Lead: Eileen Murphy)
NJDEP: Bob Hazen, Alan Stern, Linda Cullen, Gloria Post, Tom Ledoux, Teruo Sugihara
NJDHSS: Jerry Fagliano
- Air and Dust Transport Subgroup (Lead: Joanne Held)
NJDEP: Greg John, Joanne Held, Teruo Sugihara

NJDEP Chromium Workgroup

The overall charge to the workgroup, as identified by Commissioner Campbell:
The workgroup will review the application of the current chromium standards and any revised standards.

Some miscellaneous items to keep in mind as you work.

OPRA

Material that is considered deliberative is not disclosable under the Open Public Records Act. However, once the workgroup report is final, all documents used in the development of that report will become disclosable, as they are no longer considered part of the deliberative process. Please maintain records as you use them. It will make fulfilling later OPRA requests easier when the time comes when the records are considered open public documents.

- Keep copies of materials that are used in decision-making. The chair of each subgroup will be the records-keeper for each subgroup. All research articles, documents, etc. considered by the group in making decisions needs to be maintained.
- Note-taking: if notes are taken, they must be given to the chair and kept with all other material.
- Email: if keeping emails, chair should retain a file of them with the other records.

Website

During the 6 months or so that the workgroup is deliberating and writing, the Department will maintain a website where stakeholders, including the general public, can access information about the process. Periodic updates may be requested of each subgroup, as needed. Stakeholders are invited to submit material for consideration by the workgroup but must indicate what type of material it is. Only material that fulfills the description in the workgroup charge will be considered.

Press Inquiries

You may receive a call from a reporter. Please forward all press calls to the Press Office at 2-9289. Arrangements for any interviews will be handled by that office.

ATTACHMENT II:

Review of Particle Analysis and Particle Analysis Fractionation Evaluation
Leo Korn, Ph.D.

1. the right types of statistical tests were selected for data evaluation

The sign test looks at whether the probability of bulk > fraction is greater than 0.5. This is a reasonable thing to do if that is what you are interested in.

Note that it does not test whether the mean bulk concentration is greater than the mean fraction concentration. If the distributions are skewed (as they usually are), this test is not good if you are interested in means rather than probabilities.

The test assumes independent samples. When drawing samples from a site, this is often not true (most tests have this drawback) so the p-values may not be accurate.

The sign test has low power. When sample sizes are small this can be a concern. (This comes into play in the re-analyses with non-detects removed).

2. the correct data were used in running the tests

I get almost the same counts as in the main report. The differences would not alter the conclusion. However, most of the pairs of data have non-detect values with the detection limit being used as data. This makes the analyses more about detection limits than about actual concentrations. For this reason I would not consider the correct data to have been used.

3. The conclusions are based on the results of the statistical tests.

Assuming that the counts are meaningful, the conclusions are correct. However I do not believe that these counts are meaningful.

The last page of the report indicates that Dave Barskey requested that the analyses be redone while omitting the non-detects. They have presented the results for bulk vs. the 75 fraction. They did not present the results for bulk vs. 10 fraction. This is a more appropriate way to look at the data, although removal of the non-detects can lead to bias if small concentrations have different fraction proportions than large concentrations.

The report claims that after removing non-detects there are 22 bulk > fraction and 22 bulk < fraction. I count 12 bulk > fraction and 12 bulk < fraction.

The argument is then made that even though there is no evidence that bulk is greater than fraction, they are equivalent. This kind of testing has low power, so it should not be considered as strong evidence of equivalence.

For the 10 fraction with non-detects removed, I counted 5 bulk > fraction and 13 bulk < fraction. This is marginally significant in the opposite direction of what they seem to want to find, which may explain why it was not presented.

Overall, I would not consider this report to be adequate for the conclusions that are presented.