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COMMENTS OF AVX CORPORATION

ON

THE PROPOSED CLEANUP PLAN FOR THE UPPER AND LOWER NEW BEDFORD HARBOR RELEASED TO THE PUBLIC FOR COMMENT ON OCTOBER 30, 1996

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PART I

COMMENTS OF AVX CORPORATION ON THE PROPOSED CLEANUP PLAN FOR THE UPPER AND LOWER NEW BEDFORD HARBOR RELEASED TO THE PUBLIC FOR COMMENT ON OCTOBER 30, 1996[1]

I. INTRODUCTION

These are the comments of AVX Corporation ("AVX") on the Environmental Protection Agency's ("EPA") Proposed Cleanup Plan (the "1996 Plan") for the New Bedford Harbor Superfund Site's (the "Site") second operable unit (upper and lower New Bedford harbor, sometimes "OU2"), which was released to the public for comment on October 30, 1996. The 1996 Plan calls for dredging approximately 450,000 cubic yards of sediment from the upper and lower harbor, and storage of dredged sediments in four shoreline Confined Disposal Facilities ("CDFs") pending the outcome of five-year reviews to determine the availability of potential treatment technologies for the stored sediments. This plan differs dramatically from that which was proposed by EPA in 1992: instead of a site-wide Target Cleanup Level ("TCL") of 50 ppm, a TCL of 10 ppm was set for the upper harbor; the amount of sediment to be dredged has increased by approximately 150,000 cubic yards; and the cost has risen from $42,000,000 to $116,000,000.

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[1] This part of AVX's comments were prepared by Mary K. Ryan and Gary L. Gill-Austern of Nutter, McClennen & Fish, LLP. The discussion of the scientific and technical issues is based on the comments of AVX's expert consultants, which should be consulted for further elaboration and detail. The second and third parts of this submittal include their comments; their qualifications are in the final part.

These comments are made more than:

- 15 years after EPA added the Site to the National Priorities List,
- 13 years after EPA issued a Feasibility Study of the upper harbor,
- 8 years after EPA completed and published a proposed plan for the cleanup of the first operable unit (the "Hot Spot"),
- 7 years after EPA issued a Record of Decision ("ROD") for the permanent cleanup of the Hot Spot which called for dredging sediment within the 4,000 ppm isopleth, temporary storage in CDFs, and treatment of the sediment through onsite incineration,
- 4 years after EPA suspended plans to incinerate the dredged sediments, and
- 2 years after EPA issued an Explanation of Significant Differences doing away with the incineration component of the Hot Spot ROD, providing for long-term storage of the sediments in CDFs, and pursuit of alternative treatment technologies.

At the same time that the work has been suspended to determine a "better" course of action at the one operable unit for which EPA has published a ROD which ostensibly details the steps EPA was to take to implement a permanent remedy, the 1996 Plan -- the Agency's final step before issuing a second ROD -- unbelievably proposes what is no more than an interim remedy based on dated and seriously flawed studies for the second operable unit, and strongly suggests the future creation of yet a third operable unit. In the context of the above-cited protracted history of ill-advised decisions, compounded or modified by still further ill-advised decisions, EPA is on the verge of initiating steps that offer no one -- not the citizens of New Bedford or the neighboring communities, not public officials or state and federal agencies, not potentially responsible parties who could be forced to bear significant portions

of the ever-expanding costs, and certainly not those committed to the appropriate response to site conditions -- any ability to rest assured that the 1996 Plan will result in the selection of a remedy that is "protective of human health and the environment, that maintain[s] protection over time, and that minimize[s] untreated waste," nor any ability to rest assured that the 1996 Plan will not become next year's or the year after's "plan-to-modify."

AVX will make clear in the comments below that EPA's actions and decisions which culminated in the 1996 Plan do not meet the applicable legal standards. In addition, Dames & Moore, Inc. ("Dames & Moore"), on behalf of AVX, is submitting a compilation of its technical and scientific comments and those of other expert consultants addressing the major flaws in the 1996 Plan. These materials are included in the second and third parts of these comments. Finally, AVX references the comments submitted by it, its consultants and attorneys in 1989 and 1992, including the Requests for Admissions prepared and served on the United States and the Commonwealth of Massachusetts in June, 1990, which presented the scientific and technical work undertaken by AVX as of that date.

II. LEGAL STANDARD

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 ("CERCLA"), promulgated at 42 U.S.C. §§ 9601 *et seq.*, provides the standards by which EPA's actions and decisions are to be evaluated. First, § 9613(j)(2) states:

> In considering objections raised in any judicial action under this chapter, the court shall uphold the President's decision in selecting the response action unless the objecting party can demonstrate, on the administrative record, that the decision was arbitrary and capricious or otherwise not in accordance with law.

Second, § 9613(k)(2)(B) states further:

> The President shall provide for the participation of interested persons, including potentially responsible parties, in the development of the administrative record on which the President will base the selection of remedial actions and on which judicial review of remedial actions will be based. These procedures developed under this subparagraph shall include, at a minimum, each of the following:
>
> (i) Notice to potentially affected persons and the public, which shall be accompanied by a brief analysis of the plan and alternative plans that were considered.
>
> (ii) A reasonable opportunity to comment and provide information regarding the plan.
>
> (iii) An opportunity for a public meeting in the affected area, in accordance with section 9617(a)(2) of this title (relating to public participation).
>
> (iv) A response to each of the significant comments, criticisms, and new data submitted in written or oral presentations.
>
> (v) A statement of the basis and purpose of the selected action.
>
> For purposes of this subparagraph, the administrative record shall include all items developed and received under this subparagraph . . ."

III. EPA'S CONDUCT IS ARBITRARY AND CAPRICIOUS: DESPITE TAKING MORE THAN SIX YEARS TO CHOOSE FROM THE REMEDIAL ALTERNATIVES EPA HAS IGNORED TECHNICAL, SCIENTIFIC AND REGULATORY DEVELOPMENTS SINCE 1990 AND CONTINUES TO RELY ON SERIOUSLY FLAWED STUDIES.

If AVX were limited to naming only one problem with EPA's proposal to adopt the 1996 Plan as the OU2 ROD, it would be EPA's continued reliance on the August 1990 Feasibility Study, described unequivocally in the 1996 Plan as the basis of EPA's remedy selection process. For the reasons fully elaborated in these and earlier comments, the studies that form the basis for the 1996 Plan are seriously flawed. During its recent exhaustive review of the administrative record (the "Record") for the Site, AVX was unable to find any indication that EPA, in its reconsideration of the remedial alternatives first proposed in 1990, reviewed, applied or in any way took into account post-1990 developments that would, if considered, have had a considerable impact on the selection of the remedy. By failing to take advantage of technical, scientific and regulatory developments in the last six years, to say nothing of the valuable, site-specific field experience gained during Hot Spot remediation and its associated monitoring, EPA has lost a valuable opportunity to correct earlier deficiencies and to provide a sound basis for reasoned decision-making.

Among the errors documented in AVX's earlier comments -- and summarized in the materials submitted by Dames & Moore and others as comments to the 1996 Plan -- are the following:

- the ecological risk assessment is speculative, lacking scientific validity;
- the human health risk assessment is premised on wholly unrealistic, overly conservative exposure scenarios and an outdated cancer slope factor ("CSF"), resulting in overstated threats to human health;
- the effects of the preferred remedy are unknown because the modeling efforts by Battelle and Hydroqual are not scientifically reliable, and cannot be used to make even qualitative comparisons of remedial alternatives; and
- the impact of dredging and CDF construction has not been properly evaluated.

Perhaps the most important event that has occurred over the last seven years is the Hot Spot dredging, which cost $33,000,000.[2] EPA's selection of the preferred remedy for OU2 rests in large part on its assertion that dredging is a "proven technology." Yet EPA has done little to evaluate its feasibility for this Site, or the projected scale, in light of recent experience with the Hot Spot dredging. There is absolutely nothing in the Record that suggests EPA ever critically evaluated whether the Hot Spot work achieved the ROD's cleanup objectives, i.e., elimination of approximately 45% of the mass of PCBs in the entire estuary through dredging and treating all contaminated sediments within the 4,000 ppm isopleth. All that is to be found is some raw, uninterpreted data. Most significantly absent is an evaluation of the risks of the extensive dredging called for by the 1996 Plan by extrapolating from the Hot Spot data. Common sense and good scientific protocol, to say nothing of National Contingency Plan ("NCP") requirements, suggest that these are essential elements of any remedy selection effort. EPA's failure to pursue such a course of action can only be seen as arbitrary and capricious.

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[2] When the costs of treatment are added in, the Hot Spot remedy will cost close to $50 million.

If the Hot Spot dredging experience is an accurate predictor of what will happen in future dredging efforts -- and there is no reason to think it is not -- then the preferred remedy is highly likely:

- to have disastrous environmental consequences;
- to take far longer than anticipated;
- to be ineffective in reaching targeted TCLs, particularly the 10 ppm TCL in the upper estuary; and
- to cost far more than present estimates, especially if treatment of dredge materials is adopted in a subsequent ROD amendment.

The Record also does not include any documentation or data with respect to the track record at the very limited number of sites where the removal of major volumes of contaminated sediments has been implemented. As discussed in the comments submitted by Dames & Moore and others, only Marathon Battery, a site quite different from New Bedford Harbor, was tested to verify that cleanup levels were met.

The remedial alternatives apparently have been evaluated in a hermetically-sealed world in which the movement of time has simply stopped. Region I has failed to apply the ecological and human health risk assessment procedures, analyses and approaches called for by EPA's own guidances, updated since 1990. The 1990 Baseline Ecological Risk Assessment, for example, which provides the basis for the current cleanup criteria, is nothing more than a Tier I risk assessment, deemed inadequate for a site of this complexity by EPA's

own guidance. EPA has failed to develop a conceptual site model that is a fundamental foundation for an ecological risk assessment. Further, EPA has failed to use the time since 1990 to collect and analyze the data regarded by the scientific community as vital to the endeavor to develop a realistic and credible ecological risk assessment.

EPA's most egregious failure, however, to integrate post-1990 scientific developments that would have most materially impacted the remedy selection process and which exposes the arbitrary and capricious nature of its actions and decisions, comes in the area of human health risk assessment, and specifically with respect to the CSF EPA used for PCBs. EPA continues to rely on a CSF of 7.7 $(mg/kg/day)^{-1}$, despite the fact that EPA guidance now calls for a CSF of 1.0 $(mg/kg/day)^{-1}$ for the same exposure pathways that predominate in New Bedford Harbor. In addition, EPA guidance has also recently recommended a greater role for human epidemiological data. In response to this recommendation and as more fully explained in the technical comments, TERRA, Inc., AVX's toxicological expert, has derived a CSF based on human epidemiological studies of chronically exposed workers. Using the new EPA and TERRA CSF numbers, and conservative but appropriately realistic exposure assumptions, it is clear that adoption of a site-wide 50 ppm TCL will be protective of human health. Thus, EPA's persistent reliance on a human health risk assessment which is obsolete under its own guidances makes its evaluation of the remedial alternatives, particularly its cost benefit analysis, worthless. Furthermore, it is clear from the Record that EPA failed to make the New Bedford Forum aware of the changes in its approach to risk assessments that have occurred since 1990.

IV. EPA'S CONDUCT IS ARBITRARY AND CAPRICIOUS: THE 1996 PLAN DOES NOT REFLECT THE PROPER BALANCING OF THE NINE EVALUATION CRITERIA IN THE SUPERFUND REMEDY SELECTION PROCESS.

The NCP prescribes nine criteria to be used by EPA to evaluate remedial alternatives and to select a preferred remedy. 40 C.F.R. §300.430(e)(9)(iii). The nine criteria are categorized into three groups: threshold criteria; primary balancing criteria; and modifying criteria. 40 C.F.R. §300.430(f)(1)(i). Each remedial alternative must meet the threshold criteria to be eligible for selection. 40 C.F.R. §300.430(f)(1)(i)(A). Seven of the ten remedial alternatives considered by EPA for the second operable unit met the threshold standards, therefore making the second category of criteria -- designated by the NCP as the *primary* balancing criteria -- the real focus of the decision-making. The final two criteria -- state and community acceptance -- are modifying criteria that the NCP states "shall be considered in remedy selection." 40 C.F.R. §300.430(f)(1)(i)(C).

A. Primary Balancing Criteria Have Not Been Given Adequate Weight As Record Does Not Support Conclusion That Preferred Remedy Satisfies These Criteria.

The inadequacies of the data and the analyses referenced above, documented in AVX's previously submitted comments and in the materials below, lead to the conclusion that EPA was unprepared to apply the balancing criteria in a reasoned and meaningful way that would have allowed it to ground the remedy selection on a solid foundation, supported by scientific methodology, and immune from claims that its actions and decisions were

arbitrary and capricious. EPA's actions and decisions, unfortunately, were arbitrary and capricious, because it is impossible to apply criteria, evaluate alternatives and make decisions when the critical foundation tools, such as risk assessments, are seriously deficient and outdated, or when there is very little documented experience with central remedial components, e.g., sediment dredging projects of this size and complexity. The following discussion will just touch on key points relevant to the balancing criteria, which are discussed in greater detail in AVX's scientific and technical comments.

The implementability of the proposed plan is highly suspect in light of EPA's track record at the Hot Spot. Time and cost -- where the TCL was 400 times greater than that proposed for the upper harbor -- were well beyond anything forecast. Do any of the involved constituencies want a project that will last 20 years or more? Or a project where likely cost escalations will bring work to a halt well before any significant portion can be completed? Or a project where the community, once better informed about dredging, will object to it as it did to incineration? Such outcomes are highly probable based on the review of the Hot Spot data by AVX's experts. Had EPA paid attention to AVX's comments regarding incineration, some of the difficulties of the last several years might have been moderated.[3] Had EPA paid attention to its own experience with the Hot Spot and to the data from the Hot Spot and the absence of precedent from prior experiences, it could only have reached the same conclusions in 1996 as AVX's experts do. EPA's failure to do so has led

[3] In 1989 AVX's experts criticized many aspects of the incineration alternative in 40 pages of comments on that aspect of the Hot Spot remedy alone. These comments stated that the plan for incineration was flawed as it did not adequately consider air quality impacts.

it to propose the 1996 Plan; EPA's failure to do so also supports AVX's contention that its actions and decisions were arbitrary and capricious.

What EPA relies on when it asserts that the preferred remedy will be effective, in the short- or long-term, remains a mystery. AVX's review of the Record revealed no data from prior or recent computer simulations supporting EPA's conclusions with respect to the reduction of risk resulting specifically from the preferred remedy. EPA has, by some means known only to it, extrapolated results from unverified simulations of other alternatives to project the results of the preferred remedy. The results of the monitoring of the Hot Spot certainly were not used in any quantitative fashion to verify the predictions resulting from the hydrodynamic or food chain models. Although AVX believes the model is useless for either comparative or quantitative analysis of different remedial alternatives, the modeling results, if credited, show no significant difference between the effects of a 50 ppm level versus a 10 ppm cleanup level.

A capping remedy -- as proposed and designed by AVX, and not EPA's version -- is a more effective remedy than dredging. Capping controls contaminant mobility better than dredging. Capping will not have the major, harmful, environmental impact that dredging is likely to cause with respect to the substantial remobilization and transport of PCBs and sediment-associated metals such as cadmium, copper, nickel and lead through the water column, as well as substantial volatilization of PCBs to the air. Furthermore, dredging necessitates extensive use of the CDFs. The 1996 Plan envisions the CDFs as a temporary

measure, implicitly acknowledging that there is an insufficient degree of certainty that the preferred remedy, without more, will prove successful. See 40 C.F.R. §300.430(e)(9)(iii)(C).

As to cost criteria, it is incredulous that EPA's evaluation of cost could conclude that the preferred remedy is cost effective. The 1996 Plan does not address, for example, the question of whether the amount of money at stake, whether $116,000,000 or a more realistic -- and significantly larger -- dollar amount, creates the additional protection of human health and the environment which might warrant such costs. EPA's arbitrary and capricious actions and decisions are best evidenced in this regard by the fact that, with the exception of some working notes on unit dredging costs by Mark Otis which were attached to the since superseded Feasibility Costs update from Foster-Wheeler, the only substantive documentation with respect to the costs associated with the Hot Spot were placed in the Record on January 21, 1997, and are dated December 4, 1996 and after. These documents were generated after EPA had selected the preferred remedy!

EPA's ability to carefully assess the cost effectiveness of each of the remedial alternatives is further called into doubt by the omission or understatement of certain cost items. In its detailed comments below (Attachment E), Dames & Moore discusses several areas where costs are missing or underestimated: costs for material that will be needed as a result of settlement of the CDF dikes; costs to purchase the land for the CDFs; costs for the

proposed water treatment system; and costs for long-term monitoring of the CDFs. The 1996 Plan also fails to separate and document the costs for items which may be appropriate to include with the remedial work, but are not recoverable cleanup costs, e.g., sheetpiling walls for one CDF, and navigational dredging.

Nothing renders EPA's cost estimates and its evaluation of the cost effectiveness of each remedial alternative's potential to protect human health and the environment more suspect than the arbitrary drop in the estimated costs for air monitoring from approximately $10,500,000 to approximately $2,100,000. This was the one tangible modification made to the preferred remedy following the report of the Remedy Review Board. A variance of 80% leads inexorably to the conclusion that the comparison of alternatives on the basis of costs was for EPA an arbitrary and capricious exercise.

B. Community Acceptance Has Been Given Weight in Excess of its Status as a Modifying Criterion.

The NCP envisions that the opportunity for community opinion concerning a preferred remedy will occur in the first step of the remedy selection process, i.e., during the public comment period that comes after the publication of a proposed plan. 40 C.F.R. §300.430(f)(1)(ii) and (f)(3)(i). It also anticipates that EPA, in the second and final step of the remedy selection process, will assess such comments, "now factoring in any new information or points of view expressed by the . . . community during the public comment period" and that EPA will present the results of that assessment in the ROD. 40 C.F.R.

§300.430(f)(3)(i)(F) and (f)(4)(i)(emphasis added). Further, the NCP calls for EPA to modify the preferred remedy to the extent "new information is made available that significantly changes the basic features of the remedy with respect to scope, performance, or cost." 40 C.F.R. §300.430(f)(3)(ii). If the preferred remedy is modified, EPA must include in the ROD a discussion of the changes, the reasons for the changes and must provide an additional public comment period. 40 C.F.R. §300.430(f)(3)(ii)(A).

The community acceptance criterion, therefore, has an advisory status. The regulations give EPA the discretion to assess the nature of the community's comments and, on the basis of the assessment, to modify or leave alone a preferred remedy. This status is confirmed by the fact that on pages 10 and 11 of the 1996 Plan, in the bottom row of the tabular presentation of the remedial alternatives and each alternative's satisfaction of each criterion, it states with respect to the community acceptance criterion: "To be determined after the public comment period."

Notwithstanding the foregoing regulatory scheme, the community's involvement through the New Bedford Harbor Community Forum (the "Forum"), and the care and time given to the facilitated process which led to this community involvement, was a worthwhile effort to anticipate and meet community concerns. That the citizens of New Bedford and neighboring communities already have had more than one year[4] to comment on the preferred

[4] AVX concludes this because one of the documents in the Record from the Poster Session of November 29, 1995 is a 7-page document (with attachments) entitled "EPA Responses to Concerns Listed by the Towns of Acushnet and Fairhaven." The document is dated November 29, 1995.

remedy and to receive EPA's responses is not the basis for AVX's assertion that EPA's actions and decisions were arbitrary and capricious. AVX does not object that EPA took seriously -- even if belatedly -- the concerns of the community; indeed, the Forum was created in 1993 because the citizens of New Bedford had come to support AVX's opposition to incineration of the Hot Spot sediments.[5] AVX believes, however, that EPA has abrogated the NCP when its interpretation of community acceptance -- as the text on the first page of the October 30, 1996 press release states -- includes an understanding that through the Forum there had "develop[ed] community and state and federal agency consensus for a solution." Indeed, on June 20, 1996, EPA actually signed an agreement with members of the Forum that requires it to remove PCBs and heavy metals from the river and harbor and to use CDFs for storage and containment of sediments, including some portion of the navigational dredging spoils.

AVX has at all times relied on the established administrative process, as summarized above, which provides the opportunity for it to submit comments on a proposed plan at <u>this</u> point in time, not earlier.[6] To protect its due process rights, AVX has previously, first in

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[5] Although the Forum was convened to address the incineration issues at OU1, the Agreement of November 1994 between EPA and members of the Forum not only articulated consensus regarding incineration, but authorized the Forum's ongoing involvement with the selection of the OU2 remedy. The November 23, 1993 memorandum from Harley Laing, EPA Regional Counsel for Region I, to William White, Enforcement Counsel for Superfund, with respect to the "Nomination of New Bedford Harbor Superfund Site Hot Spot Operable Unit for Non-Binding Alternative Dispute Resolution," however, appears to have limited the Forum to issues concerning the Hot Spot. Without further authorization, resulting from the nomination of the second operable unit for ADR -- evidence of which cannot be found in the Record -- the conclusion can be drawn that EPA Region I's unilateral extension of the Forum's jurisdiction to consideration of the remedy selection for the second operable unit was arbitrary and capricious or otherwise not in accordance with law.

[6] Surely, there can be no expectation that AVX would have spent tens of thousands of dollars to be actively involved in ongoing informal community participation activities, particularly when no one ever solicited

1989, and then again in 1992, submitted extensive and detailed comments. It appears at this point, however, that EPA is already irrevocably committed to the preferred remedy, making it impossible for AVX, or any other party who did not participate in the Forum's proceedings, to provide "new information" that -- if taken seriously -- might significantly change the basic features of the remedy with respect to scope, performance, or cost.[7]

The arbitrary and capricious nature of EPA's actions and decisions extends to its participation in the Forum's process (regardless of whether that process complied with the NCP). As noted above, EPA failed to call attention to the fact that its consideration of remedial alternatives was based on an outdated risk assessment. The Forum's process was also infused with EPA's disregard for costs. OU2 cost considerations were discussed at Forum meetings on several occasions. Meeting minutes indicate that such discussions were initiated by local citizens interested in getting EPA's response to the feasibility of permanent treatment of contaminated sediments. EPA's response, as recorded in minutes and discussed in written responses to comments dated August 5 and November 29, 1995, emphasized funding constraints. EPA reported that approximately $56 million was available, but that it would likely be insufficient to cover the OU2 costs, assuming a CDF remedy. EPA also stated that it would have to access the "national fund" to make up the difference. The Forum

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AVX's participation and when EPA has never responded to the extensive comments AVX submitted in 1992?

[7] This is confirmed by a statement of Richard Cavagnero, Chief, Technical and Support Branch Office of Site Remediation and Restoration -- Region I, in a memorandum to the Remedy Review Board dated July 9, 1996. In the context of discussing the agreement with the Forum, Mr. Cavagnero comments that "the Region has in a sense already negotiated this proposed remedy with the community, including our Congressional delegation."

was told that costs associated with a permanent treatment remedy ranged from $200 million to $400 million. Though EPA said funding was limited, as late as November 29, 1995, less than three months prior to the initial drafting of the final Forum agreement with respect to the OU2 cleanup, EPA -- while acknowledging that the cost estimate was dated (1993) -- told the Forum that the preferred remedy would cost $40 million! EPA's written statement went on to say that "[o]nce consensus for the phase 2 cleanup plan is developed at the Forum, EPA intends to update[] this cost estimate to more accurately estimate what the ROD 2 costs would be." This was patent manipulation of the Forum: EPA asserted that funding was limited to get the Forum's approval of CDFs; then, once that approval was gained, proceeded to estimate costs with no regard for such constraints. In a matter of months, a $40 million remedy more than tripled.[8]

V. EPA'S CONDUCT IS ARBITRARY AND CAPRICIOUS: REMEDY ENHANCEMENT IS INCONSISTENT WITH NCP.

EPA, upon the request of the Massachusetts Department of Environmental Protection, proposes an enhancement to the preferred remedy pursuant to 40 C.F.R. §300.515(f). EPA states, in the 1996 Plan, that the enhancement would be "administered and funded entirely by the Commonwealth," consistent with the requirements in 40 C.F.R. §300.515(f)(ii)(A) and (B). The 1996 Plan discusses the "benefits" of linking performance of the preferred remedy and the navigational dredging, but, unfortunately, does not directly address whether this

[8] The estimated cost of the proposed remedy when presented to the Remedy Review Board on July 10, 1996 was $127 million.

proposed change "would not conflict or be inconsistent with the EPA-selected remedy." 40 C.F.R. §300.515(f)(ii).

The question as to whether the proposed enhancement significantly increases environmental risks and impacts is raised squarely in the December 5, 1996 letter to David Dickerson from Kenneth Finkelstein, Ph.D., of the National Oceanic and Atmospheric Administration ("NOAA"):

> Prior to an EPA decision to include this activity within the scope of the remediation of New Bedford Harbor, [NOAA's National Marine Fishery Service] strongly recommends the completion of a Clean Water Act 404(b) evaluation. This undertaking needs to include a thorough alternatives analysis that identifies the least environmentally damaging practicable alternative for the spatial extent of dredging and available disposal options. The Proposed Cleanup Plan indicates that the navigational dredging would result in an additional 1 million cubic yards of sediments, more than tripling the total quantity of dredged material. Impacts associated with this large increase in dredging activity and dredge material disposal could lead to a significant degradation of the aquatic environment of the New Bedford Harbor region. However, the only mention of these impacts in the Proposal is a reference to a "likely" sediment disposal site in a large "navigational" combined [sic] disposal facility (CDF) just north of the hurricane barrier. Without additional information and until the impacts are fully analyzed, NOAA/NMFS cannot concur with the proposal for navigational dredging and would have to object to that portion of the project.

Dr. Finkelstein's comments, pointing to the problems sure to result from dredging over an extended time and an enlarged geographic area, are consistent with AVX's comments made in 1992 and with this submission.

As to costs, although James Colman's letter of November 22, 1995 and David Struhs' letter of October 10, 1996 both discuss the Commonwealth's pursuit of state bond funding in the amount of $45 million for the navigational dredging, nowhere in the Record is there any delineation of the costs associated with the navigational dredging which would establish beyond a doubt that EPA will comply with the relevant provisions of the NCP.

AVX is concerned that the remedy enhancement, as described to date, raises more questions than can be answered on the Record to date. Navigational dredging of New Bedford Harbor has long been identified as a pressing community need. There is no doubt that adding this enhancement to EPA's preferred remedy will ensure strong community support. But without further detail and elaboration, it is impossible for anyone -- including EPA -- to properly determine how it will impact remedial action implementation, and, in turn, whether it will "conflict or be inconsistent with the EPA-selected remedy."

VI. EPA'S CONDUCT IS ARBITRARY AND CAPRICIOUS: RECORD FAILS TO EXPLAIN EPA'S DECISIONS AND ITS DECISION-MAKING PROCESS.

The public can only comment on a proposed plan to the extent that EPA complies with CERCLA's and the NCP's provisions with respect to public involvement and the administrative record. The public can only provide reasoned comments to the extent that EPA adheres to the procedures and mechanisms in the regulations that have been included to ensure that the public's reasonable expectations of reliable actions and reasoned decisions will have been implemented with respect to the opportunity to comment. The relevant

regulations in this area are Subpart E of the NCP, which states what EPA must do to ensure public participation in the selection of the remedy, and Subpart I, which describes more specifically the administrative requirements with respect to establishing, compiling and maintaining the Record.

EPA failed to execute its above-enumerated responsibilities with respect to the Record. The 1996 Plan, which was released for public comment on October 30, 1996, announced that EPA would accept written comments from November 7 through December 9, 1996. The Record, however, on October 30, 1996, did not contain one relevant document with respect to the selection of the proposed plan dated later than 1992. The documents were not in the Record on November 7, 1996, nor on December 9, 1996. It was not until December 10, 1996 that EPA placed into the Record 46 files of documents that were not ordered, grouped or indexed (as Subpart I requires). Nor, for that matter, were they complete, because on December 20, 1996 EPA placed additional documents -- again without any organization -- in the Record. EPA's arbitrary and capricious performance undermines the public's confidence generally with respect to its actions and decisions regarding the Site.

EPA's handling of the Record, unfortunately, is representative of its piecemeal approach to the Site. The "stop-and-start" decision-making -- highlighted by the detailing of only a portion of the Site's history on page 2 of these comments -- is further evidenced in EPA's use of the NCP's program management principles which establish the standards for designating operable units at a site. The Hot Spot experience demonstrates the fallacy in

making decisions without a full understanding of all consequences, without factoring how benefit and cost are balanced, and without weighing community acceptance. (The theme of improved decision making is addressed extensively in a forthcoming National Academy of Science report entitled "Contaminated Sediments in Ports and Waterways, Cleanup Strategies and Technologies.") EPA's decision with respect to the first operable unit would have been very different had it known -- as it would have had it not rushed to achieve quick results -- that the Hot Spot would cost $43-48 million, that the technology to treat the contaminated sediments would not be available, and that the community would not find it acceptable.

A major thrust of the comments offered below by AVX's expert consultants is that the Record does not support EPA's selection of the preferred remedy. Given the Site's history, including the fact that there is still no resolution regarding treatment of the Hot Spot sediments, and that the preferred remedy rests on a phantom technical and scientific foundation, EPA should not be tempted once again to take an ill-advised course of action, based on historical predispositions or political compromises.

Perhaps the most outrageous instance of EPA's deviation from the NCP's process for reasoned decision-making is its commitment to an interim remedy. In accordance with paragraph 6 of "New Bedford Harbor Superfund Site Community Forum Agreement," EPA has committed itself, after the signing of the ROD for OU2 to a continuing "literature review of viable treatment alternatives during the early stages of the Phase 2 remediation, before the

CDFs are capped."[9] What this means is that if a treatment alternative proves to be viable before the CDFs are capped, then EPA will amend the OU2 ROD! This is not what CERCLA §121(c) or 40 C.F.R. §300.430(f)(4)(ii) and (5)(iii)(C) had in mind for five-year reviews. An "interim remedy" is not the basis for a ROD. EPA's proposal of such a remedy is a blatant example of actions and decisions that are arbitrary and capricious or otherwise not in accordance with law.

VII. EPA'S CONDUCT IS ARBITRARY AND CAPRICIOUS: EPA FAILED TO EXERCISE PROCEDURAL DUE PROCESS

A. EPA Region I's Failure To Exercise Its Discretion With Respect to The Remedy Review Board Could Only Have Been Based On The Fear That Review Board Would Not Support The Preferred Remedy.

1. AVX should have been afforded the opportunity to participate in the Remedy Review Board's process.

The first full paragraph on page 4 of the September 26, 1996 memorandum from Stephen D. Luftig, Director of the Office of Emergency and Remedial Response, regarding the National Remedy Review Board (the "Board"), states with respect to PRP involvement that "[t]he Board recognizes that PRPs who do not conduct the RI/FS may conduct studies that might also be valuable to the Board's review process. In these cases, the Region may, at its discretion, solicit similar input from these stakeholders." In light of AVX's earlier

[9] The Forum Agreement singles out one treatment alternative -- bioremediation. In its prior comments, AVX suggested *in situ* biodegradation. EPA would be well advised to track developments of this alternative.

comprehensive and detailed comments (in both 1989 and 1992), including extensive scientific and technical work, such an exercise of the Region's discretionary authority would have been reasonable and appropriate; its failure to do so was arbitrary and capricious.

In all aspects save one -- its disagreement with EPA's remedial alternative selection -- AVX was eminently qualified to participate in the Board's process. No other party has invested the time and expense -- through the services of highly qualified experts from multiple fields -- to address the complex issues at the Site. Region I's decision to exclude AVX could only have resulted from EPA's fear that AVX's voice would have caused the Board to call into question the Region's preferred remedy.

2. Remedy Review Board failed to exercise its responsibility.

The goals of the Board are to "promote cost-effectiveness and appropriate national consistency in remedy selection at Superfund sites." The Board is charged with ensuring remedy consistency with current laws and regulations, including the NCP, and must consider relevant Agency guidance. The Board is supposed to consider, among other things, the position(s) of PRPs, the rationale behind exposure scenarios and risk assumptions, the appropriateness and attainability of cleanup goals, whether other approaches to achieve the cleanup goals have been evaluated, and the reasonableness of cost estimates.[10]

[10] The source of the quoted statement and the information in this paragraph is a 3-page fact sheet, attached to Mr. Luftig's memorandum, that Mr. Luftig refers to as "Questions and Answers on EPA's NRRB."

There is nothing in the Record describing the Board's review of the 1996 Plan of August 14, 1996 except for the memorandum of September 11, 1996 from Bruce Means, chair of the Board, to Linda Murphy, concerning "National Remedy Review Board Recommendations on the New Bedford Harbor Superfund Site." The memorandum states that the Board "generally supports the Agency's proposed cleanup strategy as presented in the proposed plan." Beyond that, the Board's substantive comments are limited to four "observations":

- an acceptance of the Forum's Memorandum of Agreement announced on August 1, 1996, "outlining the community's support of the proposed remedy as representing community concerns and issues."
- a recommendation to re-evaluate the "overly extensive air monitoring program."
- a recommendation to evaluate ARARs to determine whether a less costly water treatment process would be adequate.
- a recommendation to re-examine metal remediation if PCB TCLs should change in the future.

The Record does not indicate to what extent, if at all, the Board exercised its responsibilities when reviewing the preferred remedy, in particular those responsibilities enumerated above. It appears from the Record that all of the input the Board received came from those who would not be expected to raise any question regarding the selection of the

preferred remedy.[11] Nonetheless, AVX believes that had the Board:

- consulted relevant Agency guidance, it would have discovered that EPA had adopted a CSF of 1.0 $(mg/kg/day)^{-1}$;
- assessed the position(s) of PRPs, it would have had to address AVX's detailed critique of EPA's 1992 preferred remedy and the studies on which it was based;
- sought to understand the rationale behind exposure scenarios and risk assumptions, it would have learned of the deficiencies of the 1990 Baseline Ecological Risk Assessment;
- assessed the appropriateness and attainability of cleanup goals, it would have inquired about the Hot Spot dredging and its ineffectiveness as evidenced by its leaving hundreds and thousands of parts per million residual concentrations of PCB in the Hot Spot, even after three passes of the dredge, and it would have assessed the lack of precedent at the very limited number of sites where the removal of major volumes of contaminated sediment has been implemented and the failure to document the meeting of performance criteria at those sites;
- determined whether alternative approaches to achieve the cleanup goals had been evaluated, it would have sought more information about AVX's proposed capping remedy; and
- assessed the reasonableness of cost estimates, it would have demanded more data regarding the Hot Spot dredging costs and how they were extrapolated.

It is well within reason for the public to expect that the Board, to be considered a valuable addition to the remedy selection process, should have conducted a review of the 1996 Plan with at least the same rigor as the peer review process that occurs with the submission of any

[11] Review of the Record indicates that at the time of its discussions concerning the preferred remedy, the Board had before it only those documents forwarded on July 10, 1996 under cover of memorandum from Rich Cavagnero, and those documents forwarded on July 25, 1996 under cover of memorandum from David Dickerson. The Record also indicates that the Board spoke with Commonwealth of Massachusetts Project Officer Paul Craffey, EPA RPM David Dickerson, EPA site attorney Cindy Catri, and Office of Site Remediation and Restoration Deputy Director Frank Ciavattieri.

scientific or technical papers to a journal. That not one of these items resulted in any comment from the Board in the September 11, 1996 memorandum to the Region leads inescapably to the conclusion that the Board failed to exercise its responsibilities, and that EPA's decisions and actions were arbitrary and capricious.

B. The Record Is Improperly Maintained and Is Incomplete.

The NCP states that EPA must "[m]ake the proposed plan and supporting analysis and information available" in the Record at the beginning of the public comment period. 40 C.F.R. §300.430(f)(3)(i). Prior to December 10, 1996, one day after the last day of the original comment period, EPA had not added any documents to the Record since 1992. On December 20, 1996, an additional and substantial number of documents were placed in the Record.[12]

On December 9, 1996, AVX submitted to EPA a Freedom of Information Act ("FOIA") request for all documents added to the site file for New Bedford Harbor since the last submittal of comments in 1992. The basis for the request was AVX's view that the site file holds documents rightly belonging in the Record, i.e., documents that form a basis for the selection of the preferred remedy, documents that the NCP affords AVX the opportunity to comment on. Selected documents from the "site file" were subsequently produced in response to AVX's FOIA request, e.g., backup data for the first operable unit's costs to

[12] AVX's inspection of the Record does not include the review of any documents placed in the Record by EPA after December 20, 1996.

date, substantiating AVX's view. Additional documents from the site file, responsive to AVX's FOIA request, have yet to be made available. EPA's failure to include in the Record all of the documents required under 40 C.F.R. §300.810 confirms that its actions and decisions were arbitrary and capricious.

C. EPA Did Not Allow Sufficient Time for These Comments.

AVX twice requested extensions to the public comment period. The first request, dated November 19, 1996, sought a 90-day extension. The request was timely, as well as appropriate, reasonable, and necessary. EPA's response, providing a 45-day extension, (bringing the end of the comment period to January 23, 1997), was inadequate. The NCP obligates EPA to provide an automatic 30-day extension at a minimum, provided only that the request is timely. 40 C.F.R. §300.430(f)(3)(i)(C). EPA's willingness to extend the comment period by only 15 days more than the minimum failed to acknowledge the complexity of the Site, failed to deal with EPA's delay in making central documents available in the Record, and failed to compensate for the time of year. The 15 days beyond the 30-day minimum were largely consumed by the holidays, which impacted, among other things, the availability of EPA staff as well as AVX's expert consultants.

AVX's second request for an extension, dated January 3, 1997, pointed out that a substantial number of additional documents were added to the Record on December 20, 1996. By letter dated January 8, 1997, EPA stated that "the public comment period will be

extended 45 days from December 20, and will now end on February 3, 1997." Truth be told, there was no 45-day extension; there was only a 45-day comment period. According to the NCP, the public comment period begins after the proposed plan and the supporting analysis and information is placed in the Record. 40 C.F.R. §300.430(f)(3)(i)(C). The public comment period, therefore, did not begin until December 20, 1996. EPA provided only 15 days more than the mandated minimum, and 15 days less than the mandated minimal extension. Given the length of time since EPA released the first proposed plan for the second operable unit in January 1992 -- more than 4½ years -- EPA's reluctance to extend the comment period for a fraction of the time that the Region took for its deliberations can only be seen as arbitrary and capricious.

D. EPA Has Never Addressed Previous AVX Comments Despite CERCLA Mandate.

References to the public comment period are interspersed throughout the 1996 Plan. On page 12 there is a graphics box in which EPA answers the question, "What's a Formal Comment?" The text in the box explains that "[o]nly those comments received during the public comment period, either oral or written, are considered "formal" comments." Formal comments are distinguished from informal comments -- comments received outside the official public comment period -- because "[f]ederal regulations require that EPA respond in writing only to "formal" comments." Elsewhere, EPA states that it will respond to all formal comments already received on the January and May 1992 Proposed Plans in the Responsiveness Summary included in the second ROD. Finally, the document states that

"[c]ommunity acceptance is usually not evaluated until the public comment period closes in order to provide interested parties with an opportunity to review the Proposed Plan and comment on it. Consistent with that, EPA will not select a final remedy until the public comment period is closed and all comments have been considered." Presumably, all of this explains why EPA has never responded to the extensive comments AVX submitted in 1992: it has never had to.

Indeed, EPA never had to. Yet, at the same time, there is a disingenuousness in these words and explanations. Consider that the 1996 Plan also says that "[t]oday's proposal reflects the EPA's consideration of the comments received on the two documents [the proposed plan and addendum for the upper and lower harbor issued in January and May, 1992, respectively], as well as extensive dialogue with the local Forum." Consider further, as already noted, that EPA provided written responses to informal comments generated by members of the Forum. In other words, EPA appears to have considered, wrestled with and responded to the thoughts, criticisms, questions, concerns, etc., from the entire community, except for those from AVX! Could it be that AVX presented the one formidable challenge that EPA has sought to avoid? In the context of EPA having agreed to a dredging and CDF remedy with the Forum, EPA's extended failure to respond to AVX's earlier comments is an arbitrary and capricious maneuver to have the remedy selection dictated, without requiring any convincing encounter or argument with AVX's substantial and substantive expert comments.

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PART II

I. EPA HAS NO SCIENTIFICALLY DEFENSIBLE BASIS TO JUSTIFY THE PROPOSED REMEDY.

A. The proposed cleanup plan misrepresents the risks to human health and, furthermore, any risk reduction that may be gained by the preferred remedy.

As discussed in AVX (1992) and TERRA, Inc. (1997), the potential for risk to human health resulting from PCBs in New Bedford Harbor sediment water or in animal tissue was overstated in 1992. Use of cancer slope factors derived by TERRA in 1992, even when applied to the overly conservative exposure models developed by E.C. Jordan (EBASCO 1989) in their baseline human health risk assessment, indicated that risks from PCBs in New Bedford Harbor as presented by EPA were overstated and that a 50 ppm cleanup level was protective of human health. Since 1992, EPA has substantially revised the cancer slope factor for PCB, and it is now very similar to that derived by TERRA in 1992. Application of this cancer slope factor using realistic exposure assumptions confirms that cleanup levels of 50 ppm are protective of human health (TERRA, 1997).

Thus, despite statements by EPA in the 1996 Proposed Cleanup Plan (the "1996 Plan") to the contrary there are no realistic exposure scenarios that would result in risk to humans if the TCL in the Upper Estuary was left at 50 ppm. Epidemiological studies conducted during the New Bedford Harbor Health Study, as well as Miller et al. (1991), state there is no elevation of PCBs blood serum levels found in the New Bedford population. It is, therefore, unlikely that there is any potential for human health risk. It is surprising that

with all of EPA's concern about the levels of PCBs in New Bedford Harbor, it has been unable to demonstrate, in any scientific study, that there is any evidence of increase in risks to human health due to the presence of PCBs.

B. The purported foundation for decision-making, the hydrodynamic, PCB transport and fate and food chain models, is seriously flawed and has not been improved since 1992.

EPA originally touted the Battelle hydrodynamic and PCB transport and fate and food chain models as the basis for deciding between various remedial alternatives. As discussed previously (AVX 1992) the initial objectives of these modeling "efforts" were never realized. In fact, the models came up short in almost every measure used to evaluate the success of this task (See Tables 1 and 2 from AVX (1992) comments, attached). Not only did the development of these models take five years longer than originally intended, the cost of these models increased more than ten-fold. EPA continues to mislead the public by implying that while quantitative results from these models are not to be trusted, somehow it is appropriate for EPA to use these results to make qualitative comparisons of remedial alternatives.

As indicated by Spaulding Environmental Associates (1997), the authors of the report presenting the PCB transport and fate model and its application in New Bedford Harbor to evaluate the various remedial measures Battelle (1990) repeatedly stated that the results of the model should not be used in a strict quantitative sense, but only comparatively. As examples:

- In Volume II, Section V, page 5-153, the authors state: "...although these observations are in general agreement with field measurements, the estimated concentrations computed by the model should be used as a baseline to compare the relative effectiveness of the modeled remedial actions. The results should not be viewed in an absolute sense, because a rigorous validation of the model was not possible."

- Similarly in Section VII, page 7-124, "discussed earlier, due to the inherent uncertainties in performing modeling studies of this size and complexity, it is important to view the results in a comparative sense."

- In the July 10, 1996 memo from R. Cavagnero (EPA, Chief, Technical and Support Branch Office of Site Remediation and Restoration, Region I) to the Remedy Review Board, he says that "We certainly recognize the limitations of the model and do not view the results as absolute predictions, but we believe the model estimates are helpful for comparing alternatives in assessing the qualitative impact of the various remedial alternatives."

As discussed in both AVX (1992) and Spaulding Environmental Associates (1997) the above cited examples and others overstate the capability of the model. Not only was the hydrodynamic model not verified, it was unable to even estimate, with any degree of accuracy, basic hydrodynamics of the estuary such as flushing time (AVX 1992).

EPA's contention that the model nonetheless can be used in a qualitative sense is an untenable one. Nowhere in scientific methodology or in the literature is

there precedent for this. At the very least, had EPA taken steps to develop an estimate of the uncertainty of the modeling predictions, AVX would then have been able to determine whether in fact one could qualitatively compare various scenarios evaluated by the model. This was never done.

As to the Hydroqual food chain model, it is highly dependent on the results of the hydrodynamic model. The fact that the hydrodynamic model essentially does not work is a fundamental and fatal flaw in the operation of the food chain model.

In spite of these deficiencies, EPA states in its 1996 Plan for the Upper and Lower New Bedford Harbor (the "1996 Plan") (page 5) that "computer modeling suggests that the PCB levels in the water column will drop to levels at or below the EPA's chronic water standard" and "computer modeling does suggest however that PCB levels in many commercially important species will be well below the FDA criteria of 2 ppm at the 10 year mark using the proposed cleanup levels", leading to its conclusion on page 15 of the 1996 Plan that "the new plan will provide an additional measure of risk reduction." **This is simply not the case!** These continuous efforts by EPA to support the 1996 Plan by suggesting that the model is capable of making such differentiations is a disingenuous means of making quantitative comparisons despite the fact that EPA has already said the models are not capable of making such quantitative comparisons. A blatant example of this is in the material provided to the Remedy Review Board which claims quantitative differences in:

- time to reach certain tissue residue levels in organisms living near New Bedford Harbor,

- time to reach Ambient Water Quality Criteria (AWQC), and
- human health risk

amongst the remedial alternatives.

Not only are the models useless for their intended purposes, i.e., to facilitate decision making between several complex remedial alternatives, the preferred remedy was never simulated by these models at any time. In fact, although there is the suggestion that there is a scientific basis for the choice of the preferred remedy, there is only speculation that a totally unevaluated outcome would achieve any of the results implied in the announcement of the 1996 Plan.

The Hot Spot dredging provided an excellent opportunity for EPA to again attempt to calibrate and verify its hydrodynamic model so that it could be used more effectively to choose among the various alternatives. There was no attempt on EPA's part, however, to utilize the results of the intensive monitoring of the Hot Spot dredging for that purpose. EPA's failure to do so suggests a total lack of confidence in its model to predict even the most rudimentary dynamics of the estuary or, at best, that EPA considered it was unimportant or unnecessary to definitively evaluate the effects of the remedial alternatives as they relate to sediment contamination, PCB flux, attainment of Ambient Water Quality Criteria, or PCB body burdens in organisms. If the latter is the case, it is inexcusable considering the significant financial impact of that decision.

Comments by AVX (1992) and Spaulding Environmental Associates (1997) point out many other shortcomings of both the hydrodynamic and PCB transport and fate models. Even if Battelle's own results [(summarized in Figures 7.72, 7.73 and 7.74, Battelle (1990)] were considered to be an accurate representation of the effects of the alternative remedies, there are no significant differences between the 10 ppm and 50 ppm cleanup scenarios. The net PCB flux at selected locations where the results can be compared, show that there is little difference in the net flux of total PCBs under the 10 ppm and the 50 ppm scenarios after 10 years (Battelle's Figure 7.72), nor are there significant differences in the predicted water column concentrations or the averaged sediment PCB concentrations in the Upper, Lower and Outer Harbor (Spaulding Environmental Associates 1997).

C. **The scientific basis for the ecological risk assessment is flawed. Not only does it fail to address the true risk to ecological receptors in New Bedford Harbor in any realistic way, it is incapable of differentiating between the outcomes, in terms of ecological risk, of any of the various remedial alternatives. It, therefore, cannot be used as a basis for concluding whether risk is in any way reduced by the preferred remedy.**

There is no scientifically defensible information that would indicate that the 1996 Plan will result in any significantly less ecological risk than the 1992 Plan or the capping plan proposed by AVX in 1990.

As discussed in AVX's (1992) comments on the Baseline Ecological Risk Assessment (EPA 1990) for New Bedford Harbor, EPA has taken very superficial data resulting from a few poorly designed environmental studies and

a progression of simplistic assumptions, and reached conclusions, that, while they have little relationship with the real world, are bestowed with artificial reality because of a superficially complex and involved analysis. EPA (1990) itself observes in the introduction to the report that "[the aforementioned] combination of factors necessarily limits to some degree confidence in the accuracy of the risk probabilities for PCBs generated in this assessment" (page 1-11).

While the intention of this baseline ecological risk assessment was to evaluate the existing conditions within New Bedford Harbor and to evaluate the relative effectiveness of various remedial alternatives once the results of the hydrodynamic and food chain model were available, this has never been done up to the present day. This is remarkable! The tools to evaluate ecological risk with more resolution than was initially done in the ecological risk assessment were available in 1990. These tools have been refined and improved through use and through precedent as well as guidance (EPA 1992; 1994; 1996a). With these evaluative tools, EPA has the ability to closely examine and compare risks between various alternatives, but has failed to do so.

The accepted methodology in ecological risk assessment is to perform the analysis in a tiered fashion. One starts with an initial analysis to determine whether there is any potential for ecological risk. Using this method it is customary to make simplifying, conservative assumptions with much of this Tier I assessment based upon information in the literature (EPA 1994; 1996a). The Baseline Ecological Risk Assessment (EPA 1990) is representative of a Tier I risk assessment and adequate for that purpose.

However, when the conclusions of a risk assessment become the basis for developing cleanup criteria which potentially involve the expenditures of tens if not hundreds of millions of dollars, it is imperative that the evaluation of potential ecological risk extends beyond such a limited preliminary conservative evaluation. Yet, EPA has never suggested that the New Bedford Harbor ecological risk assessment be taken beyond a Tier I stage. Guidance from EPA itself (EPA 1992; 1994; 1996a) describes how to do this. It does not involve the expenditure of extraordinary amounts of money or time; it involves only the use of scientific tools and methods that were readily available to scientists who in 1990 studied ecological risk.

These evaluative tools and methods consider such factors as fate and effects modeling, food chain modeling, population modeling and in-situ and laboratory toxicological evaluations. As discussed in AVX (1992) none of these studies were ever attempted, and the only in-situ toxicological evaluations that were conducted, those associated with pilot dredging tests (EPA 1988), showed no effects from the ambient water and were never used or reconciled against the dire predictions of the ecological risk assessment. Not only does this border on irresponsibility, but EPA's continual reference to the fact that the preferred remedy results in a reduction of risk to the environment, i.e., to ecological receptors, is a misrepresentation of any information that it has.

With the results of the baseline ecological risk assessment, EPA cannot even predict risk from ecological risk under the baseline conditions. Obviously then, it cannot choose amongst any of the remedial alternatives and it cannot use the results of its ecological risk assessment and associated food chain model to

determine what marginal benefit, in terms of decrease in risk, will result from the expenditure of these additional tens of millions of dollars.

- The ecological risk assessment did not initially develop a framework, now called a conceptual site model, which laid out a systematic approach to evaluating and quantifying pathways of exposure to PCBs such that one could differentiate between remedial alternatives. This is a fundamental foundation for an ecological risk assessment, the omission of which was, and remains, glaring.

- The analysis of effects, or toxicological analysis, went no further than a very rudimentary review of the literature. It considered the effect of total PCBs on ecological receptors, an effect which has no bearing on the relevant questions in New Bedford Harbor given that as it is well recognized that differential effects result from exposure to the 80 to 100 congeners typically found in PCB mixtures in the environment.

- After this baseline ecological risk assessment concluded that there was some potential risk, further work should have been conducted to evaluate the toxicity of New Bedford Harbor water and sediments to test organisms. This was not specifically done, although in 1987 and 1988 a series of toxicity tests that were part of the pilot dredging pre-operational monitoring programs were conducted (EPA 1988). That study concluded "that despite some problems with test acceptability, this preliminary study of New Bedford Harbor water was successful. The receiving water (New Bedford Harbor water) quality was found to be generally acceptable to the organisms tested. Where effects were

observed, they were marginal in nature and not believed to be significant." EPA's followup study also found that only one of the test species exhibited toxic effects and "that toxicity was due to factors other than PCB concentrations." (EPA 1988) With this information at hand, it is surprising there were no attempts at that time, nor since, to reconcile this discrepancy nor to conduct further tests to examine whether PCBs in the waters or sediments of New Bedford Harbor are potentially toxic to ecological receptors. Moveover, the only bioassays that have been conducted with New Bedford Harbor waters or sediments (Nelson et al. 1996) have not attempted to differentiate amongst PCB and other environmental stressors in New Bedford Harbor.

- Likewise, as discussed in AVX (1992) the exposure analysis is extremely limited because of its use of simplifying assumptions and its failure to consider site-specific exposure dynamics. Not only did it fail to use, for the most part, species which were endemic to New Bedford Harbor, it did not consider the time and space-varying nature of the ecological receptors whose risk was assessed. The simplifying assumptions used in the Baseline Ecological Risk Assessment (EPA 1990) assume that the representative receptors were exposed in various regions of New Bedford Harbor on a continuous basis. This is far from realistic as many of the species, e.g., finfish species like the winter flounder, are transitory and only enter the harbor at certain times of the year and are variable in their habits, feeding in different places at different times and under different tidal conditions. While the evaluative tools are easily available to model this type of variable exposure, EPA apparently did not consider it really necessary to do so,

even though the results of that decision could lead to the unnecessary expenditure of tens of millions of dollars.

- In considering concentrations of PCB in the water and sediment, EPA assumed, in a simplistic and conservative fashion, that all PCB measured in the sediment and in the water column were bioavailable to ecological receptors. This is simply not the case; this was well-recognized in 1992 and commented on by AVX. Further work over the last six years has documented the importance of considering site-specific dynamics when evaluating how much of a contaminant found in an environmental medium is available to receptors. Many factors, such as absorption onto sediment, depth within a sediment column, and the nature of the interaction between the contaminant and receptor exposure are necessary to consider in evaluating ecological risk.

- Lastly, in addition to the absence of site-specific ecological and toxicological information as well as site-specific information on the dynamics of exposure, the risk assessment is further flawed because it only considers the effects of exposure to contaminants on an organism level. It is well accepted by ecologists that effects on individual organisms cannot be translated into population effects. The fact that laboratory tests show that congeners of PCBs can have adverse effects to individual organisms does not necessarily mean that these effects are the same in the environment nor that these effects will be proportional to those experienced in a population. Ecological risk assessment guidance that was available when the risk assessment was conducted as

well as EPA's guidance for conducting ecological risk assessments developed since that time (EPA 1992; 1994; 1996a) specifically discuss the necessity for considering population effects. The fact that many other factors in the environment control the size and success of populations, e.g., predation, availability of space, and availability of food, requires that to fully evaluate the effect of a contaminant in the environment one must consider that effect within the framework of other variables that affect or modify the success of the populations of ecological receptors. This type of analysis was neither conducted nor apparently even considered by EPA, even though the results of that type of analysis could have consequences involving the unnecessary expenditure of tens of millions of dollars.

For the reasons stated above, the Baseline Ecological Risk Assessment cannot be used to differentiate among the risk resulting from various remedial alternatives. EPA's statements that the preferred remedy described in the 1996 Plan results in less risk on the environment is totally misleading. The fact that the ecological risk model developed by EPA (1990) was never used again to compare differential risk of various alternatives, even after the food chain model --- flawed as it was --- was available, is further evidence that EPA has no sound scientific basis for choosing among remedial alternatives.

EPA is also remiss for not fully considering the risk associated with mobilizing PCBs and metals from the sediment and the impact that will result from the 10 to 15 year long dredging remedy. The comments of Bohlen (1997) and Reibel and Thibodeaux (1997), amply demonstrate that the potential for contaminant loss during dredging is great. This is clearly illustrated by the fact that during

Hot Spot dredging even three passes of a dredge were unsuccessful in decreasing the surficial sediment concentrations of PCB in the Hot Spot to less than several hundreds of parts per million (Otis memorandum to D. Dickerson April 19, 1995). While it did not appear that the contaminant flux was significantly elevated during Hot Spot dredging, it is noteworthy that the production rate of Hot Spot dredging and the effective operational time were such that on the average only 50 cubic yards were dredged per day. This does not provide a basis to compare the Hot Spot dredging to an operation with two dredges operating and multiple CDFs being filled simultaneously.

D. The conclusions drawn in the Long-term Monitoring Program Report (Nelson et al. 1996) are not necessarily representative of the underlying data.

As discussed in AVX (1992), there are many confounding variables that effect the biota of New Bedford Harbor. The conclusions by Nelson et al. (1996) that all the effects, including the results of the bioassays and the characteristics of the benthic community, reflect the stresses caused by PCBs are simplistic and misleading. There are many factors in urban estuaries that result in stresses on organisms in benthic communities, and, as discussed in Bohlen (1997) there are many estuaries in the northeast that have similar characteristics in terms of sediment toxicity and species diversity which cannot be explained by the presence of PCBs.

While the long-term monitoring study is useful in tracking trends in contaminant distribution, the suggestion that there is some causal relationship between PCBs and biological effects, or by extension, that these effects or

characteristics will change after the preferred remedy is implemented, is misleading. There has been no attempt to establish a scientifically defensible foundation for such conclusions.

Likewise, the suggestion that the bioaccumulation studies have any relationship to toxicological risk is misleading. There is no evidence in the literature that there is any cause and effect relationship between bioaccumulation of PCBs in New Bedford Harbor and any toxic effect to the species bioaccumulating the PCBs. Similarly, the results of sediment toxicity tests using *Ampelisca abdita* cannot be explained by the presence of PCB. Lead, mercury, copper and cadmium as well as other, non-chemical, stresses such as dissolved oxygen levels, nutrients and sediment ammonia levels could just as likely explain the results from the sediment toxicity tests. Some of these chronic stressors are even discussed by Nelson et al. (1996), "chronic stressors can include non-contaminant water quality parameters such as low dissolved oxygen concentration". However, the long-term monitoring studies did not measure any of these non-contaminant potential stressors.

II. IN RECOMMENDING THE PREFERRED REMEDY, EPA HAS IGNORED NEW INFORMATION WHICH SHOULD HAVE BEEN CRITICAL TO ITS DECISION, THUS MISREPRESENTING THE EFFECT OF THE PREFERRED REMEDY.

Since 1992 when the last proposed plan was announced for the Upper, Middle and Lower Harbors, there have been developments that materially affect EPA's conclusions with regard to the potential human health risks of PCB. Most important are the changes that have occurred in the way EPA evaluates the potency of carcinogens in

general (EPA, 1996b, EPA, 1996c) and in the cancer slope factor that EPA has derived specifically for PCBs. These facts are discussed in detail in the attached review by TERRA (1997). The fact that EPA neither made the New Bedford Community Forum aware of this matter and its implications on potential human health risk from PCBs in New Bedford Harbor, nor indicated in any fashion in the announcement of the proposed cleanup plan that these changes have occurred is inexplicable! AVX's independent evaluation of the implications of these changes reconfirms the evaluation performed by TERRA, Inc. in 1992 (TERRA 1992). That is, the human health risk, evaluated using realistic exposure scenarios and the newly revised cancer slope factors (EPA 1996c), indicate that risks associated with PCBs in New Bedford Harbor or in PCB-contaminated seafood is within the acceptable range.

In addition, as discussed above the several guidelines that have been issued for conducting ecological risk assessments since 1990 (EPA 1992; 1994; 1996a) reinforce AVX's position that EPA's initial ecological risk assessment conducted in 1989 (EPA 1990) was unrealistically simplistic and overly conservative. With the choice of target cleanup level so dependent on the results of the ecological risk assessment, EPA should have re-evaluated the potential for ecological risks prior to recommending the preferred remedy. EPA should have moved beyond the Tier I risk assessment provided in the baseline ecological risk assessment and examined the variables affecting ecological risk with greater resolution. This more realistic assessment should have included those variables relating to toxicological effects of PCB as well as those relating to exposure and bioavailability, as discussed above. In addition, EPA should have evaluated the potential for risk to the populations of organisms that either temporarily or permanently inhabit New Bedford Harbor rather than dwelling on the risk of the total PCBs on individual organisms. Not only are the evaluative tools

available to do this, EPA itself has recommended these factors be considered in the various guidance referred to above.

The fact that EPA has ignored these developments in the field of human health and ecological risk assessment certainly raises the question whether EPA has seriously evaluated the risk to the environment or to human health due to the presence of PCBs in New Bedford Harbor. The public is entitled to more than this cavalier approach to scientific work when there are so many millions of dollars at stake. Given that the human health and ecological risk assessments are flawed, it is obvious that any cost-benefit decisions made using risk reduction as their basis are also flawed!

III. IN RECOMMENDING A DREDGING PROJECT OF SUCH MASSIVE PROPORTIONS AS THE PROPOSED REMEDY, EPA HAS FAILED BOTH TO ADEQUATELY CONSIDER THE EXPERIENCES OF THE HOT SPOT DREDGING AND TO SYSTEMATICALLY EVALUATE THE RISKS TO THE ENVIRONMENT RESULTING FROM DREDGING.

As concluded by AVX (1992), as well as Bohlen (1997) and Thibodeaux and Reibel (1997), the potential for loss of PCBs to the environment during the dredging process is substantial. EPA's 1996 Plan anticipates dredging for a period greater than 10 years and perhaps as long as 20, a period that may be substantially longer with navigational dredging. During this time, there will be substantial remobilization and transport of PCBs and sediment-associated metals such as cadmium, copper, nickel and lead (Nelson et al. 1996) through the water column, as well as substantial volatilization of PCBs to the air (Reibel and Thibodeaux 1997). The results of this contaminant loss

have not been systematically evaluated either in terms of the mass of contaminants lost or in terms of the resulting risk related to the exposure of ecological or human receptors to this type of contaminant loss. This should have been a necessary and integral part of choosing amongst alternative remedies, but apparently EPA chose to ignore the potential for this loss. EPA's failure to fully consider the potential environmental consequences of implementing the preferred remedy is inexplicable, particularly as this proposed project is a precedent-setting one in terms of scope (Applied Environmental Management 1997). Of the less than 10 sites in the United States for which major removal of contaminated sediment has been performed, only Marathon Battery, a site quite different from New Bedford Harbor, was tested to verify that cleanup levels were met (Applied Environmental Management 1977).

It is irresponsible for EPA to go blithely along without more systematically and realistically examining the feasibility of this dredging project and the environmental impacts that will results from it. If EPA's confidence is based on the results of the Hot Spot dredging, there is grave cause for concern. EPA's dredging effort was apparently successful to the extent that it lowered sediment levels to below 4,000 ppm, but in many cases only after three passes of the dredge. Even after three passes, however, hundreds of parts per millions of PCBs were left in the sediment (Otis 1995). It should be stressed that the objective of the Hot Spot dredging was to remove all contaminated sediments within the 4,000 ppm isopleth. The 4,000 ppm level was not intended to be a target cleanup level, but due to the ineffectiveness of the dredging process, was apparently considered to be. Even so, it took, in some instances, three passes of the dredge to get average sediment concentrations to less than 4,000 ppm. In some areas, concentrations of greater than 1,000 ppm were left as the residual concentration. It is likely that what EPA succeeded in doing was moving the contaminants around, resuspending and diluting them, but that it was not very

effective in removing them. If EPA is using this example as the basis for an expanded dredging remedy, one should remember that there is a 400-fold difference in "cleanup level" (4,000 ppm versus 10 ppm in the Upper Estuary) and a substantial difference in volume (450,000 cubic yards versus 14,000 cubic yards) between the two projects. As noted in Dames & Moore (1997), if EPA conducts the Operable Unit 2 dredging at the same production rate as occurred in the Hot Spot dredging, 450,000 cubic yards will take 20 years to dredge. There is no way of knowing what concentrations of PCBs will be left or where PCBs either associated with sediments or volatized into the air will end up.

EPA may respond that there was not a materially significant increase in flux of PCBs under the Coggeshall bridge during the Hot Spot dredging. However, EPA was only dredging at a rate of approximately 50 cubic yards per day. If this experience is extrapolated to 450,000 cubic yards, and 50 cubic yards per day is the rate necessary to keep the transport of PCB below background, this implies dredging will take <u>over 40 years!</u> If EPA assumes that the preferred remedy will be implemented using two dredges simultaneously while filling multiple confined disposal facilities (CDFs), there will be a great deal of potential for contaminant loss to the estuary and the air (Reibel and Thibodeaux 1997). As Bohlen (1997) indicates, dredging these estuarine sediments will result in destabilization of the sediment column near the sediment water interface, thus increasing its vulnerability to resuspension both under natural tidal currents and particularly under any episodic events. In addition, as Bohlen (1997) indicates, the modification of the water depth in the estuary will also contribute to increased current velocities, resulting in an increase in potential for resuspension and transport of PCB.

As summarized in AVX (1992), there are many other adverse environmental side effects of a dredging remedy other than just increased probability of exposure to the remobilized contaminants. These effects include destruction of benthic communities, burial of nearby benthic communities that are smothered by the resuspended sediment, and entrainment of planktonic forms of organisms in the hydraulic dredges. Since the proposed dredging will take anywhere from 10 and 20 years (and longer with the navigational dredging), it is apparent that this dredging project has the potential to have a major, harmful, environmental impact. EPA has not done the necessary in-depth evaluation to compare these effects to the ongoing impact of PCBs under baseline conditions nor to the AVX proposed capping remedy.

As to the estimated costs of the 1996 Plan, the best way to ground truth them is to consider them in light of what the Hot Spot remediation experience to date can teach us. When reviewing EPA's estimated cost for the preferred remedy it is frightening to realize that in 1989 EPA estimated that the Hot Spot dredging would cost $14,000,000 and would be completed in 80 days. As we now know, the Hot Spot dredging took over 260 days to complete, with costs of $33,000,000 to date. This is without incineration and decontamination of the PCB-contaminated sediments originally included in the $14,000,000 estimate. A reasonable estimate of the complete Hot Spot Operable Unit costs once the remediation is completed, by means not yet defined, is likely to approach $50,000,000. Thus, the Hot Spot dredging cost is in excess of 300% more than originally estimated and will take at least 5 years longer to complete than estimated.

As a result of these serious problems, AVX is concerned that EPA may change the remedy half way through its implementation, as it did in the Hot Spot Operable Unit, thus adding substantial cost to the project. EPA's record in managing the Hot Spot

Operable Unit 1, first adapting an incineration remedy despite comments that incineration was not a viable remedy, and then changing its views mid-way through the project has provided little confidence to the public that EPA has anticipated all the variables of the 1996 Plan or adequately estimated all the costs for them.

While EPA would have the public believe that the estimate for the Operable Unit 2 preferred remedy is much more accurate because it depends upon, and benefits from, the experience gained in the Hot Spot dredging, this is far from the truth. Upon close examination, the extrapolation of the cost factors for the Hot Spot dredging to the Operable Unit 2 is overly simplistic, based not only on unclear assumptions, but also on misuse of data. Documentation of a defensible foundation for the extrapolation of these costs as well as any showing of attention to detail is nowhere to be found. Some of these problems are pointed out in Dames & Moore (1997), and include the following:

- During the Hot Spot dredging 14,000 cubic yards of sediment were dredged and stored for a capital cost of $26,693,000, yielding an average price of $1,907 per cubic yard. If this were extrapolated directly to Operable Unit 2, the projected cost based on the Hot Spot experience would be approximately <u>$850,000,000</u>! As pointed out in Dames & Moore (1997), there would be obvious efficiencies of scale but these are not quantatively documented or explained in any manner other than the fact multiple dredges would be working. Based upon EPA's estimate of $141,684,000 as the capital costs for dredging and storing of 450,000 cubic yards, the preferred remedy is a unit cost of $315 per cubic yard. There is absolutely no justification for the 600% increase in efficiency claimed for Operable Unit 2. Even if a 50% gain in

efficiency due to economies of scale were assumed, the potential capital cost for Operable Unit 2 would be approximately $430,000,000.

- Although dredging for the Hot Spot did meet its preliminary goal of dredging within the 4,000 isopleth, it is essential to remember that upon completion of dredging, the sediments in the Hot Spot area still had concentrations of hundreds and in some areas thousands of parts per million PCBs. The record is devoid of anything that suggests how EPA applies this experience to estimate the feasibility and costs for Operable Unit 2. Certainly there is no reason to believe that EPA will be any more efficient in dredging contaminated sediments in the rest of the estuary than it was in the Hot Spot. It is likely dredging of these areas will also require multiple passes to reduce concentrations to less than hundreds of parts per million (to say nothing of 10 ppm). EPA has made no attempt to provide for costs associated with the extra effort required to dredge below the residual level in the Hot Spot, or explain why the situation is any different. Nor has it included any contingency in the event it is unable to dredge beyond 100 ppm in the upper estuary to reach the 10 ppm TCL. Is it possible EPA will dredge to some residual level and because it cannot effectively do better than it did in the Hot Spot remedy, decide that an alternative remedy, e.g., capping on top of the dredged areas, would be in order? EPA's history with the Hot Spot dredging unfortunately suggests that any number of scenarios like this are likely to unfold in the future.

- Though EPA predicted a production rate of 35 cubic yards per hour and 100% operational time in the Hot Spot ROD, it experienced a production rate of only 13.4 cubic yards per hour and only 75 percent operational time. EPA used this

estimate for extrapolating the dredging cost for the upper third of the estuary. However, EPA inexplicably increased the production rate to 20 cubic yards per hour and to 80 or 85 percent operational time for the remainder of the upper estuary.

- For the purpose of estimating the cost of dredging, Foster Wheeler (1996) estimated an operating cost of $9600 per day using two dredges and two eight hour shifts. However, the actual costs of the Hot Spot dredging results were dramatically higher, 80 hours at $525 per hour and 1211 hours at $569 per hour (Otis 1996 in Foster Wheeler 1996). Using these latter rates, the operating cost for an 8 hour shift would be either $4200 or $4500 per shift, and for 2 dredges and two shifts, as assumed by Foster Wheeler, the estimated cost would be somewhere between $16,800 and $18,200 per day. This is nearly <u>double</u> the cost that was used as the basis for the Foster Wheeler estimate. In addition, the cost estimate prepared for the preferred remedy does not even include costs for downtime.

- The costs for the proposed water treatment system are also underestimated. Since the 1992 Plan EPA has collected cost data for the Hot Spot CDF effluent treatment. Rather than use this cost information directly, EPA used an average of two cost estimates without bothering to explain the fact that the basis for both these costs were far different.

- As far as can be determined from the Administrative Record, the cost estimate for the preferred remedy also omits various required costs for long term monitoring. The only monitoring of the CDFs is for inspection and erosion control. Apparently, no costs were included in the estimate for ground water

or long term monitoring of the CDFs. There are also no costs included for monitoring the performance of the wetland restoration or for refilling the excavated mud flats.

- The EPA has not included costs for time that will be spent on resolving issues associated with locating the CDFs. There do not appear to be any costs included in the 1996 Plan that show property purchase costs associated with coordinating the acquisition, development, and reuse of the CDFs.

- The cost of construction of CDFs does not account for material that would be needed as a result of settlement. AVX (1992) commented that the consolation of silts underlying the dike walls of the CEFs will result in the dike settling 3 to 5 feet and possibly even failing. There was no consideration in the cost estimates for the preferred remedy to provide makeup material to compensate for the dike settling or any contingency allowed for reconstruction of areas that may fail during settling. While EPA may want the public to believe that the preferred remedy can be implemented without problems, this was certainly not the case for the Hot Spot project nor is it likely with Operable Unit 2.

IV. IN RECOMMENDING THE PREFERRED REMEDY EPA HAS IGNORED OR UNDERESTIMATED OTHER KEY FACTORS.

A. There would be far less contaminant loss and potential for environmental impact under AVX's Proposed Capping Plan (AVX 1990) than under a dredging remedy.

In the announcement of the 1996 Plan EPA compares the preferred remedy to a capping remedy. Although the implication is that EPA has compared the preferred remedy to the capping remedy AVX proposed, this is far from the truth. The capping remedy AVX proposed involved capping with only 45 (about 18 inches) centimeters of sediment, an amount which was found to be effective in isolating the contaminated sediments from the surrounding environment, armoring the cap in areas which had a potential for erosion, and capping only to a 50 ppm TCL. EPA's capping remedy contemplates a cap 3-5 feet deep and capping to 10 ppm. As a result EPA finds, not surprisingly, that in the shallow upper estuary, much of the intertidal areas would be elevated to above tide. EPA's designed cap is not realistic or necessary and AVX's (1990) proposed capping remedial action plan explains why. The breakthrough time of PCBs for a cap of 45 centimeters is in the hundreds of years.

In addition, although EPA has alarmed the public, to the contrary, it is not true that a cap would be susceptible to erosion. As summarized in Bohlen (1997), given that the Upper Estuary is not only very narrow, but is protected from major storm surges by a hurricane barrier, and given that the AVX cap design calls for armoring at the head of the estuary where the river enters, erosion and failure of the cap is no more likely than erosion and failure of the CDFs. EPA's comparative analysis of the two remedial alternatives is unfair because of the extremely conservative and unnecessary factors in the design of EPA's cap. These factors also result in inflation in cost of the capping remedy, thus portraying it in an unfavorable light. A cost comparison of the preferred remedy to the AVX proposed capping remedy is presented in Table 3.

A comparison of the preferred remedy to the capping remedy proposed by AVX (1990) one would see that the capping remedy compares very favorably (116 million dollars versus approximately 40 million dollars, a difference of 76 million dollars). Given the fact that the capping remedy proposed by AVX also results in substantially less contaminant loss and environmental impact, it is clear that AVX's proposed remedy should be accorded significantly more consideration.

Not only would a cap be effective at immediately reducing mobility, it would promote an anaerobic environment, thus facilitating anaerobic biodegradation of PCBs. Although this is a relatively slow process, it would occur over time. Meanwhile, the immediate reduction in mobility, as opposed to dredging which effectively mobilizes contaminants, would lead more quickly to reaching both AWQC and tissue residue goals. Construction of the cap AVX has proposed would also eliminate the need to use valuable shoreline to site CDFs, thus avoiding millions of dollars in cost and the attendant adverse environmental impacts of CDFs. Taking all these factors into consideration, AVX's proposed cap remedy compares quite favorably to the preferred remedy and other EPA remedial alternatives (Figure 1).

B. The loss of contaminants during filling of the CDFs and from the CDFs has not been adequately evaluated.

Considering that CDFs are the intended ultimate disposal area for the contaminated sediments within New Bedford Harbor (absent some yet unknown scientific developments), EPA failed to evaluate properly how much contaminant loss will occur during filling of the CDFs as well as from leaching

through the CDFs once they have been filled. While there have been some simplistic calculations of the rate of leaching and loss of PCBs and other contaminants to the estuary after water treatment, these results have not been used to fully assess total mass of the contaminants that will be released.

C. **Most importantly, EPA has misrepresented the cost of the preferred remedy because it has not considered that, in effect, this remedy is an interim remedy and significant additional cost will be required to further treat the contaminated sediments and de-mobilize the CDFs.**

While all remedies which leave contaminants in place are subject to the five year review in accordance with the requirements of CERCLA § 27(c), EPA goes beyond the requirement to "assure the human health and environment are being protected" and has promised in both the 1996 Plan as well as in the Agreement with New Bedford Harbor Forum, that it will also review treatment alternatives for potential use on the materials stored in the CDFs.

Given the high priority within the research community for development of a cost effective treatment for PCBs, it is not only possible, but likely, that in the near future a treatment technology will be developed that is applicable to the sediments stored in the New Bedford Harbor CDFs. EPA is required under the Agreement with the New Bedford Harbor Forum to seek funding for implementation of such sediment treatment. This outcome is also promoted by the State of Massachusetts as testified to by the statement of Trudy Coxe, Secretary of the Massachusetts Executive Office of Environmental Affairs, who said at the public meeting announcing the 1996 Plan on November 20, 1996 "...we hope that EPA will continue to agree to consider destroying the PCBs as

part of Phase II". By approaching remediation of the New Bedford sediments with the option that they may at some point undergo treatment, the EPA has made the 1996 Plan, in effect, an interim remedy. Thus, EPA will spend hundreds of millions of dollars over the next ten years to dredge and then landfill these sediments, only to reopen the CDFs and handle the material a second time for treatment. The potential costs of such an approach are staggering! Accepting for the moment that the underestimated cost presented for the preferred remedy in 1996 Plan is, in fact, the real cost, the total cost for the final plan if EPA reopens the CDFs and decontaminate the PCBs (as well as the associated capping material that has subsequently been contaminated) could approach $215,000,000 based on fairly simplistic assumptions (see Table 2 in Dames & Moore 1997). This potential has neither been presented in or discussed either with the New Bedford Harbor Community Forum or in the 1996 Plans.

D. The weakness of the foundation underlying the preferred remedy was demonstrated after the review of the preferred remedy by the Remedy Review Board.

Upon review, the Remedy Review Board indicated that the costs for air monitoring seemed high. EPA immediately trimmed $8,000,000 out of the $10,000,000 air monitoring budget reflecting an 80% budget cut with no explanation as to why the same degree of protection could be afforded by a program only 20% of the magnitude that the originally proposed. That $8,000,0000 cut accounts for the difference between the $127,000,000 proposed cost for the preferred remedy presented to the Remedy Review Board and the final preferred remedy with an estimate cost of $116,000,000.

E. It is unclear from the 1996 Plan how the navigational dredging will be separated from the preferred remedy for OU2.

Although EPA indicates that the costs for the navigational dredging will be paid from the State, there is a substantial potential that there will be overlap between remedial and navigational dredging both in the areas to be dredged as well as in the use of CDF in Area 7. This concern is illustrated by paragraph 8 in the Agreement with the New Bedford Harbor Community Forum which says "The Forum supports the utilization of some portion of the remediation CDFs to store navigational dredging spoils from the harbor." There is no indication of how, if the navigational dredging is implemented, these costs will be separated and accounted for. Substantial costs should be allocated to the preferred remedy just for documenting separation of these costs. This additional cost has not been accounted for.

F. Limiting the dredging in the upper estuary to periods of high tide is inefficient and results in unnecessary costs.

EPA persists in limiting the dredging operation to periods of high tide when it would be easy to hydraulically control the upper estuary by damming it. Hydraulically controlling the upper estuary would allow dredging to continue throughout the tidal cycle. If the concern is for potential environmental impact, that should be compared to the environmental impact that will result from prolonging the dredging 4 to 6 times longer than is necessary.

Likewise the restriction of the dredging operations to only two eight-hour shifts unnecessarily extends the period of time necessary to complete the dredging

operation. Why can't EPA institute a round-the-clock or at least two eight hour shifts operation thus substantially decreasing costs and potential for environmental impact.

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TABLE 1

HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELING

Item	Promised in Work Plan	Actual Study
Schedule	6/11/84 to 8/26/85, Final Report due 9/85	6/11/84 to 9/21/90 (5 years late!)
Contamination parameters to be modeled	Four PCB isomers and three heavy metals (copper, cadmium, and lead)	Total PCBs, no metals
Budget	$382,964	??
Fluid characteristics to be modeled	Salinity and Temperature	Salinity and Temperature not included
Turbulence	Improvements of existing K-E turbulence model	No turbulence model, Eddy viscosity assumed constant
Cohesive sediment deposition and erosion formulation	Improvements on existing formulations by Krone & Partheniades	No improvements made
Bioturbation/Bed sediment modeling	Transport model to be modified to include effect of bioturbation of sediment and sediment-sorbed within seabed	No modeling of bed sediments included
Long term simulations	Composite tidally driven base case with typical wind driven cases	Tidal base case plus one wind driven (storm) case
Tidal simulations	Assume water surface is flat and use rigid lid approximation in hydrodynamic model	Abandoned rigid lid approximation because it was incorrect and implemented time varying free surface in model

From: AVX 1992

TABLE 1 (continued)

HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELING

Item	Promised in Work Plan	Actual Study
Remote imagery	Proposed to use Landsat 4 and 5 imagery to calibrate circulation model	No remote sensing data used to calibrate model
Wave	Proposed to calibrate wave model using US Army Corp of Engineers wave data at hurricane barrier	No calibration of wave model
Calibration	Proposed for summer (stratified), winter (no stratification) and storm conditions	No effective calibration. Model incapable of simulating stratified conditions (no density forcing)
Three dimensional (3-D representation)	Proposed to have full 3-D simulation	Vertical gridding strategy in upper bay allows only 2-D representation

References:

1. Work Plan:
Battelle, 1984, RI/FS Work Plan for modeling of the transport distribution, and fate of PCBs and heavy metals in the Acushnet River/New Bedford Harbor/Buzzards Bay system, prepared for NUS Corporation, Pittsburgh, Pennsylvania, May 1984.

(Amendment of July 16, 1984)

2. Model Result:
Battelle, 1990, Modeling of the transport, distribution, and fate of the PCBs and heavy metals in the Acushnet River/New Bedford Harbor/Buzzards Bay system, prepared for ESBASCO, Boston, Massachusetts, September 21, 1990.

From: AVX 1992

TABLE 2

BIOLOGICAL FOOD CHAIN MODELING

Item	Promised in Work Plan	Actual Study
Evaluation of Existing Data	Proposed to obtain best_ available information for: respiration rates, growth rates, migratory habits, food assimilation efficiencies, contaminant assimilation efficiencies, contaminant bioconcentration factors, and contaminant excretion rates for species being modeled	Sparse citations from the referenced literature, most quite dated.
	Proposed detailed review of available New Bedford Harbor data, including data analyses and syntheses, as required, to assess the characteristics of extent PCB and copper contamination in the New Bedford Harbor ecosystem	Yes
Application of biological food web model to New Bedford Harbor ecosystem	Development of food web structures for the species of interest	Yes
	Detailed literatures review of prey preference, feeding habits, respiration, age-weight relationships, and migration patterns of each species	Literature review not detailed and not current
	Model application	Yes

From: AVX 1992

TABLE 2 (continued)

BIOLOGICAL FOOD CHAIN MODELING

Item	Promised in Work Plan	Actual Study
Preliminary calibration of food web model using existing information	Proposed to compare model calculated and observed organism contaminant concentrations	Yes
	Proposed to adjust model as necessary	Not done
Evaluation of the 1984-1985 field and laboratory data and detailed calibration of the food web model	Proposed detailed calibration of model	Detailed calibration not done
Evaluation of effectiveness of remedial action	Proposed to apply model to various remedial scenarios	Yes
Reporting and documentation of analysis	Proposed comprehensive final report	Yea

References:

1. Work Plan:
   Battelle, 1984, RI/FS Work Plan for modeling of the transport distribution, and fate of PCBs and heavy metals in the Acushnet River/New Bedford Harbor/Buzzards Bay system, prepared for NUS Corporation, Pittsburgh, Pennsylvania, May 1984.

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From: AVX 1992

TABLE 3

NEW BEDFORD HARBOR
AVX CAPPING REMEDY
ESTIMATED COSTS

Assumptions: Utilize same scaling factor for AVX alternative as EPA used for the alternatives from the Feasibility Study:

Means Construction Cost Data (indices)
1989 Index = 92.1
1996 (Jan) = 108.3

$$\% \text{ Increase} = \frac{108.3 - 92.1}{92.1} \times 100 = 18\%$$

Apply 18% increase to direct costs.

A. CAPITAL COSTS

1.	Hydraulic Control $900,000 x 1.18 =	$1,062,000
2.	Construction of Staging Area $4,500,000 x 1.18 =	5,310,000
3.	Management of CSO Discharges $300,000 x 1.18 =	354,000
4.	Surveying Control $30,000 x 1.18 =	35,400
5.	Cap Construction $12,000,000 x 1.18 =	14,160,000
6.	Saltmarsh Remediation $70,000 x 1.18 =	82,600
7.	Demobilization of Staging $200,000 x 1.18 =	236,000
8.	Bathymetry Survey $20,000 x 1.18 =	23,600

9.	Establishment of Saltmarsh $350,000 x 1.18 =	413,000
10.	Adjustment of Hydraulic Controls $20,000 x 1.18 =	23,600
	1996 Total Capital Costs =	$21,700,200

Note that the FS cost estimates include a 50% markup for indirect costs (IDCs) such as health and safety, fees, engineering, plus a 20% contingency. The AVX alternative cost estimate includes engineering and a 30% contingency. It is unclear whether the other IDCs were included in the AVX proposal. Assuming roughly 25% of the IDCs have not been incorporated would raise the total to $27,125,250.

- Recommend using a range of $21.7 to $27.1 million.

B. LONG-TERM (O&M) COSTS

The AVX proposal assumed a 20-year monitoring period, quarterly monitoring in the first 5 years, and a 60% reduction in the monitoring for the last 15 years. The program included 10 SW/SED samples and 20 biota samples.

While this monitoring program may be possible, it is not the typical program prescribed by EPA. By comparison, EPA's O&M estimates include:

a. Cap Maintenance
   - Replacement of 10% of sand every 10 years
   - Annual hydrographic survey
   - Annual monitoring of cap thickness

b. Monitoring Program
   - 50 SW, 50 SED, 50 biota samples, 25 locations in estuary, 25 in lower harbor
   - Quarterly events every year for 30 years
   - 5 year reviews for 30 years

The FS estimated costs for monitoring program
(1996, present worth @ 7% for 30 years) = $8,695,000

Using EPA's assumptions for cap maintenance, applied to the AVX alternative is as follows:

10% of 330,000 cy/sand = 33,000 cy sand every 5 years

Assume $36/cy purchase and placement

Assume $150,000 for mob/demob

(33,000) $36 + $150,000 = $1,338,000 every 5 years

Annual Costs: $23,600/yr surveying
$ 4,800/yr cap thickness
$28,400/yr

Present Worth @ 7% for 30 yrs = $352,400 + $2,887,000
of Cap Maintenance
= $3,239,400

Therefore, cost of AVX proposal, in 1996 dollars, including EPA required maintenance and monitoring =

Capital:	$21,700,000 to 27,100,000
Maintenance:	$3,239,400
Monitoring:	$8,695,000
Total:	$33,634,400 to $39,034,400

Note that the air monitoring during construction is not included, but could be required to alleviate public concern. Cost for air monitoring could be $2 to $3 million additional.

	No Sediment Cleanup	10 ppm Cleanup Level				
Nine Criteria	1 Limited Action only	2 Capping	3, 3d Dredging with CDF Disposal	4 Alt. 3 Plus Solidification	5 Alt. 3 Plus Solvent Extraction	6 Alt.3 Plus Incineration
Protects human health and environment	○	◖	●	●	●	●
Meets or waives* Federal and State requirements	◖	●	●	●	●	●
Long-term effectiveness & permanence	○	◖	●	◖	●	●
Reduction of mobility, toxicity & volume thru treatment	○	○	○	◖	●	●
Short-term effectiveness	●	◖	●	◖	◖	◖
Implementable	◖	●	●	●	◖	◖
Total Cost millions	$9.5	$147.6	$145.9-3 184.5 - 3d	$305.7	$533.4	$575.9
Preliminary State Acceptance	○	○	●	◖	◖	○
Community Acceptance	To be determined after the public comment period					

*Waiver applies to FDA tolerance level for PCB concentration in fish tissue and a Clean Water Act discharge regulation. See discussion on page 14.

Figure 1. Comparison of remedial alternatives including AVX's proposed capping alternatives.

	50 ppm Cleanup Level			10 ppm Upper, 50 ppm Lower Harbor	50 ppm
Nine Criteria	7 Upper Harbor only; Capping 50-500 ppm, Dredging > 500 ppm	8 Dredging with CDF Disposal	9 Dredging > 50 ppm, Treating > 500 ppm, CDF Disposal	10 Proposed Remedy	AVX Multi Media Cap
Protects human health and environment	◖	●	●	●	●
Meets or waives* Federal and State requirements	◖	●	●	●	●
Long-term effectiveness & permanence	○	●	●	●	●
Reduction of mobility, toxicity & volume thru treatment	○	○	◖	○	○
Short-term effectiveness	◖	●	◖	●	●
Implementable	●	●	◖	●	●
Cost millions	$81.7	$85.4	$176.1	$115.5	$35-42
Preliminary State Agency Acceptance	○	●	◖	●	?
Community Acceptance	To be determined after the public comment period				?

○ does not meet criteria ◖ partially meets criteria ● meets or exceeds criteria

Figure 1. Comparison of remedial alternatives including AVX's proposed capping alternatives.

PART III

PCB Cleanup Guidelines for New Bedford Harbor Sediments: Re-Evaluation of the 50 ppm Target Cleanup Level Using New PCB Cancer Slope Factors

January 1997

TERRA, Inc.
Toxicological Evaluations, Research and Risk Assessment

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EXECUTIVE SUMMARY

The baseline risk assessment performed by EC Jordan and submitted to the US Environmental Protection Agency (USEPA) in the late 1980s by Ebasco Services, Inc., adopted overly conservative exposure assumptions from which the risks associated with direct exposure to PCB-contaminated sediments and contaminated seafood taken from New Bedford Harbor were estimated. These overly conservative assumptions included the sediment ingestion rate, the amount of New Bedford Harbor fish consumed by area residents, the toxicokinetic (bioavailability) factors for PCBs, the number of years that an infant or small child would contact site sediments or consume fish from the area, and the frequency of exposure to site sediments. The use of these overly conservative exposure assumptions leads to an exaggeration of exposure levels and lifetime average daily doses of PCBs and thus to an overestimation of the theoretical lifetime risks associated either with present site conditions or any proposed remedial alternatives.

Using more realistic exposure assumptions where appropriate, TERRA, Inc. (TERRA), previously performed an evaluation of the proposed 50 ppm PCB clean-up standard by determining the excess lifetime cancer risks associated with child and adult beachcomber exposures to sediments containing PCB contamination at levels that would result should this cleanup goal be adopted (TERRA, 1992). To calculate these risks, TERRA applied three different PCB cancer potency factors to the dosages derived from each exposure scenario. The first value, 7.7 $mg/kg/day^{-1}$, represented the USEPA's estimate of the cancer slope factor (CSF) for PCBs at that time. Two alternative CSFs of 1.1 $mg/kg/day^{-1}$ and 0.18 $mg/kg/day^{-1}$ were also considered and were felt, at the time, to represent reasonably conservative CSFs that could be derived from a recent re-evaluation of the animal data that had been performed using current National Toxicology Program guidelines for evaluating liver tumor pathology.

In the almost five years that have elapsed since TERRA's last evaluation, important changes have occurred in the way the USEPA evaluates the potency of carcinogens in general (USEPA, 1996a) and in the CSF (or potency estimates) the USEPA has derived specifically for PCBs. In this later analysis, the USEPA has proposed a CSF of 1.0 $mg/kg/day^{-1}$ for the same exposure pathways that

predominate at New Bedford Harbor, i.e., the sediment and food exposure pathways. This value is nearly identical to the 1.1 mg/kg/day^{-1} CSF that TERRA previously derived from tumor incidence data reported by the Institute for Evaluating Health Risks (IEHR, 1991).

As part of the USEPA's new guidance on the evaluation of carcinogenic substances in general, the Agency is proposing to move towards a greater use of human data from which it might derive CSFs or benchmark dose estimates. In keeping with this expanded consideration of human data, TERRA has derived an upper bound CSF for PCBs from the currently available epidemiology studies. The highest of these theoretical CSFs, derived by assuming PCBs cause cancer in humans, was 0.042 mg/kg/day^{-1}. This value is just four-fold lower than the lowest animal-derived CSF of 0.18 mg/kg/day^{-1} TERRA previously derived from the 1991 IEHR re-analysis of the then available animal data. The highest human-derived CSF is equivalent to the lowest CSF the USEPA itself recently derived from newly available animal studies, a value of 0.04 mg/kg/day^{-1} for Aroclor 1016.

Using these three CSFs (i.e., 7.7, 1.0 and 0.42 mg/kg/day^{-1}), the risks from exposure to contaminated sediments were calculated for direct exposure to Area II and Area III sediments assuming a cleanup levels of 50 ppm. All risks were found to be well below the 1 x 10^{-6} risk level. Likewise, the highest risks for both the young and older children from consumption of New Bedford Harbor seafood contaminated with low levels of PCBs were near or below the 1 x 10^{-6} risk level when the new USEPA CSFs were applied to the exposure assumptions adopted by TERRA in 1992. The risk estimates associated with this exposure pathway and these receptors were some 20-fold lower using a CSF derived from human data. The highest theoretical risks resulting from the proposed 50 ppm cleanup levels were those calculated for the adults consuming an average of 46.5 g of seafood per day for 30 years. This was considered an overly conservative assumption to make because it assumes that all of the seafood an individual ingests comes from a single source (i.e., New Bedford Harbor). Still, the highest theoretical risk for this exposure scenario was only 1.2 x 10^{-5} using the new USEPA CSF and was as low as 5.1 x 10^{-7} when using TERRA's human-derived CSF. Based on these analyses and the conservative nature of these risk estimates, the adoption of the 50 ppm cleanup guideline for Area II and III sediments would clearly provide a remediation goal for these areas that is protective of human health. Because Area

I is an industrialized area without suitable beaches or recreation areas, and given the warning signs in this area, an exposure scenario appropriate for Area I would involve significantly less total exposure than Areas II and III. This means the risk estimates calculated for Areas II and III would represent an overly conservative, upper bound estimate of the risks posed by Area I. Therefore, the present risk assessment demonstrates that a 50 ppm cleanup level would be acceptably safe for Areas I, II and III of New Bedford Harbor.

In conclusion, the USEPA-revised PCB CSF (1.0 $mg/kg/day^{-1}$) represents a CSF that is almost an order of magnitude lower than their original CSF of 7.7 $mg/kg/day^{-1}$. The worst-case CSF, calculated based on human data, is approximately 183-fold lower than the USEPA's original CSF, which is the slope factor used in the EC Jordan risk assessment. The use of these lower PCB CSFs to predict risk will significantly impact the cost-benefit analysis for remediation.

1.0 AN INTRODUCTION TO THE PROBLEM

In an earlier report, TERRA (TERRA, 1992) critiqued the scientific bases of the EC Jordan risk calculations for New Bedford Harbor residents (Ebasco, 1989), and analyzed the risks posed by the adoption of a 50 ppm sediment clean-up guideline. In this earlier report, TERRA had proposed the use of alternative CSFs based on the IEHR re-analysis of the chronic animal bioassay data available at the time. Since the submission of the TERRA report, two important developments have occurred that further call into question the EC Jordan risk calculations. First, the USEPA has completed a fourth evaluation of PCB CSFs based on a new chronic animal bioassay. As these CSFs are significantly lower than the USEPA CSF available at the time the EC Jordan report was completed, this change in the CSFs applicable to PCB exposures undermines the credibility of USEPA decisions that were based on the now outdated EC Jordan analysis.

Second, the USEPA has issued new carcinogen risk assessment guidance (USEPA 1996a) that encourages the use of human epidemiology data. In response, TERRA has recently derived PCB CSFs from the currently available epidemiology data by using occupational exposure studies to place an upper bound on what the CSF theoretically should be. While this newly derived CSF represents a worst-case analysis of this epidemiology data, its use would be consistent with new USEPA guidance on cancer risk assessment principles. That these human-derived CSFs for PCBs are lower than even the most recent USEPA CSFs for PCBs further indicates how seriously flawed the EC Jordan risk assessment now is, and yet the USEPA apparently continues to rely upon this risk assessment as it selects a final remedial alternative for New Bedford Harbor.

2.0 THE USEPA'S DERIVATION OF PCB CANCER SLOPE FACTORS (CSFs) FROM THE AVAILABLE ANIMAL DATA

The following paragraphs briefly discuss the limitations of the earlier USEPA CSFs, and the derivation of the USEPA's newly proposed CSFs for PCB mixtures. This perspective will help explain why the USEPA's much earlier risk calculations for New Bedford Harbor, as performed by its consultant EC Jordan,

are now outdated and should not be relied upon by the USEPA when determining the applicability of remedial options for New Bedford Harbor.

2.1 The Earlier USEPA CSFs For PCBs

Since 1980, the USEPA has derived four different estimates for the PCB CSF. The initial PCB slope factor was 3.9 per mg/kg/day, and was based on the rat bioassay study of Aroclor 1260 reported by Kimbrough et al. (1975). This was first changed to 4.3 per mg/kg/day (USEPA, 1984), and then with the publication of the Norback and Weltman (1985) study to 7.7 per mg/kg/day (USEPA, 1988; USEPA, 1996b).

All three earlier evaluations were based upon a single rat study and reflected the animal potency of a 60% chlorine PCB mixture. Each of the three previous CSFs was derived using conservative assumptions regarding the tumor incidence observed in the animal studies (i.e., all combined benign and malignant liver lesions) and the dose scaling factor for converting the animal dose-response relationship to a projected human dose-response relationship (i.e., all used a surface area conversion). In addition, even though the published rat bioassays had failed to identify lower chlorinated PCB mixtures as rat carcinogens, each of the three former CSFs universally applied the positive findings for a 60% mixture to all PCB mixtures regardless of chlorine content:

> *The potency estimate is intended to be representative of other PCB mixtures as well. At present there is no information about which constituents of Aroclor 1260 or any other PCB mixture are carcinogenic. Given this lack of information about individual constituents, Aroclor 1260 is assumed to be representative of other PCB mixtures.* (USEPA, 1988)

Although the former CSFs did follow USEPA default assumptions for deriving this type of toxicity constant, several of these default assumptions, given the animal data available at the time, were arguably overly conservative for many PCB exposure situations. Some of the features that contributed to the conservative nature of these three CSFs are:

- Although the chronic rat bioassays completed in the 1970s and 1980s had failed to find any convincing carcinogenic potential for 54% and 42%

chlorine PCB mixtures (NCI, 1978; Schaeffer et al., 1984), the CSF was nonetheless based upon data for the more potent mixture, i.e., 60% chlorine mixture. This exaggerated the carcinogenicity of the lower chlorinated mixtures compared with the animal evidence available at that time.

- Second, the USEPA default model for calculating CSFs during this period was the linearized multi-stage model, which assumes that carcinogenic response is a linear function of the cumulative dose. According to this model, zero risk is not attained until the dose becomes zero. While it can be argued that such a model is appropriate for mutagenic, initiating carcinogens that produce permanent genetic alterations, many in the scientific community have long maintained that such a model is inaccurate and inappropriate for non-mutagenic carcinogens. Because PCBs are generally considered to be non-mutagenic carcinogens (USEPA, 1996c), many scientists would argue that some type of a threshold model should be used for PCBs as well as other, non-mutagenic chemicals.

- Third, the tumor incidence data that had been used to calculate the CSF that had been applied to all PCB mixtures until September of 1996 had been based on pathological criteria that became outdated and no longer used by the National Toxicology Program in 1986 (Maronpot et al., 1986; Moore et al., 1994). So, while this change in tumor classification criteria had led to a complete re-evaluation of the PCB animal tumor incidence data by the scientific community, the USEPA had simply continued to ignore these important changes during the intervening decade. And even though the re-analysis conducted by the Institute for Evaluating Health Risks (IEHR) concluded that the PCB CSF should be reduced (IEHR, 1991; TERRA, 1993; Moore et al., 1994), the USEPA failed to respond until 1996.

- Fourth, studies performed at the request of the USEPA and other federal agencies had indicated that the USEPA's default use of a surface area scaling factor for all carcinogens was not necessary because a body weight scalar was both reasonably conservative and more consistent with the human data (Allen et al., 1987; Crump et al., 1989). Other studies also led to a recommendation that the USEPA should, at least, adopt a scalar of body weight to the 0.75 power (USEPA, 1992). Until very recently, however, there was no indication that the USEPA would actually institute this important change, even though the impact of the latter scaling factor on the old PCB cancer slope factor of 7.7. $mg/kg/day^{-1}$ would be relatively small (USEPA, 1996a; USEPA, 1996c).

- Fifth, and as will be illustrated in the next section of this report, a section dealing with the derivation of a human-based cancer potency factor, it can be shown that the USEPA's former CSF of 7.7 $mg/kg/day^{-1}$ greatly overstated the actual human risk. This is easily demonstrated when one compares the estimated cancer incidence this CSF predicts to the

observed mortality incidence that as been reported in the available epidemiology studies of capacitor manufacturing workers (TERRA, 1993; TERRA, 1996).

In summary, prior to EC Jordan's analysis of the risks posed by New Bedford Harbor, there was considerable scientific evidence indicating their use of the USEPA's 7.7 $mg/kg/day^{-1}$ CSF would overstate the actual human risk associated with the PCB exposures EC Jordan assumed for their risk assessment. In addition, after EC Jordan's submission of their risk assessment, TERRA commented on a number of the overly conservative features of the EC Jordan risk assessment (TERRA, 1992). While these criticisms of the EC Jordan risk assessment remain, the recent change in the USEPA's CSF for PCBs raises yet another concern for the reliability of the risk estimates provided in the now outdated EC Jordan report. The following paragraphs discuss this recent change in Agency policy.

2.2 The USEPA's Analysis of the Brunner et al. (1996) Study

Recently, the USEPA has derived its fourth cancer slope factor based on new animal studies performed under the sponsorship of the General Electric Company (GE) that were completed at the Battelle Laboratories located in Columbus, Ohio (Brunner et al., 1996; USEPA, 1996c). The animals, 50 male and 50 female rats per dose group, were fed laboratory chow supplemented with varying concentrations of four PCB mixtures for 104 weeks (Aroclors 1016, 1242, 1254, and 1260). The control group was comprised of 100 male and 100 female rats who were fed chow that did not contain PCBs. The experiment was terminated at 104 weeks, and according to the recent USEPA analysis of these data the following data for liver lesions were obtained at necropsy (see Table 2.1).

According to the USEPA's analysis of these data (USEPA, 1996c), statistically significant increased incidences were measured in the female animals for all Aroclor mixtures. A slight increase was also observed in male rats administered 100 ppm Aroclor 1260. Reasonably consistent with the older literature, the newer Brunner et al. (1996) data also suggest that the lower the average chlorination content of the mixture, the lower the cancer potency. The only exception to this generality is the Brunner data for Arcolor 1254 administered to female rats (see Table 2.2), but questions have been raised regarding the actual

congener composition of this particular batch of Arcolor 1254. However, when test response variations resulting from potential batch differences, rat strain differences, and multiple testing are taken into consideration, this result may viewed as an anomaly; therefore, in general the cancer potency of a PCB mixture declines with average chlorine content of the mixture.

Table 2.1

Tumor Incidences from the GE Study*

		Liver Tumor (Response/Total)†	
Aroclor (% Chlorine)	**Dose (ppm)**	**Females**	**Males**
	Control	1/85 (1%)	7/98 (7%)
1016 (41%)	50	1/48 (2%)	2/48 (4%)
	100	6/45 (13%)	2/50 (4%)
	200	5/50 (10%)	4/49 (8%)
1242 (42%)	50	11/49 (24%)	1/50 (2%)
	100	15/45 (33%)	4/46 (9%)
1254 (54%)	25	19/45 (42%)	4/48 (8%)
	50	28/49 (57%)	4/49 (8%)
	100	28/49 (57%)	6/47 (13%)
1260 (60%)	25	10/49 (20%)	3/50 (6%)
	50	11/45 (24%)	6/49 (12%)
	100	24/50 (48%)	10/49 (20%)

*From USEPA, 1996c.

†Brunner et al. (1996) study data. One control group was used for all Aroclor tests. These incidences represent combined nonmalignant and malignant lesions.

The Brunner et al. (1996) study was also unique in that it evaluated the incidence of tumors in PCB treated animals whose exposure to PCBs was stopped after 52 weeks. These animals are referred to as the "stop" group animals. The "stop" study animals were terminated at 104 weeks as were the animals comprising the lifetime exposure study whose results are listed in Table 2.1. For the "stop" animals exposed to Aroclors 1242 and 1254, the tumor incidences were half those observed in the lifetime exposure groups, i.e., about 25% for female rats receiving Aroclor 1254 and 12-25% for female rats receiving Aroclor 1242. No tumors were

observed in the "stop" animals receiving Aroclor 1016. In female animals receiving Aroclor 1260 the results included tumor incidences that were less than, equal to, and greater than the results obtained in animals receiving lifetime exposures. However, it is difficult to determine whether or not the Aroclor 1260 differences are meaningful given the variations that occurred with variations in dosages and the small sizes of the test groups, i.e., only 24 animals were tested.

Based almost solely on the recent Brunner study, the USEPA as of September 1996 changed the PCB cancer slope factor listed in its Integrated Risk Information System (see USEPA, 1996c; USEPA, 1996b). Because there is no regulatory precedence for using these numbers at New Bedford Harbor, and because the USEPA in developing these numbers has continued its past policy of ignoring certain portions of the available animal test data, several implications associated with the use of this new CSF are described in greater detail below.

2.3. The USEPA's Re-analysis of Its PCB Cancer Potency Factor

As mentioned above, for some time there has been considerable pressure upon the USEPA to re-evaluate the PCB CSF. Last year, the USEPA proposed its fourth set of PCB CSFs in the final document that became available September 1996 (USEPA, 1996c). According to the USEPA, the following CSFs can be generated from the Brunner study.

Based on the observation by Safe and others that the composition of PCB mixtures in environmental extracts does not resemble the composition of the commercial products, Cogliano (USEPA, 1996c) has proposed that the USEPA abandon Aroclor mixture-specific CSFs in favor of a range of CSFs that are applied to specific exposure pathways. The basis of the USEPA's argument is that with partitioning in the environment, or by the congener-specific differential in congener biodegradation and metabolism, PCB mixtures will change over time in the environment, moving towards either a more heavily chlorinated or lower chlorinated mixture. On this assumption alone, the USEPA now apparently will recommend that all PCB mixtures be essentially treated as either a 1260 or 1242 mixture, regardless of their original or present composition. The USEPA proposal for each exposure pathway is as follows.

Table 2.2

USEPA PCB Cancer Potency Factors (Slope Factors) for Various Rat Studies*

Study/Sex/Strain/Aroclor mixture	Central CSF†	Upper bound CSF§
Brunner/F/Sprague Dawley/1260	0.4	0.5
Brunner/F/Sprague Dawley/1254	1.2	1.5
Brunner/F/Sprague Dawley/1242	0.3	0.4
Brunner/F/Sprague Dawley/1016	0.04	0.07
Brunner/M/Sprague Dawley/1260	0.1	0.2
Brunner/M/Sprague Dawley/1254	0.06	0.1
Brunner/M/Sprague Dawley/1242	0.03	0.08
Brunner/M/Sprague Dawley/1016	0.02	0.04
Kimbrough/F/Sherman/1260	1.0	1.1
Schaeffer/F/Wistar/A60	1.7	2.1
Norback/F/Sprague Dawley/1260	1.6	2.2
Norback/M/Sprague Dawley/1260	0.1	0.2
NCI/M/Fischer-344/1254	0.1	0.2
NCI/F/Fischer-344/1254	0.08	0.2
Schaeffer/F/Wistar/A30	0.05	0.1

* USEPA, 1996c. All values are in $mg/kg/day^{-1}$.

† Computed as the $.01/ED_{10}$. The ED10 was estimated as the dose associated with a 10% increased tumor incidence. This is essentially the maximal likelihood estimate value.

§ Computed as the $.01/LED_{10}$. The LED10 was estimated as the 95% lower bound on the dose associated with a 10% increased tumor incidence.

Table 2.3

USEPA Tiers of CSFs Applied to Different Environmental Mixtures

A. High Risk and Persistence

Central Tendency CSF	Upper Bound CSF	Criteria For Use
1	2	Food chain exposure Sediment or soil ingestion Dust or aerosol inhalation Dermal exposure, if absorption factor has been applied Presence of dioxin-like or persistent congeners Early-life exposure (all pathways and mixtures).

(Range based on results from Aroclor 1254 in females.)

B. Low Risk and Persistence

Central Tendency CSF	Upper Bound CSF	Criteria For Use
0.3	0.4	Ingestion of water-soluble congeners Inhalation of evaporated congeners Dermal exposure, if no absorption factor is applied

(Range based on results from Aroclor 1242 in females.)

C. Lowest Risk and Persistence

Central Tendency CSF	Upper Bound CSF	Criteria For Use
0.04	0.07	Only when congener or isomer analyses verify that congeners with more than 4 chlorines comprise less than 0.5% of total PCBs.

(Range based on results from Aroclor 1016 in females.)

The preceding reasoning assumes, of course, that the PCB mixture in question in fact has undergone significant alteration in the environment. That is, according to the recent USEPA re-analysis of PCB CSFs – *it is invoked when information on the mixture of interest is limited* (see page 59, USEPA, 1996c). When information on the mixture's alteration in the environment is not available, the exposure route

specific CSF approach does not seem to be a reasonable change from the Aroclor specific CSF approach (an approach that was the very basis for doing the Brunner et al. (1996) study).

Thus, it would appear that the current approach for estimating environmental PCB risks would be to use the newly derived CSFs for Aroclor mixtures that have recently been released into the environment or for those environmental samples that are well characterized as to the type of commercial Aroclor mixture they represent. For example, analytical data often describes the "percent pattern match" between the environmental sample and a "neat" Aroclor standard. This information could be used as a quantitative measure of the alteration of the mixture in the environment. If these data suggest that the environmental mixture has maintained a high degree of similarity to the parent Aroclor, an Aroclor-specific CSF should be used. The central and upper bound CSFs could then be used to present the typical individual's (or population's) risk and the upper bound on that risk, respectively. If, however, these data suggest that the type of mixture is unknown, or has been altered sufficiently by partitioning, bioaccumulation, etc., the default USEPA guidance for environmental media may be warranted.

The USEPA (1996c) also noted that there was little difference between the central tendency CSF estimates and the upper bound estimate of the CSF. As the central tendency estimate represents that potency measured in the bioassay, the USEPA now recommends that:

> *Central estimates describe a typical individual's risk while upper bounds provide assurance that this risk is not likely to be underestimated if the underlying model is correct. Central estimates are useful for estimating aggregate risk across a population.*

Here the USEPA indicates that the central tendency represents the risk posed by a typical individual's exposure, and is therefore useful for estimating the average or aggregate risk within a given population. The upper bound risk estimate may still be used to indicate the highest risk estimate for that population, i.e., to provide a worst-case analysis. However, as the USEPA itself notes, the difference between these two considerations is only two-fold or less.

2.4 Summary

The recent USEPA re-analysis of CSFs for PCB suggests that if the USEPA or its consultant were to perform a risk assessment today for New Bedford Harbor, the CSFs it would apply would probably range from 0.3 to 2.0 $mg/kg/day^{-1}$ depending upon the exposure pathway under consideration. Further, the highest central tendency CSF of 1.0 $mg/kg/day^{-1}$ approximates the intermediate CSF of 1.1 $mg/kg/day^{-1}$ that TERRA in its 1992 report recommended be considered. Using a CSF of this magnitude, TERRA (1992) previously demonstrated that all risks associated with a 50 ppm sediment cleanup guideline would fall within the USEPA's acceptable risk range of 10^{-4} to 10^{-6} for a lifetime risk. Thus, the recent USEPA re-analysis of its PCB CSFs has led to PCB CSFs that are now consistent with recommendations TERRA proposed in 1992, recommendations that result in significantly lower risk estimates than those provided by USEPA's consultant EC Jordan.

3.0 A NEW PCB CANCER SLOPE FACTOR DERIVED FROM HUMAN DATA

3.1 Introduction

The primary objective of the current USEPA risk assessment policy is to provide the regulatory decision-maker with some quantitative estimate of risk associated with a site-specific exposure to a particular chemical or chemicals. In order to develop this numerical expression of risk, the USEPA has developed chemical-specific toxicity factors, i.e., numerical constants that allow the risk assessor to generate an estimate of the likelihood a particular chemical exposure will or will not induce some form of toxicity in the general *human* population at that level of exposure. Toxicity constants developed for the purpose of deriving a quantifiable estimate of the carcinogenic risk associated with chemical exposure are typically referred to as "cancer slope factors" (CSF). To date, the vast majority of USEPA CSFs developed for chemicals are based solely on responses measured in animal species. Further, these chronic cancer bioassays are typically limited by monetary and logistical constraints to the test responses of only one strain each of two rodent species, rats and mice. These laboratory species are used rather than selecting a specific strain or species because their metabolic, physiologic,

and biochemical responses to the chemical are known to be the same as those induced in humans.

With the exception of a few minor modifications, the methodology used by the USEPA to derive CSFs for chemical carcinogens has remained unchanged since the 1970s. As pointed out by McConnell (1995), *"unfortunately, 'testing guidelines' seem to have taken on a life of their own and, although not necessarily embedded in cement, are extremely difficult to change or even amend."* No significant change has taken place, in spite of the fact that during this same interval, numerous publications have discussed the limitations associated with both the mathematical models applied to the animal data (e.g., first the one-hit and later the linearized multi-stage models), and the methodology by which the animal cancer bioassay itself is developed (e.g., see OTA, 1981; USEPA, 1986; Swenberg, 1995; McConnell, 1995; Munro et al., 1995).

For example, until very recently the USEPA continued to use the linearized multi-stage model as the default presumption even though it is recognized that many carcinogens will have real or practical thresholds, particularly carcinogens with nongenotoxic mechanisms like promoters (Weisburger and Williams, 1991; Cohen, 1995; Pitot and Dragan, 1996; USEPA, 1996a). Other scientists have long questioned the continued use of animal bioassay procedures promulgated by the National Cancer Institute two decades ago (NCI, 1978). Of particular concern is the required use of a Maximum Tolerated Dose and the impact the induction of chronic organ toxicity may have on normal physiologic or hormonal homeostasis (Squire 1984; Ames et al., 1987). Some of the changes induced by high-dose toxicity may result in carcinogenesis due to initiation or promotion through mechanisms that are not relevant to lower doses such as those associated with human exposures, e.g., reactive oxygen species generated during chronic inflammation, recurrent cytotoxicity, and cellular regeneration (Gehring, 1989; Ames et al., 1987; Swenberg et al., 1995; USEPA, 1996a).

One consequence of the conservatism associated with current modeling and animal testing procedures is that cancer slope factors derived from animal data can often overstate the actual human cancer risk by several orders of magnitude (James, 1985; Gehring, 1989). The degree to which risks may be overstated can be estimated by comparing cancer risks predicted from animal data with observed

cancer risks in humans (from epidemiological studies). Obviously, this can only be done with chemicals for which both types of data are available, but the results of this type of comparison can be instructive. For example, Gehring (1989) has noted that the predicted cancer risk from the average dietary exposure to aflatoxin would account for more than all of the observable liver cancer cases in this country. This is hardly plausible, given the presence of other etiologic agents which no doubt contribute to the liver cancer incidence in this country (e.g., genetics, alcohol abuse, hepatitis, etc.). Similarly, using cancer risk estimates based on animal data, certain occupational chemical exposures should lead to cancer mortality rates that are so high that epidemiologic studies could not fail to detect them, when in fact little or no excess cancer has been observed (James, 1985; Gehring, 1989; TERRA, 1996). Table 3.1 contains data from Gehring (1989) showing the magnitude of cancer risk posed by common occupational exposure levels, based on the use of animal-derived CSFs. These cancer risks are so high that, if true, they would easily be seen and repeatedly measured in cancer mortality studies. This is not the case, however.

Table 3.1

Risk Estimates Extrapolated from Animal Data*

Chemical	Exposure	Relative Risk
PCE	60 ppm for 20 yrs	0.23
TCE	60 ppm for 20 yrs	0.08
Acrylonitrile	10 ppm for 20 yrs	0.13
Butadiene	500 ppm for 20 yrs	0.26
EDB	3 ppm for 4.2 yrs	0.20

*Adapted from Gehring (1989).

A similar exaggeration of risk can be shown with PCBs, if it is assumed that the old cancer slope factor used by USEPA of 7.7 mg/kg/day^{-1} is applicable to humans. If one also assumes that the average daily dosage for capacitor workers was 70 to 140 x 10^{-3} mg/kg/day (Kimbrough, 1995), then the lifetime average daily dose (LADD) for these workers would have been 1-2 x 10^{-3} mg/kg/day, for each year

worked. This in turn means that the cancer risk among the capacitor workers, per year worked would be predicted by:

$$\text{Risk Per Year Worked} = \text{LADD} \times \text{Slope Factor}$$
$$\text{or}$$
$$\text{Risk Per Year Worked} = 1\text{-}2\times10^{-3}\ \text{mg/kg/day} \times 7.7\ (\text{mg/kg/day})^{-1}$$
$$\text{or}$$
$$\text{Risk Per Year Worked} = 0.8 \text{ to } 1.4 \times10^{-2}$$

In the largest cohort study of PCB-exposed workers completed to date, Taylor et al. (1988) found 3 liver cancers among 510 deaths when 2.6 were expected. Using the risk per year worked estimate derived above, at least 4 to 7 additional liver cancer deaths should have been observed, even if the entire cohort had worked only one year. The average employment exposure period for this cohort was, in fact, 4.1 years (Renate Kimbrough, personal communication), meaning that between 16 and 30 additional liver cancers should have been observed if the USEPA CSF is accurate. Stated another way, the USEPA CSF would predict a standard mortality ratio (SMR) for this cohort of between 730 and 1,260, while a value of 1.15 was reported instead. In addition, about 25% of this cohort was exposed for more than eight years, and many of these workers had more than 15 years of exposure. The additional liver cancer risk in this portion of the cohort would be so high that the SMR for this group would be well above 2,000, an easily identified risk. If the old USEPA CSF had been correct, it should have been easy to illustrate the obvious dose-response relationship that should have occurred among capacitor workers. The dose-response relationship is an important feature of any epidemiology study that is expected to provide a link between human cancer and chemical exposure, a feature that is absent from all PCB cohort studies completed to date.

Thus, the third PCB cancer potency factor developed by the USEPA (i.e., 7.7) clearly overpredicted the human PCB cancer risk when compared to the magnitude of the risk observed in the PCB epidemiology studies completed thus far. This in turn means that any cancer risk projections based on the old PCB CSF of 7.7 $mg/kg/day^{-1}$ inappropriately exaggerates the risk from PCB exposure. As the older USEPA CSF of 7.7 $mg/kg/day^{-1}$ was used in the EC Jordan risk assessment, and as this risk assessment has been a key element in the USEPA's analysis of remedial alternatives, the USEPA's selection of a final cleanup plan has been based upon a flawed analysis.

Scientists and regulatory agencies recognize that no one model or set of assumptions regarding the preferred method for species extrapolation would ever be appropriate for all carcinogenic substances (USEPA, 1996a). Therefore, it seems reasonable to question the limited use by regulatory agencies of human data that might also be available for carcinogenic substances. That is, rather than focus on the myriad of problems that will always plague interspecies extrapolations, perhaps more attention should be focused on methods that allow for the use of human data. In fact, the USEPA has recently encouraged the use of epidemiological data, if available, in the development of chemical-specific criteria:

> *Typically, insufficient data are available from epidemiological studies to form the basis for derivation of a dose response relationship suitable for criteria development. Where such epidemiologic data are available, however, today's proposed Guidance specify that they should be used to calculate a criterion.* (USEPA, 1993; emphasis added)

and has recognized that negative human data is useful in setting an upper bound on the cancer risk when animal data suggest the chemical is potentially carcinogenic in humans:

> *Null results from a single epidemiology study cannot prove the absence of carcinogenic effects because they arise either from being truly negative or from inadequate statistical power, inadequate design, imprecise estimates, or confounding factors. However, null results from a well-designed and well-conducted epidemiologic study that contains usable exposure data can help to define upper limits for the estimated dosage of concern for human exposure if the overall weight of the evidence indicates that the agent is potentially carcinogenic in humans.* (USEPA, 1996a; emphasis added)

A number of chemicals exist for which the available epidemiological evidence provides the type of quantitative information required to allow estimation of the upper bound on a human CSF (TERRA, 1996). PCBs represent one such example. Since the mid-1970s, these compounds have been the focus of intensive study, and numerous morbidity and mortality studies have been performed in relatively well-defined and heavily-exposed worker populations. In addition, PCBs represent an animal carcinogen whose occupational exposures should have consistently generated an easily measured additional cancer incidence in the

larger epidemiology studies if the cancer slope factor developed from animal data was accurate.

In this section, a previously described technique (James et al., 1993; TERRA, 1996) is used to develop a theoretical, upper bound estimate of the CSF for PCBs based on the mortality experience of PCB-exposed cohorts. This estimate is compared with CSFs derived from animal data to gain an appreciation of the extent to which the use of animal data CSFs for PCBs overestimates cancer risk by comparing it to an upper bound estimate of the assumed human risk that can be derived from human studies.

3.2 Method

A human cancer slope factor can be derived from an epidemiologic study in which the cohort exposed to a particular chemical has a standardized mortality ratio (SMR) greater than 1.0. To illustrate this procedure the following equation variables are defined as:

SMR = Standardized Mortality Ratio

Δ = Incremental number of worker deaths due to exposure

Σn_i = Total person years for worker cohort

r_A = Age adjusted background cancer risk rate ($\frac{EXP}{\Sigma n_i}$)

r_Δ = The incremental cancer risk rate (for that same target organ) that results from the observed chemical exposure ($\frac{\Delta}{\Sigma n_i}$)

EXP = Number of deaths expected for the cohort based on national background mortality rates ($\Sigma n_i r_i$)

OBS = Observed number of worker deaths (EXP + Δ)

Given these definitions, and recognizing the SMR is simply the observed cancer incidence divided by the expected cancer incidence as shown in equation 1:

$$(1) \qquad SMR = \frac{OBS}{EXP}$$

and further recognizing that the observed number of deaths (OBS) equals the expected number of deaths (EXP) plus the incremental (Δ) number of worker

deaths due to chemical exposure, i.e., that OBS = EXP + Δ, then equation (1) becomes equation (1a):

$$\text{(1a)} \quad \mathbf{SMR} = \frac{\mathbf{OBS}}{\mathbf{EXP}} = \frac{\mathbf{EXP} + \Delta}{\mathbf{EXP}} = 1 + \frac{\Delta}{\mathbf{EXP}}$$

Rearranging and solving for the incremental number of cancer deaths observed (Δ), equation (2) is derived:

$$\text{(2)} \quad \Delta = (\mathbf{SMR} - 1) \times \mathbf{EXP}$$

Dividing both sides of the equation by the total person-years of the cohort converts equation (2) into equation (3):

$$\text{(3)} \quad \frac{\Delta}{\Sigma n_i} = (\mathbf{SMR} - 1) \times \frac{\mathbf{EXP}}{\Sigma n_i}$$

Note, however, that this step yields both incremental risk rate and the age-adjusted risk rate for the cancer type being evaluated (i.e., $\frac{\Delta}{\Sigma n_i} = r_\Delta$ and $\frac{EXP}{\Sigma n_i} = r_A$); so equation (3) becomes equation (4),

$$\text{(4a)} \quad r_\Delta = (\mathbf{SMR}\text{-}1) \times r_A$$

or, more simply, the incremental cancer risk rate associated with the observed level of chemical exposure is that shown in equation (4b):

$$\text{(4b)} \quad r_\Delta = (\mathbf{SMR}\text{-}1) \times \frac{\mathbf{EXP}}{\Sigma n_i}$$

Equation 4a simply shows us that the incremental risk rate (r_Δ) associated with chemical exposure is nothing more than the age-adjusted background cancer risk rate for that cohort times that ratio by which the observed number of cancer cases exceeded the expected number of cases. The form of this equation shown in 4b emphasizes the fact that this incremental risk rate (r_Δ) associated with the chemical exposure for the cohort is therefore easily derived from the SMR, the expected number of cases, and the accumulated person-years of the cohort used to derive the expected number of cancer cases used in the SMR calculation. Therefore, whenever the authors of an epidemiologic study report these three factors (i.e., SMR, the accumulated person-years of the cohort, and the

expected number of cancer cases), the incremental cancer risk rate that matches the excess cancer incidence observed for the cohort is easily derived. A human cancer potency factor can then be derived by dividing the incremental cancer risk rate one calculates from these three factors by some reasonable estimate of the lifetime average daily dosage (LADD) of the chemical that was experienced by the cohort.

3.3 Results

3.3.1 Average PCB Capacitor Worker Dose Estimates

Although PCB dosages for capacitor workers have been recently reported elsewhere (Kimbrough, 1995), the following dosage estimates were derived from the primary literature describing the conditions in the plants where the cohorts analyzed for cancer risk actually worked. Two different procedures were used to develop these dose estimates. The first approach estimated the daily PCB dose capacitor workers received based on reported workplace exposure levels and assumed or reported absorption constants for both the inhalation and dermal routes of exposure. The second approach, used predominantly as a check on the accuracy of these exposure/dose estimates, derived the average daily inhalation dose received by capacitor workers using basic pharmacokinetic principles, reported worker PCB body burdens, and PCB half-life data collected during an interval when workplace exposures in general were being reduced or eliminated.

3.3.1.1 Dose Estimates Based on Workplace Air and Surface Measurements

A human PCB cancer slope factor can be estimated from two cohorts from capacitor manufacturing plants located in New York and Massachusetts (Brown, 1987; Taylor et al., 1988). Air measurements taken at both plants in the mid-1970s reported the following ranges: 260 to 1,160 $\mu g/m^3$ for the large capacitor plant in New York, 360 to 2,000 $\mu g/m^3$ for the small capacitor plant in New York, and 170 to 1,260 $\mu g/m^3$ for the Massachusetts plant (Brown, 1987; Lawton et al., 1985). The midpoints of these three exposure ranges are 710 $\mu g/m^3$, 1,180 $\mu g/m^3$, and 715 $\mu g/m^3$ respectively. Further, two of these midpoint concentrations mirror the 690 $\mu g/m^3$ geometric mean air concentration Lawton et al. (1985) reported for the capacitor filling area of the New York facilities. However, based on

measurements reported in the older literature (Elkins, 1958) and even measurements reported in more recent studies (Ouw et al., 1976; Lawton et al., 1985; Brown, 1987), PCB air concentrations in these plants were often higher during the 1950s to early 1970s. For example, in discussing PCBs in *The Chemistry of Industrial Toxicology,* Elkins (1958) reported on the PCB air levels measured in one of the capacitor plants located in Massachusetts. As shown below, these ranged between 100 and 10,500 $\mu g/m^3$, depending upon the work area, with the impregnating area having PCB air concentrations five to ten times higher than those recommended by the American Conference of Governmental Industrial Hygienists (ACGIH, 1956) and later by the Occupational Health and Safety Administration (OSHA, 1989). Similarly, Ouw et al. (1976), Brown (1987), and Lawton et al. (1985) all reported PCB air concentrations that exceeded the long-standing occupational exposure guidelines of 500 $\mu g/m^3$ for Aroclor 1254 and 1,000 mg/m^3 for Aroclor 1242.

Table 3.2

PCB Air Concentrations at a Capacitor Manufacturing Plant

	Chlorodiphenyl Fume Concentration ($\mu g/m^3$)	
Process	**Maximum**	**Average**
Condenser impregnating	10,500	5,800
"	5,500	4,500
"	300	200
Condenser soldering	900	800
Oil mixing	1,100	600
Regulator filling	200	100

Adapted from Elkins (1958)

Therefore, the 700 $\mu g/m^3$ concentration assumed for the purpose of estimating daily workplace doses, a value representing the geometric mean air concentration in the New York capacitor plants studied by Brown (1987) and Lawton et al. (1985), is considered to be reasonably conservative because it primarily reflects measurements taken during a period of time when efforts were generally being made to reduce worker exposure to PCBs.

For the purposes of estimating the average daily exposure for these cohorts, an average daily air concentration of 700 $\mu g/m^3$ appears to be a reasonable assumption for the mid-1970s exposure period. Assuming an average daily air concentration of 700 $\mu g/m^3$, that the amount of air inhaled per eight hour work shift is 10 m^3 (Williams et al., 1994; Paustenbach, 1991), and that pulmonary absorption is complete (i.e., 100%), the average daily PCB dose for a worker in these capacitor manufacturing plants would be 7,000 µg/day. The corresponding average daily dose for each year worked, recognizing that most workers will only work about 250 days per year, becomes 4,794 µg-PCBs/day.

After comparing the various routes of exposure that might occur in the workplace, Lees et al. (1987) have suggested that the oral and dermal routes of exposure may be even larger than that posed by inhalation, particularly when PCBs were used at room temperature. These authors calculated that the dermal exposure from a single drop (0.05 ml) of PCBs spread over the hand would represent an exposure to 54,000 µg of PCBs per day. Conservatively assuming that only 10% of this amount would be absorbed during an eight hour work-shift (Wester et al., 1983), the daily dermal dosage resulting from a single drop of a technical grade PCB mixture spread over the surface of one's skin would still be a 5,400 µg/day dose. Clearly, then, even limited dermal contact with PCB fluids might easily match or surpass the inhalation exposure in a capacitor plant or other facility using PCBs.

While only a limited number of skin or work surface measurements have been taken in capacitor manufacturing plant measurements, these can still be used to estimate the magnitude of the dermal dose associated with capacitor manufacturing work. In the study of Maroni et al. (1981), the typical work-surface contamination in the capacitor plants studied ranged from about 0.4-6.2 $\mu g/cm^2$ (eliminating the one spuriously high measurement of 159 $\mu g/cm^2$). The corresponding dermal levels ranged from 4-27 $\mu g/cm^2$ in the high-power capacitor department with a mean of 19 $\mu g/cm^2$, and from 2-28 $\mu g/cm^2$ in the low-power capacitor department with a mean level of 10 $\mu g/cm^2$. Similarly, Smith et al. (1982) reported skin smear wipe measurements of 0.1-6.7 $\mu g/cm^2$ in a small capacitor facility and 0.05-4.87 $\mu g/cm^2$ at a private utility company. Table and floor surfaces in the latter facility yielded 8 $\mu g/cm^2$ of PCBs. However, both of these studies involved facilities whose air concentrations were at the lower end of those

reported by Brown (1987), which probably reflects the fact that these measurements were taken in the early 1980s after PCB air concentrations had been reduced by regulation and workplace changes. Thus, it seems reasonable to assume that the dermal exposure typical of capacitor plants from the 1950s through the 1970s, when air concentrations were higher and work practices allowed for more exposure, were no doubt higher.

Nevertheless, taking a geometric mean of the two mean values in the Maroni et al. (1981) study and the comparable levels reported in Smith et al. (1982), one derives an average dermal exposure level of 8.9 $\mu g/cm^2$ for a worker who is working around PCB fluids. Taking this mean PCB surface concentration, and assuming that only one-half of the surface area represented by the head (1300 cm^2), hands (990 cm^2), and forearms (1,310 cm^2) of these individuals was exposed, the daily dermal dose during an eight hour shift becomes 1,602 µg/day (1,800 cm^2 x 8.9 $\mu g/cm^2$ x 10%/day = 1,602 µg/day). [Note: This is a potential underestimate of the dermal exposure, as clothing in contact with other areas of the body no doubt became contaminated.] When this dose is added to the inhalation dose previously calculated, the estimated average workday dose experienced by a capacitor worker becomes some 8,602 µg/day. The corresponding average daily dose for each year worked, recognizing that most workers will only work about 250 days per year, becomes 5,892 µg-PCBs/day.

3.3.1.2 Pharmacokinetic Confirmation Of Workplace Exposures

A second method for estimating the daily PCB dose received by capacitor workers is to use basic pharmacokinetic principles to estimate daily exposure levels from reported PCB body burdens. For example, Lawton et al. (1985) reported the mean body weight of the capacitor workers in their study was 77 kg, of which 22 kg was fat tissue. Based on these values the authors then estimated the mean PCB body burden to be 2.2 grams during this mid-1970 exposure period. Lawton et al. (1985) also reported the PCB half-life in these same capacitor workers to be one year.

Given that these capacitor workers had undoubtedly achieved steady-state, their daily absorbed dose of PCBs for all routes of exposure can be estimated using the following equation:

$$(1)\ \text{Body Burden}_{\text{steady-state}} = \frac{\text{PCB intake (average daily dose)}}{\text{elimination rate constant}}$$

This equation merely states that at steady-state, the amount of PCBs being absorbed each day is equivalent to the amount of PCBs being eliminated each day. The elimination rate can be derived directly from the known half-life of PCBs by the following equation:

$$(2)\ \text{elimination rate constant} = \frac{0.693}{\text{half-life}}$$

Using a half-life of 1.0 year, the elimination rate constant for PCBs would be approximately 0.0019 days^{-1}. Using this elimination rate constant, and a total body burden of 2.2 grams (Lawton et al., 1985), the total daily dose absorbed by capacitor workers during the mid-1970s would be approximately 4,180 µg/day. This estimate, however, is largely a reflection of only the inhalation exposure pathway because it is based on a half-life estimate derived in persons whose dermal exposure was still occurring. Thus, the data and the resulting dose estimate derived from the pharmacokinetic parameters provided in the Lawton study best reflect the magnitude of the exposures occurring in this plant. For comparative purposes, the pharmacokinetic inhalation dose estimate of 4,180 µg/day compares favorably with the average daily inhalation dose of 4,794 that was estimated from PCB air measurements.

3.3.1.3 Summary Of Workplace Dose Estimations

Based on measurements of the PCB air concentrations of capacitor plants taken in the mid to late 1970s (when the use of PCBs was being phased out), the typical inhalation dose for a capacitor manufacturing worker, particularly those working in the capacitor impregnation areas, was on the order of 7,000 µg/day and may have been as high as 12,000 to 20,000 µg/day. Limiting the exposed surface area of these workers to one-half of the head, hands and forearms, the estimated dermal dose was found to approximate 1,602 µg/day. Thus, a conservative estimate of the average total daily dose appears to have been on the order of 8,602 µg/day. When this workday dose estimate is converted into a yearly average daily dose, the daily PCB dose becomes more like 5,892 µg/day for each year worked.

This daily dose estimate appears to represent a reasonably conservative average daily estimate for the following reasons. First, it represents a total dose that is no greater than the dermal dose estimated for a single drop of PCB fluid. If, as descriptions of the working conditions and actual surface measurements suggest, dermal contact with PCBs fluids was a common, if not unavoidable, problem, the dermal component of this estimated dosage has potentially been underestimated. Second, the total PCB dose estimated from air and dermal measurements is only about 1/4 to 1/2 half the inhalation dose associated with the higher workplace air concentrations frequently reported in the capacitor filling area. Also, it is equivalent to the geometric mean air concentration reported for this area during a period in time when PCB exposures were being reduced in response to regulatory concern for the use of and exposure to this chemical. Third, a conservative estimate of the inhalation doses estimated from air measurements and from pharmacokinetic measurements proved to be in reasonably good agreement. The pharmacokinetic estimate was hampered by concurrent PCB exposures, a factor which would act to increase the apparent half-life and to reduce the estimated daily exposure level below actual past exposure levels. The fact that it provided an estimate that was only 30% lower than that estimated via air/surface measurements suggests the latter is a reasonably accurate and conservative approach to take, especially as PCB exposures in the 1950 to 1970 era were probably higher. Finally, by taking the average workday dose estimate of 5,892 µg/day, and converting it to an average daily dosage rate based on body weight (by assuming the typical male weighs 70 kg), the air/surface measurement approach for estimating daily capacitor worker PCB dosages generates a 84 µg/kg/day dosage for each year that individual worked. This value tends to fall within the low end of the capacitor worker dosage range of 70 to 140 µg/kg/day that was recently reported by Kimbrough (1995).

3.3.2 Lifetime Average Daily Dosage Calculations

As indicated in the method section of this analysis (see Section 2.2), the derivation of a human cancer or slope factor requires that the lifetime average daily dosage be estimated. Thus, for each of the two cohorts under consideration we must calculate the average years of exposure for the total cohort. Based on the employment history of the Brown cohort, the average number of years worked for the entire cohort was 3.0 years (see Table 3.3). A recent re-analysis of the Taylor

cohort is currently underway (Kimbrough, personal communication), and the employment history and average years worked for this cohort are listed in Table 3.4. Based on these average exposure durations, the Lifetime Average Daily Dosage (LADD) for the Brown cohort was 3.6 µg/kg/day ([84 x 3] ÷ 70 = 3.6), and the LADD for the Taylor cohort was 4.9 µg/kg/day ([84 x 4.1] ÷ 70 = 4.9).

Table 3.3
Duration of PCB Exposure for the Brown Cohort

Duration of Employment In Exposed Job (years)	Number of Employees	Estimate of the Total Accumulated Person-Years*
0.25-0.5	634	237.75
0.5-1.0	435	326.25
1.0-2.0	478	717
2.0-3.0	240	600
3.0-10	558	3,627
> 10	222	2,220
Total =	**2,567**	**7,728**
Average Per Cohort Member =		**3.0**

Adapted from Brown and Jones (1981)
*The midpoint of the duration of employment was assumed to represent the average exposure duration for each grouping and was multiplied times the number of employees to generate the estimate of the total accumulated person-years for that group.

Table 3.4
Duration of PCB Exposure for the Taylor Cohort

Duration of Employment In Exposed Job (years)	Number of Employees	Estimate of the Total Accumulated Person-Years*
0.25-0.5	1,129	423.4
0.5-1	1,135	851.3
1-2	1,118	1,677
2-3	547	1,367.5
3-4	407	1,424.5
4-5	306	1,377
5-6	245	1,102.5
6-7	192	1,248
7-8	208	1,560
>8 (10x)	1,789	17,890
Total =	**7,076**	**28,921.2**
Average Per Cohort Member =		**4.1**

Personal communication, Kimbrough (1996)
*The midpoint of the duration of employment was assumed to represent the average exposure duration for each grouping and was multiplied times the number of employees to generate the estimate of the total accumulated person-years for that group.

3.3.3 Human Cancer Potency Estimates for PCBs Based on the Studies of Brown (1987) and Taylor et al. (1988)

Although a causal relationship between occupational PCB exposures and cancer of any specific kind has not yet been demonstrated, it is still possible to generate a human cancer slope factor for liver cancer since a statistically significant association has been reported for this target organ (Brown, 1987). Because Sinks et al. (1992) do not report the person-years accumulated by their cohort, an incremental risk estimate could not be derived for the significantly elevated malignant melanoma reported in this study. Therefore, TERRA only derived cancer potency estimates for liver cancer based on the reported standardized mortality ratios (SMRs) for the positive Brown (1987) study and the elevated but nonsignificant Taylor et al. (1988) study.

As stated earlier, whenever the authors of an epidemiologic study report three factors (i.e., SMR, the accumulated person-years of the cohort, and the expected number of cancer cases), the incremental cancer risk rate that matches the excess cancer incidence observed for the cohort can be derived from the following equation.

$$r_\Delta = (SMR-1) \times r_A$$

where,

SMR = Standardized Mortality Ratio

r_A = Age adjusted background cancer risk rate $(\frac{EXP}{\Sigma n_i})$

r_Δ = The incremental cancer risk rate (for that same target organ) that results from the observed chemical exposure $(\frac{\Delta}{\Sigma n_i})$

EXP = Number of deaths expected for the cohort based on national background mortality rates ($\Sigma\, n_i r_i$)

OBS = Observed number of worker deaths (EXP + Δ)

The needed parameters (i.e., SMRs, EXP, person-years) for the Brown and Taylor cohorts are listed in Table 3.5. As an additional measure of conservatism, and recognizing there is some degree of uncertainty in the incremental risk rates that have been calculated, we can also estimate the 95% upper confidence limit on the

incremental risk rate for both studies by calculating the 95% UCL of the observed number of cases, assuming the number of deaths follows a Poisson distribution. This number divided by the expected number of cases yields the 95% UCL of the SMR and is also listed in Table 3.5.

Table 3.5

Characteristics of the Epidemiology Studies

Study	Person-years	Expected Deaths*	Observed Deaths* (95% UCL)	SMR	95% SMR
Brown cohort	55,545	1.9	5 (10.5)	2.63	5.53
Taylor cohort	122,783	2.6	3 (7.75)	1.15	2.98

Note: Data was taken from Tables 1 and 3 of Brown (1987) and Tables III.3-III.5 of Taylor et al. (1988).
*Note the observed and expected number of deaths listed in this table are for liver cancer.

Using the data provided in Table 3.3 we find that the age adjusted risk rate for the Brown cohort is:

$$r_A = 1.9/55545 = 3.4 \times 10^{-5}$$

As the SMR = 2.63 for the liver/biliary cancers observed in the study by Brown (1987), the incremental risk rate (r_Δ) caused by exposure to PCBs is calculated as:

$$r_\Delta = (2.63 - 1) \times (3.4 \times 10^{-5}) = 5.6 \times 10^{-5}$$

These calculations have been summarized in Table 3.6, as well as the outputs of similar calculations for the Taylor cohort.

Table 3.6

Computed Incremental Risk Rates for the Brown and Taylor Cohorts

Study	r_A	r_Δ (for SMR)	r_Δ (for 95% UCL SMR)
Brown cohort	3.4×10^{-5}	5.5×10^{-5}	1.5×10^{-4}
Taylor cohort	2.1×10^{-5}	3.2×10^{-6}	4.2×10^{-5}

Cancer risk, as typically defined by the USEPA, is equal to the lifetime daily dosage times the cancer slope factor (CSF). Solving for the slope factor and using the incremental risk rate for the Brown cohort produces the following equation and estimate of the CSF:

$$\text{CSF} = \frac{\text{Risk}}{\text{Lifetime Average Lifetime Dosage}}$$

Solving this equation for both the Brown and Taylor cohorts yields the human CSFs listed in Table 3.7. This table provides CSF estimates that have been based on either the SMR or the 95% UCL SMR that can be calculated from the Brown (1987) and Taylor et al. (1988) studies using the Poisson distribution. So, Table 3.7 provides both the maximal likelihood estimate CSF and the 95% UCL of the CSF in keeping with the procedures and approaches the USEPA has adopted when it develops CSFs from tumor incidence data.

Table 3.7

Assumed PCB Cancer Slope Factors as Derived from Human Data

Value Used for Slope Factor Calculation	LADD (mg/kg/day)	Incremental Risk Rate (r_Δ)	Cancer Slope Factor † (mg/kg/day^{-1})
Measured SMR–Brown	0.0036	5.5×10^{-5}	1.5×10^{-2}
95% UCL SMR–Brown	0.0036	1.5×10^{-4}	4.2×10^{-2}
Measured SMR–Taylor	0.0049	3.2×10^{-6}	6.5×10^{-4}
95% UCL SMR–Taylor	0.0049	4.2×10^{-5}	8.6×10^{-3}

† Note: These theoretical estimates were derived by assuming PCBs cause cancer at a rate equivalent to the SMRs reported in these studies.

Note that these theoretical human-derived CSFs are considerably lower than the old USEPA CSF of 7.7 mg/kg/day^{-1} that the USEPA had previously developed from animal data, and the CSF that EC Jordan utilized when performing the risk assessment for New Bedford Harbor that the USEPA currently relies upon. In fact, the highest of these upper bound estimates, a CSF of 0.042 mg/kg/day^{-1}, is still lower than all but the very lowest of the new PCB CSFs that USEPA recently proposed in September of 1996 (USEPA, 1996c). The

highest human-derived CSF is also approximately 20 to 50-fold lower than the exposure-pathway specific CSFs of 1.0 to 2.0 mg/kg/day^{-1} that the new USEPA guidance document would most likely now recommend for most exposure pathways relevant to New Bedford Harbor. This in turn suggests that even if the USEPA updated the EC Jordan risk assessment with more accurate exposure assumptions and the new USEPA CSFs for PCBs, the new risk assessment so conceived would still be likely to conservatively overestimate the true human risk associated with exposure to PCBs from New Bedford Harbor by at least an order of magnitude.

4.0 A COMPARISON OF THE CHANGES IN PERCEIVED PCB RISK THAT IS ASSOCIATED WITH THE USE OF THE NEW PCB CSFs

The risks associated with PCB intake stemming from sediment exposure in the beachcombing scenario developed in the earlier TERRA risk assessment (TERRA, 1992) were originally calculated from two basic exposure scenarios. The first involved exposure to New Bedford Harbor sediments under a "beachcomber scenario," and the second exposure scenario involved the consumption of seafood (see Section 3.1 of the 1992 TERRA report for specific exposure scenario assumptions and dose calculations). Lifetime risks were then calculated for different exposure intervals using three CSFs for PCBs. The highest of these was the then current USEPA CSF of 7.7 mg/kg/day^{-1}. The intermediate PCB CSF of 1.1 mg/kg/day-1 was derived from the IEHR re-evaluation of the Schaeffer et al. (1984) study and surface area species scaling factor consistent with USEPA guidance. The third and lowest PCB CSF of 0.18 mg/kg/day^{-1} was also derived from the Schaeffer et al. (1984) dataset using body weight species scaling factor. At the time this was considered the lowest reasonable PCB CSF for regulatory use, as it consisted of what was believed to be one of the more defensible chronic bioassays conducted at the time and used the least conservative species scaling factor.

In the following paragraphs the same exposure scenarios, assumptions, and chronic daily intake values used in the earlier TERRA report described are again used to calculate the risks associated with PCBs. The only difference in the present risk calculations is a change in the intermediate and lower PCB CSFs used to generate the risk levels associated with each type of exposure. The highest

PCB CSF used will again be the USEPA's former CSF of 7.7 mg/kg/day^{-1} so that the relative risk reduction provided by both the new USEPA PCB CSF and the CSF derived from human data by TERRA can be illustrated. The intermediate PCB CSF of 1.0 mg/kg/day^{-1} was recently proposed by the USEPA (1996c) as the central tendency estimate for sediment and food exposure pathways. The lowest CSF of 0.042 mg/kg/day^{-1} is the highest and therefore most conservative of the CSFs that can be derived from the current mortality studies of workers receiving the highest known chronic PCB exposures.

4.1 Risks Associated with Beachcombing Activities

The risks associated with PCB intake from sediment exposures in the beachcombing scenario were calculated using the three cancer potency factors described in the preceding paragraph and the chronic daily intake values presented in the earlier TERRA report which assumed a target PCB action level of 50 ppm in sediments (TERRA, 1992). These risks are provided below in Table 4.1. Using even the outdated cancer potency factor 7.7 mg/kg/day^{-1} to calculate risk, all post-remedial risks were still ≤ 2.1 E-06, and therefore, are risks that would be considered acceptable by the USEPA . Using the now recommended USEPA CSF of 1.0 mg/kg/day^{-1} all risks are ≤ 2.7 E-07; based on the human CSF (0.042 mg/kg/day^{-1}), all risks are less than or equal to 1.1 E-08. Thus, even if the exposure frequency for contact with New Bedford Harbor sediments was assumed to be 100-fold higher than that used in this scenario all risks calculated with the newer and more realistic PCB CSFs would still fall well within the range of risks considered acceptable by the agency.

4.2 Risks Associated with Seafood Consumption

The risks associated with PCB intake for the seafood scenario were calculated using these same three cancer potency factors and the chronic daily intake values presented in the 1992 TERRA report. These risks are listed separately for young children, older children, and adults in Tables 4.2, 4.3, and 4.4. The highest lifetime risks were calculated for the adult consuming an average of 46.5 g of seafood per day for 30 years (Table 4.4). Risks associated with this level of PCB exposure range from 1.2 E-05 to 5.1 E-07, using the 1.0 and 0.042 (mg/kg/day)$^{-1}$ cancer potency factors, respectively. For both the young and older children, the

highest risk calculated was teen-agers consuming an average of 46.5 g of seafood per day for 30 years (Table 4.3). Risks associated with this level of PCB exposure range from 2.1 E-06 to 8.8 E-08, using the 1.0 and 0.042 $(mg/kg/day)^{-1}$ cancer potency factors, respectively. The highest risk calculated for young children were all well below a 1.0 E-06 level and so were below Agency *de minimis* risk levels.

Table 4.1

. Risks Associated with Exposure to PCB Contaminated Sediment

Receptor (F, YE, IR) *	Additional Theoretical Lifetime Risk		
	CSF of 7.7 $(mg/kg/day^{-1})$	CSF of 1.0 $(mg/kg/day^{-1})$	CSF of 0.042 $(mg/kg/day^{-1})$
A. Area II Risks			
Older child			
(12/year, 9 years, 50 mg/event)	4.6 E-07	6.0 E-08	2.5 E-09
(24/year, 9 years, 50 mg/event)	9.3 E-07	1.2 E-07	5.1 E-09
Adult			
(12/year, 9 years, 50 mg/event)	3.1 E-07	4.0 E-08	1.7 E-09
(24/year, 9 years, 50 mg/event)	6.2 E-07	8.0 E-08	3.4 E-09
(12/year, 30 years, 50 mg/event)	1.0 E-06	1.3 E-07	5.6 E-09
(24/year, 30 years, 50 mg/event)	2.1 E-06	2.7 E-07	1.1 E-08
B. Area III Risks			
Young child			
(18/year, 4 years, 65 mg/event)	1.4 E-07	1.8 E-08	7.7 E-10
(54/year, 4 years, 65 mg/event)	4.2 E-07	5.5 E-08	2.31 E-09
Older child			
(18/year, 9 years, 50 mg/event)	1.3 E-07	1.7 E-08	7.2 E-10
(54/year, 9 years, 50 mg/event)	4.0 E-07	5.2 E-08	2.2 E-09
Adult			
(18/year, 9 years, 50 mg/event)	8.8 E-08	1.1 E-08	4.8 E-09
(54/year, 9 years, 50 mg/event)	2.7 E-07	3.58 E-08	1.5 E-09
(18/year, 30 years, 50 mg/event)	3.0 E-07	3.8 E-08	1.6 E-09
(54/year, 30 years, 50 mg/event)	8.8 E-07	1.1 E-07	4.8 E-09

* F = Frequency of exposure (events/year); YE = years exposed; IR = ingestion rate (mg/event).

Table 4.2

Risks Associated with Consumption of Seafood: Young Children

Conditions *(C_{sf}, SI, FI, YE)	Additional Theoretical Lifetime Risk		
	CSF of 7.7 $(mg/kg/day)^{-1}$	CSF of 1.0 $(mg/kg/day)^{-1}$	CSF of 0.042 $(mg/kg/day)^{-1}$
0.114 mg/kg, 0.0062 kg, 0.2, 4 years	4.4 E-07	5.8 E-08	2.4 E-09
0.114 mg/kg, 0.0062 kg, 0.5, 4 years	1.1 E-06	1.4 E-07	6.1 E-09
0.114 mg/kg, 0.0165 kg, 0.2, 4 years	1.2 E-06	1.5 E-07	6.4 E-09
0.114 mg/kg, 0.0165 kg, 0.5, 4 years	3.0 E-06	3.8 E-07	1.6 E-09
0.17 mg/kg, 0.0062 kg, 0.2, 4 years	6.6 E-07	8.6 E-08	3.6 E-09
0.17 mg/kg, 0.0062 kg, 0.5, 4 years	1.7 E-06	2.2 E-07	9.0 E-09
0.17 mg/kg, 0.0165 kg, 0.2, 4 years	1.8 E-06	2.3 E-07	9.6 E-09
0.17 mg/kg, 0.0165 kg, 0.5, 4 years	4.4 E-06	5.7 E-07	2.4 E-08

* C_{sf} = concentration of PCBs in seafood (mg/kg); SI = amount of seafood ingested (kg); FI = fraction of seafood obtained from local catch; YE = years exposed.

Table 4.3

Risks Associated with Consumption of Seafood: Older Children

Conditions * (C_{sf}, SI, FI, YE)	Additional Theoretical Lifetime Risk		
	CSF of 7.7 $(mg/kg/day)^{-1}$	CSF of 1.0 $(mg/kg/day)^{-1}$	CSF of 0.042 $(mg/kg/day)^{-1}$
0.114 mg/kg, 0.0101 kg, 0.2, 9 years	1.6 E-06	2.1 E-07	8.9 E-09
0.114 mg/kg, 0.0101 kg, 0.5, 9 years	4.1 E-06	5.3 E-07	2.2 E-08
0.114 mg/kg, 0.0268 kg, 0.2, 9 years	4.3 E-06	5.6 E-07	2.4 E-08
0.114 mg/kg, 0.0268 kg, 0.5, 9 years	1.1 E-05	1.4 E-06	5.9 E-08
0.17 mg/kg, 0.0101 kg, 0.2, 9 years	2.4 E-06	3.2 E-07	1.3 E-08
0.17 mg/kg, 0.0101 kg, 0.5, 9 years	6.1 E-06	7.9 E-07	3.3 E-08
0.17 mg/kg, 0.0268 kg, 0.2, 9 years	6.4 E-06	8.4 E-07	3.5 E-08
0.17 mg/kg, 0.0268 kg, 0.5, 9 years	1.6 E-05	2.1 E-06	8.8 E-08

* C_{sf} = concentration of PCBs in seafood (mg/kg); SI = amount of seafood ingested (kg); FI = fraction of seafood obtained from local catch; YE = years exposed.

Table 4.4

Risks Associated with Consumption of Seafood: Adults

Conditions * (C_{sf}, SI, FI, YE)	Additional Theoretical Lifetime Risk		
	CSF of 7.7 $(mg/kg/day)^{-1}$	CSF of 1.0 $(mg/kg/day)^{-1}$	CSF of 0.042 $(mg/kg/day)^{-1}$
0.114 mg/kg, 0.0163 kg, 0.2, 9 yrs	2.6 E-06	3.4 E-07	1.4 E-08
0.114 mg/kg, 0.0163 kg, 0.5, 9 yrs	6.6 E-06	8.5 E-07	3.6 E-08
0.114 mg/kg, 0.0163 kg, 0.2, 30 yrs	8.8 E-06	1.1 E-06	4.8 E-08
0.114 mg/kg, 0.0163 kg, 0.5, 30 yrs	2.2 E-05	2.8 E-06	1.2 E-07
0.114 mg/kg, 0.0465 kg, 0.2, 9 yrs	7.5 E-06	9.7 E-06	4.1 E-08
0.114 mg/kg, 0.0465 kg, 0.5, 9 yrs	1.9 E-05	2.4 E-06	1.0 E-07
0.114 mg/kg, 0.0465 kg, 0.2, 30 yrs	2.5 E-05	3.2 E-06	1.4 E-07
0.114 mg/kg, 0.0465 kg, 0.5, 30 yrs	6.2 E-05	8.1 E-06	3.4 E-07
0.17 mg/kg, 0.0163 kg, 0.2, 9 yrs	3.9E-06	5.1 E-07	2.1 E-08
0.17 mg/kg, 0.0163 kg, 0.5, 9 yrs	9.8 E-06	1.3 E-06	5.3 E-08
0.17 mg/kg, 0.0163 kg, 0.2, 30 yrs	1.3 E-05	1.7 E-06	7.1 E-08
0.17 mg/kg, 0.0163 kg, 0.5, 30 yrs	3.3 E-05	4.2 E-06	1.8 E-07
0.17 mg/kg, 0.0465 kg, 0.2, 9 yrs	1.1 E-05	1.5 E-06	6.1 E-08
0.17 mg/kg, 0.0465 kg, 0.5, 9 yrs	2.8 E-05	3.6 E-06	1.5 E-07
0.17 mg/kg, 0.0465 kg, 0.2, 30 yrs	3.7 E-05	4.8 E-06	2.0 E-07
0.17 mg/kg, 0.0465 kg, 0.5, 30 yrs	9.3 E-05	1.2 E-05	5.1 E-07

* C_{sf} = concentration of PCBs in seafood (mg/kg); SI = amount of seafood ingested (kg); FI = fraction of seafood obtained from local catch; YE = years exposed.

4.3 Summary

The risk assessment prepared by EC Jordan concerning PCB-contaminated sediment and seafood from New Bedford Harbor contained a number of overly conservative exposure assumptions, which in turn led to an overestimation of

risk. These assumptions included the sediment ingestion rate, the amount of New Bedford Harbor fish consumed by area residents, the bioavailability factor for PCBs, the number of years that a young child would have contact with site sediments or would consume fish from New Bedford Harbor, and the frequency of visits that persons may make to the beach areas surrounding New Bedford Harbor.

Another major shortcoming in the risk assessment performed by EC Jordan is their now outdated use of the USEPA's older 7.7 $mg/kg/day^{-1}$ cancer slope factor. In the years since EC Jordan applied this number to their already exaggerated exposure estimates, the USEPA has concluded that two important revisions to carcinogen assessment policy were necessary. These revisions dramatically affect the theoretical risks posed by any remedial activity planned for New Bedford Harbor. The first of these consists of significant changes in the general assumptions and principles upon which the Agency intends to estimate the risks posed by carcinogenic substances (USEPA, 1996a). Important revisions in this general area include the use of benchmark dose estimates as a better reflection of the dose-response characteristics of the actual data. Using this new approach to deriving CSFs, the USEPA recently derived new CSFs for each PCB mixture and proposed the use of exposure-pathway-specific CSFs for environmental exposures to PCBs mixtures of unknown or seriously weathered composition. Still, the highest CSF now recommended by the USEPA for calculating the risks associated with environmental PCB exposures is about 8-fold lower than that previously used.

The second important change in USEPA policy for the evaluation of carcinogenic substances (USEPA, 1996a) regards a greater emphasis by the Agency on the consideration and potential use of human data. Reflecting this new emphasis on human data, TERRA has recently derived conservative, worst-case CSFs for PCBs from the cancer mortality studies currently available in the epidemiological literature. The reliance on human data to calculate these CSFs obviates the need for species scaling factors and concern for interspecies differences in potency. These CSFs also indicate that while the new USEPA CSFs have reduced the observed disparity that exists between the animal and observed human dose-response curves, they have not eliminated the fact that the use of

animal based CSFs for these compounds will still tend to exaggerate the risks posed by the small PCB doses that are generally found in the environment.

Using the new USEPA CSFs and the most conservative of the human-derived CSFs, in conjunction with the more realistic exposure assumptions originally presented in the 1992 TERRA report, it can be seen that the risks associated with the adoption of a 50 ppm cleanup goal for New Bedford Harbor sediments would fall well within the range of risks considered acceptable by the Agency. Using ≤ 50 ppm as the cleanup guideline for sediment concentrations, and the two new CSF derivations described above, all post-remedial risks from direct exposure to Area II and Area III sediments were determined to be well below the $1x10^{-6}$ risk level. Likewise, the highest risks for both the young and older children from consumption of New Bedford Harbor seafood were near or below the 1×10^{-6} risk level when these updated slope factors were applied to the exposure assumptions adopted in 1992. The highest risks were those calculated for the adults consuming an average of 46.5 g of seafood per day for 30 years. While this fish consumption rate probably represents consumers near the high end of the fish consumption distribution, it also conservatively assumes that all seafood these individuals eat comes from only one source, New Bedford Harbor. It is highly unlikely that anyone consuming seafood, here or elsewhere, does not eat seafood (e.g., tuna, fish sticks) that comes from other areas. Still, the theoretical risk for this exposure scenario only ranged from 1.2×10^{-5} to 5.1×10^{-7} using the two updated slope factors. Because Area I is an industrialized area without suitable recreation areas (see section 5.2 for more discussion on this issue), an exposure scenario appropriate for Area I would involve significantly less total exposure than Areas II and III; thus, the risk estimates calculated for Areas II and III would represent an overly conservative, upper bound estimate of the risks posed by Area I. Therefore, this assessment again serves to illustrate the safety of applying a 50 ppm PCB cleanup standard to the sediments in Areas I, II, and III, and re-affirms the same conclusion that was reached in 1992 when TERRA first proposed CSFs very close to those now considered acceptable to the USEPA.

5.0 THE USEPA'S PROPOSED CHANGE IN THE TCL FOR THE UPPER HARBOR IS BASED ON A FLAWED RISK ASSESSMENT

5.1 Introduction to the Problem

In the November 1996, Proposed Cleanup Plan for upper and lower New Bedford Harbor, it is stated on page 15 that the Target Cleanup Level (TCL) for the upper harbor (sediment north of Coggleshall) was reduced from 50 to 10 ppm to provide an additional measure of risk reduction for human health and ecological risks. The USEPA also states on page 5 of the 1996 plan that repeated physical contact with PCB-contaminated sediments, especially those sediments north of the Coggleshall Bridge, poses carcinogenic risks. However, the basis for these statements is the EC Jordan risk assessment, a risk assessment that uses a now outdated cancer slope factor. In previous comments on the EC Jordan risk assessment, TERRA has pointed out that the exposure assessment developed by EC Jordan was flawed. Because both problems exaggerate the risks ultimately calculated by EC Jordan, the risk levels the USEPA apparently relied upon as part of its basis for changing the TCL for the upper harbor sediments are in error. Further, if the risk levels the USEPA has relied upon are unreliable, then so are the cost-benefit analyses use to select specific remediation goals and the final cleanup plan. A brief discussion of these problems is provided below.

5.2 A Review Of the EC Jordan Exposure Assessment

In a previously submitted report, TERRA outlined a number of exposure variables or assumptions that EC Jordan used in its risk assessment that were considered to be inappropriate at the time. The problems TERRA identified were:

- the use of an inappropriately high sediment deposition factor for dermal exposures
- the use of an inappropriately high sediment ingestion rate
- the use of inflated fish consumption rates
- the use of inappropriately high bioavailability factors for both oral and dermal exposures
- the use of an inappropriately high duration of exposure for small children

- the use of an inappropriately high exposure frequency for both the moderate and conservative exposure scenarios.

It was conservatively estimated that the uses of these exaggerated exposure assumptions were such that the dermal dose and oral dose estimates EC Jordan generated for its exposure scenarios were at least 42- and 15-fold too high, respectively. Importantly, many of the excessive exposure assumptions EC Jordan adopted were higher that those considered appropriate by the USEPA. In addition, recent studies of children's activity patterns and of dermal soil loading factors for various activities indicate that even more reasonable exposure assumptions used in past years at Superfund sites may significantly overstate an individual's contact with a contaminated medium. For example, a recent study by Silvers et al. (1994) examined the activity patterns of children. It was found that children throughout the United States actually spend relatively little time outdoors. Using the measurements of children in less temperate states like New York, New Jersey, and Pennsylvania, the total number of hours spent outdoors and away from home during the summer by children is only about 2.5 hours per day. The time spent outdoors playing on a surface other than grass or a paved surface was only 0.06 hours per day for dirt surfaces, and 0.1 hour on "other" surfaces, the category which probably would correspond to the beach areas when considering the New Bedford Harbor exposure assessment. Thus, this study that indicates decidedly lower exposure frequencies and lower contact times should have been used in the risk assessment that EC Jordan performed for New Bedford Harbor.

Similarly, a recent assessment of soil adherence has been conducted by Kissel et al. (1996), who directly measured soil loading on skin surfaces of volunteers before and after normal occupational and recreational activities. Skin surfaces assayed included hands, forearms, lower legs, faces, and/or feet. Table 5.1 presents measurements of dermal soil loading for both outdoor (soccer, grounds maintenance, irrigation installation, rugby, farming, and reed gathering) and indoor (practicing the martial art of Tae Kwon Do and greenhouse work) activities.

Table 5.1 demonstrates that activities which provide an opportunity for relatively vigorous soil contact, i.e., rugby and farming, result in hand loadings (soil adherence) that are about half the value the USEPA typically recommends

for site exposure assessments (i.e., 1.0 mg/cm^2). Further, both activities had measured soil adherence factors for the hands that were 3- to 4-fold lower than the 1.5 mg/cm^2 value that EC Jordan used in its risk assessment. Thus, the EC Jordan soil adherence factor was at least 50% greater than that typically endorsed by the USEPA, and about 4-fold higher than that measured for activities that should produce higher soil contact rates than many outdoor activities including beach activities. For example, other outdoor activities examined in the Kissel et al. (1996) study, such as ground maintenance and soccer, generated soil loadings that were 10 to 100 times lower than the value assumed by EC Jordan. Thus, these data suggest the soil adherence values used in the EC Jordan risk assessment overstated a more probable soil adherence factor by 3- to 100-fold, depending upon the types of activities one assumes individuals might participate in when visiting New Bedford Harbor beaches. Furthermore, because these data also demonstrate significant differences in soil adherence with respect to different areas of the body, EC Jordan's use of a single adherence factor for all potentially exposed skin surfaces was not appropriate and further increased the conservatism of the risk estimates they generated.

Table 5.1

Field Measurements of Dermal Soil Loading by Activity*

	Range of Loading Values (mg/cm^2)				
Activity	**Hands**	**Arms**	**Legs**	**Faces**	**Feet**
Outdoor					
Soccer	0.019-0.11	0.0029-0.011	0.0081-0.031	0.012-0.016	ND
Grounds maintenance	0.030-0.15	0.0021-0.023	0.0008-0.0012	0.0021-0.010	0.0041-0.018
Irrigation installation	0.19	0.018	0.0054	0.0063	ND
Rugby	0.40	0.27	0.36	0.059	ND
Farming	0.41-0.47	0.059-0.13	0.0059-0.037	0.018-0.041	ND
Reed gathering	0.66	0.036	0.16	ND	0.63
Indoor					
Tae Kwon Do	0.0062	0.0019	0.0020	ND	0.0024
Greenhouse work	0.043	0.0064	0.0015	0.0051	ND

ND = not determined.

*Source: Kissel et al. (1996).

A final area of concern that TERRA previously expressed about the EC Jordan exposure assessment was that they ignored several facts (cited in their own report) which would all tend to reduce the frequency of leisure activities by adults and children at the New Bedford Harbor site. In their risk assessment, EC Jordan noted the following observations regarding the environmental setting for area I, the area of the harbor north of the Coggleshall bridge: 1) warning signs are currently posted, which effectively discourage residents and/or visitors from leisure activity, 2) swimming in the mud flats is unlikely, and 3) the Achushnet River is "dirty" with brown and pungent water, oil stains, and trash, which further reduces the likelihood of swimming, bathing, and other leisure activities. Given these conditions, it is not likely that any resident would choose to visit this area 20-100 times each year, one of the assumptions underlying the EC Jordan report, or that the swimming/wading scenarios for this area would be anything like those which EC Jordan applied to the somewhat more attractive beaches of the lower harbor. It also seems self-evident that the waterfront industry in this area would also discourage any recreational use of the upper harbor beaches. These facts, considered in conjunction with the recent data by Silvers and Kissel, weaken the assumptions on which the EC Jordan exposure assessment was based.

5.3 Related Issues of Concern

A related issue that impacts the cost-benefit analysis of remedial efforts is the fact that certain chemical exposures associated with the harbor sediments were not considered in the baseline risk assessment. In particular, the EC Jordan risk assessment ignored the risks posed by polyaromatic hydrocarbons (PAHs) while admitting that the impact of non-point sources which discharge PAHs into the upper harbor will *not* be eliminated by proposed remedial activities. PAHs are human carcinogens with a cancer potency factor rivaling that of PCBs. Because this consideration was omitted from the EC Jordan risk assessment, the future risks associated with any remedial effort have not been accurately portrayed, and the suggested overall risk reduction associated with any proposed remediation is misleading. If remedial efforts do not significantly reduce future site risks because of unchecked PAH discharges, are extensive remedial efforts still warranted? More importantly, is the reduction from 50 ppm to 10 ppm for sediments in the upper harbor justified? This omission is not a minor oversight,

and has a profound effect on the actual risk reduction provided by any remedial effort.

5.4 Summary

The exposure assessment performed by EC Jordan had previously been shown by TERRA to estimate exposures 15 to 42 times higher than they should be for the oral and dermal pathways. Recent studies of activity patterns in children and soil adherence rates for various outdoor activities suggest the magnitude of this error may be even greater than TERRA calculated in 1992. Given this, and the fact that the USEPA has reduced its cancer slope factor 8-fold, it would appear that the risks calculated by EC Jordan are at least 100 times higher than would be calculated today. If the risk reduction considerations the USEPA used as part of its cost benefit analysis for selecting the final cleanup plan are this seriously flawed then post-remediation risks should perhaps be adjusted downward by about 2 orders of magnitude. When this is combined with the fact that the future risks of unattenuated PAH discharge into the harbor were not considered in the baseline risk assessment, and in the future may return to risk levels significantly higher than those posed by PCBs, the reasonableness of the five-fold reduction in the TCL for upper harbor sediments would not appear to be warranted. This conclusion is consistent with the separate risk analysis provided in Section 4.0 of this report which shows that if one uses the current USEPA cancer slope factors for PCBs, and the reasonably conservative exposure assumptions TERRA adopted in 1992, the cancer risks associated with a cleanup standard of 50 ppm would still fall well within the USEPA's acceptable risk range as well as meet the Commonwealth of Massachusetts cleanup goal of achieving a 10^{-5} risk level.

6.0 Report Summary and Conclusions

The EC Jordan risk assessment stated that its intent was to provide two exposure scenarios, one based on "average" or "probable" exposure conditions and one based on "conservative" exposure conditions. However, the baseline risk assessment performed by EC Jordan and submitted to the US Environmental Protection Agency (USEPA) in the late 1980s by Ebasco Services, Inc., adopted exposure assumptions that are more conservative than assumptions typically

used by the USEPA. The use of these overly conservative exposure assumptions leads to an exaggeration of exposure levels and to an overestimation of the theoretical lifetime risks associated with either present site conditions or the TCLs generated by any proposed remedial alternatives. Ultimately, the only difference between the average and conservative or high-exposure scenarios used in the EC Jordan risk assessment was the assumed frequency of fish consumption or contact with sediments from New Bedford Harbor. Therefore, the average exposure is not composed of average or central tendency exposure assumptions as its label implies. When realistic or more probable exposure variables are used in the exposure equations listed in the EC Jordan risk assessment, the calculated risk levels decrease by several orders of magnitude. Specifically, the inflated exposure equation variables that EC Jordan used were: 1) the sediment deposition factor, 2) the sediment ingestion rate, 3) the amount of NBH fish consumed by NBH residents, 4) the absorption factors 5) the number of years that an infant/small child (ages 0-5 years) would have contact with site sediments or be likely to consume fish from the bay, and 6) the frequency of visits an individual will make to Areas I, II and III, as previously discussed in this report.

As has been stated a number of times in this report, a second major shortcoming in the risk assessment performed by EC Jordan is their now outdated use of the USEPA's older 7.7 $mg/kg/day^{-1}$ cancer slope factor. In the years since EC Jordan applied this number to their already exaggerated exposure estimates, the USEPA has completed two important revisions to its carcinogen assessment policy that impact remedial activities planned for New Bedford Harbor. The first of these consists of significant changes in the general assumptions and principles upon which the Agency intends to estimate the risks posed by carcinogenic substances (USEPA, 1996a). Based on this revised policy and data from recent animal cancer bioassays, the USEPA has published new CSFs for a number of PCB mixtures and exposure pathways. The highest central tendency estimate for a PCB CSF is about 8-fold lower than the one EC Jordan applied to New Bedford Harbor. The second important change in USEPA policy for the evaluation of carcinogenic substances (USEPA, 1996a) regards a greater emphasis by the Agency on the consideration and potential use of human data. Reflecting this new emphasis on human data, TERRA has recently derived conservative, upper bound estimates for PCBs from the cancer mortality studies

currently available in the epidemiological literature. The highest of these approximates the lower animal-derived CSFs and is two orders of magnitude lower than the CSF used in the EC Jordan risk assessment.

Using the new USEPA CSFs and the most conservative of the human derived CSFs, in conjunction with the more realistic exposure assumptions originally presented (TERRA, 1992), TERRA recalculated the risks from exposure to contaminated sediments for direct exposure to Area II and Area III sediments recognizing that the exposure assessments for these two areas would provide a conservative, upper limit of the risks associated with sediments in Area I. Using $\leq$ 50 ppm as the cleanup guideline for sediment concentrations, and the two new CSF derivations described above, all post-remedial risks from direct exposure to Area II and Area III sediments were determined to be well below the $1x10^{-6}$ risk level. Likewise, the highest risks for both the young and older children consuming New Bedford Harbor seafood were near or below the 1×10^{-6} risk level when these updated slope factors were applied to the exposure assumptions adopted in 1992. The highest risks were those calculated for the adults consuming an average of 46.5 g of seafood per day for 30 years. Still, the theoretical risk for this exposure scenario only ranged from 1.2×10^{-5} to 5.1×10^{-7} using the two updated slope factors, even after unrealistically assuming that all seafood at this consumption rate comes only from New Bedford Harbor and no other sources. Therefore, this assessment again serves to illustrate the safety of applying a 50 ppm PCB cleanup standard to the sediments in Area I, II and III, and re-affirms the same conclusion that TERRA reached in 1992 after applying CSFs very close to those now considered acceptable to the USEPA. Therefore, based on this re-analysis, and the conservative nature of these risk estimates, the adoption of the 50 ppm cleanup guideline for Area I, II and III sediments would clearly provide a remediation goal for this area that is protective of human health.

Given that the exposure assessment performed by EC Jordan resulted in dose estimates that are one to two orders of magnitude higher than they should be, and that the USEPA has reduced the cancer slope factor by one to two orders of magnitude it would now apply to PCBs exposures, it would appear that the risk reduction considerations the USEPA has used as part of its cost benefit analysis for each remedial effort are now seriously flawed. Further, based on the preceding it would appear that the baseline and future (post-remediation) risks

should be adjusted downward by at least two orders of magnitude. Presumably, the risk reduction associated with each remedial effort should also be reduced by this magnitude. When this is combined with the fact that the future risks of unattenuated PAH discharge into the harbor were not considered in the baseline risk assessment and apparently will return to pre-remediation levels, the reasonableness of the five-fold reduction in the TCL for upper harbor sediments does not seem warranted.

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Review of Hot-Spot Dredging Operations and Proposed Remedial Plan of New Bedford Harbor

Danny D. Reible and Louis J. Thibodeaux
January 31, 1997

Executive Summary

The data collected during preliminary dredging operations at New Bedford Harbor were analyzed for contaminant release and the implications of such release for full-scale remedial activities involving dredging. The ultimate effectiveness of the hot-spot dredging was also evaluated to assess the likely effectiveness of the proposed dredging of the entire upper estuary.

It was difficult to identify any effect of the dredging operations on the short term water column flux and air concentrations due to the variability caused by other factors. The single most important indicator of air and water concentrations was season, presumably reflecting the effect of seasonal variations in water temperature. Among indications of the effect of dredging on air and water concentrations, however, was the fact that the seaward flux per tidal cycle during the last two days of a dredging period were always higher than the two days at the beginning. Average air concentrations near the CDF were also about 33% higher at the end of the dredging period during summer 1995 than during the start of dredging during summer 1994 or in the subsequent summer of 1996. These changes were not statistically significant at the 90% or higher confidence level, however. The difficulty in identifying the additional releases due to dredging operations was apparently due to the large background air and water concentration levels associated with the unremediated portion of the upper estuary. Increased emissions to the air and water will likely be more significant relative to background during more extensive dredging operations.

Despite the removal of the hot spots and the expectation that this would result in elimination of a significant fraction of the PCB mass from the upper estuary, air concentrations at the end of the dredging program or afterward were not significantly lower than initial measurements. In addition, reductions in ebb tide concentrations and seaward flux between summer 1994 and summer 1995 were only significant at the 60% and 66% confidence level, respectively. Any reduction may also be the result of natural recovery by sediment deposition (natural capping) or contaminant depletion. The current rate of reduction in PCB release rate and seaward flux by natural processes is estimated to be about 3% per year.

The lack of a significant improvement in air or water quality as a result of the hot-spot dredging is consistent with the sediment mixing and redistribution that occurs with dredging. This is illustrated by the fact that three dredge passes were required to reduce PCB levels below 4000 ppm in some locations. In addition to sediment mixing and redistribution by dredging, the limited effectiveness may be due to exposure of previously buried sediments

and reductions in the short-term stability of the sediment. As a result of the reduced concentration in the sediment (whether due to sediment redistribution **or** removal), a slight but significant reduction in air concentrations was detected at the dredging location between summer 1994 and summer 1995 (88 to 77 ng/m^3 with a 98% confidence level). As indicated above, however, average air concentrations in the CDF increased by 33% during the same period (87 to 120 ng/m^3 with a 80% confidence level)

The results of the hot-spot dredging suggest that the effectiveness of a dredging based remedial alternative remains unproven. It has not been demonstrated that dredging with CDF disposal will protect human health and the environment better than, for example, the capping alternative also evaluated by EPA. In addition, capping remains the only alternative that is likely to be effective in reducing exposure and risk in the short term by reducing both seaward flux of water-borne contaminants and evaporative losses. The hot-spot dredging required more than three times the expected time (260 vs 80 days) due to the need to redredge portions of the estuary and the difficulties associated with the shallow tidal water depths. It is therefore likely that the proposed dredging will extend well beyond the current expectation of about 10 years. Workplace exposure standards (e.g. 1000 ng/m^3 in air) should not be applied to nearby residents and the ecosystem in such a situation. Chronic exposure to dredging-related emissions should instead be assessed. Even if dredging were to be implemented an alternative involving temporary damming of the upper estuary to control current flows and allow continuous dredging and more rapid contaminant removal should be considered.

Review of Hot-Spot Dredging Operations and Proposed Remedial Plan of New Bedford Harbor

Danny D. Reible and Louis J. Thibodeaux
January 31, 1997

Report

Introduction

The preliminary dredging operations involved removal of the hot-spot by reducing concentrations everywhere to below 4000 mg/kg. The planned dredging period was 80 days but 260 days of operation were ultimately required between April 26, 1994 and September 5, 1995. Operation was limited to only a portion of the day when tidal water depths were sufficient to support the dredge. Several locations required multiple passes of the dredge to reduce concentrations below 4000 mg/kg. In the short-term, dredging activities should affect PCB concentrations in the water column and, through volatization, in the air surrounding the estuary. Post-dredging, however, the sediment concentrations and the resulting air and water column concentrations should be reduced.

Seaward Water Column Flux During Dredging

The multiple dredging passes required in some locations indicates that significant sediment redistribution and mixing was occurring instead of simple removal. Resuspension and redistribution of the sediment was likely to occur both during dredging and as a result of destabilization of the sediment by dredging. Destabilization is the result of disturbing consolidated sediment. The resulting fluffy sediment is more susceptible to resuspension by currents during high water flow, high winds or during storm events. An indication of the effect of destabilization may be seen in the higher flux observed after a storm event on June 15 and 16, 1994. The PCB loss through the Coggeshall Street Bridge was 0.276 kg on June 13 and 0.230 kg on June 16 during the storm event, but 0.407 kg on June 21, after the event. These losses represent the net mass of PCB lost from the upper estuary in a single tidal cycle. It does not incorporate volatile losses from the upper estuary. Although the units of this loss are kg per tidal cycle, it is generally incorrectly referred to as a flux and that nomenclature will be continued here for consistency.

The dredging versus time record was explored in order to discover whether water column PCB release as measured by seaward flux responded to periods of active dredging. The hypothesis was that periods of dredging would result in higher PCB release rates as measured by seaward fluxes in the water column. The operational record was divided into nine different periods of dredging separated by non-dredging periods of various lengths. Each of these periods are defined and discussed in Table 1. As indicated by the summaries

during each period, the PCB loss in the water column beneath the Coggeshall Street bridge tended to be low at the start of a dredging period and high at the end. The large variability within any given dredging period, however, makes it impossible to link these observations with releases associated with the dredging activity.

Table 1 - Summary of dredging activity and seaward PCB release rates at beginning and ending of each dredging period

Period	Dates	Discussion
0	<4/26/94	No dredging activity. The first two measured losses were 0.019 and 0.098 kg on day 1 and 2 of dredging. These fluxes were assumed to represent a basis for evaluation of future flux estimates.
1	4/26-6/29	66 day period containing 33 dredging days. On the final two measurement days during this period, seaward PCB losses were higher at 0.230 and 0.407 kg.
2	6/30-7/19	20 non-dredging period. Seaward losses were lower at 0.066 and 0.015 kg on 7/21 and 7/22 at the initiation of new dredging.
3	7/20-11/11	116 day period with dredging on 66 days. On the last two measurement days during this period, PCB mass loss were again higher at 0.455 kg and 0.439 kg.
4	11/11-11/21	Short non-dredging period of 10 days. When dredging was restarted on 11/22, the first two measurements of seaward PCB losses were slightly lower at 0.389 and 0.2 kg.
5	11/22-12/19	28 day period with dredging on 18 days. The last two measurements at the end of this period were both 0.342 kg. No periods were defined between 12/19/94 and 2/3/95.
6	2/4-3/7/95	32 day period without dredging. Seaward PCB loss upon restarting dredging were 0.109 and 0.144 kg.
7	3/8-7/25	77 days of dredging over 140 calendar days. At the end of the period, seaward loss rates were up slightly at 0.195 and 0.160 kg.
8	7/26-8/6	12 days without dredging. Upon resuming dredging the first two release rate measurements were -0.073 (directed into the estuary) and 0.107 kg.
9	8/7-9/5	19 days of dredging during 30 calendar days. Measurements near the end of the period showed a PCB release of 0.147 kg and, after three days of inactivity, 0.084 kg.

Seaward Water Column Flux after Removal of Hot-Spot

The record was further analyzed to detect any effect of removal of the hot-spot on water column fluxes beneath the Coggeshall Street Bridge. An analysis by Spaulding Environmental Associates (1997) suggests that there was a significant decrease in seaward flux of PCBs between the start and end of the dredging period. This analysis is made difficult by the significant day-to-day variations in seaward flux. It is important to recognize that dissolution and volatilization of PCBs is also significantly influenced by water temperatures so that much of the variation seen in fluxes or water concentrations may be due to seasonal variations in water temperature. This effect is confirmed in the comparison of summer (June July and August, 1994 and 1995) and winter (December, January, February 1994-95) values of seaward loss rates and air concentrations shown in Table 2. As shown in Table 2, the dissolved fraction of PCB and the seaward loss rate are much higher during the winter while the air concentrations are much lower. On this basis, the results were segregated by season for further analysis.

Table 2 - Seasonal Average Parameters (± Standard Deviations)

Season	Water Concentration (Dissolved fraction-%)	Seaward Loss kg per tidal cycle	Air Concentrations CDF (On-site) ng/m^3		Air Concentrations Dredge (Off-site) ng/m^3	
			Daily Max	Average	Daily Max	Average
Summer 1994	-	0.23 ± 0.19	331±384	87±72	282±165	88±42
Summer 1995	-	0.09 ± 0.1*	319±219	120±55	251±129	77±37
Summer 1996	-	-	288±286	88±62	-	-
Summer 1994 & 1995	35% ± 8%	0.16 ± 0.20	339±353	108±70	267±154	82±39
Winter 1994-95	49% ± 13%	0.35 ± 0.17	48±43	26±24	81±77	22±20
Composite (All Seasons)	44% ± 13 %	0.20 ± 0.20	238±305	81±72	185±152	54±42

*Despite the large decrease in mean flux between the two summers, the significance of the change is uncertain due to the small number of samples and their wide variability. The change is significant at only the 66% confidence level.

The high dissolved fraction and PCB loss per tidal cycle during the winter is apparently the result of limited vaporization. This suggests that summertime water column loss measurements may underestimate total contaminant losses from the upper estuary since an additional mechanism for significant losses is vaporization. The calculated average water column losses are essentially identical to the averages reported by Spaulding Environmental Associates (1997).

The effect of dredging was further evaluated by conducting a linear regression on summer 1994 and summer 1995 ebb tide concentrations, seaward release per tidal cycle and average air concentrations near the dredge and CDF. The results of this analysis can be found in Table 3.

Table 3 - Statistical Analysis of Summer 1994 and Summer 1995 Data

Parameter	Trend Change/dredging day	Significance of trend	Regression Coeff. r^2
Seaward Water Column Loss per tidal cycle	-0.00035 kg	66%	0.045
Ebb Tide PCB Concentration	-0.00044 µg/L	60%	0.035
Average off-site air concentration (dredge)	-0.101 ng/m^3	98%	0.09
Average on-site air concentration (CDF)	+0.18 ng/m^3	80%	0.06

Air concentrations are discussed in more detail in the next section. Neither the seaward water column loss per tidal cycle or the ebb tide PCB concentration exhibited a statistically significant downward trend (at the 90% or greater confidence level) over the 16 months of dredging although some decrease in the average was noted. The lack of a clear, statistically significant trend may be due to the limited data or the variation associated with other factors. The lack of a clearly observable trend may also be due to

1. High background levels of contaminant release to the overlying water: Although the hot spots contained a significant fraction of the PCB mass, the mobile fraction that provides PCBs to the water column and to the flux measurement is solely surficial sediments. The PCBs in the hot spots are likely a lesser fraction of the exposed sediment mass.

2. Limitations of dredging as a removal mechanism: Dredging results in exposure of buried contaminated sediment which were previously largely immobile. For example, sediments in Area G that were more than a foot below the sediment surface were dredged despite the likelihood that these sediments and the

contaminants they contain were effectively isolated from the overlying water. Some areas were dredged three times before the exposed contaminants were removed even to a level of 4000 mg/kg, about an order of magnitude below initial levels. It is unclear whether the persistence of these high levels during dredging were due to the ineffectiveness of the dredge or the settling of sediment resuspended by dredging or other means elsewhere.

The average wintertime flux in Table 2 can be compared to the wintertime flux estimated by ASA (1989) and EPA (1983, as corrected by Teeter)(Both referenced in Thibodeaux et al., 1990). Note that the wintertime flux would be expected to be relatively unaffected by vaporization. The current flux is about 39% of that reported by EPA (1983) and 79% of that reported by ASA (1989) assuming that the current measurement represent the PCB loss per tidal cycle and that there are 705 tidal cycles per year. The reduction in flux represents a decrease in release, exposure and ultimately risk as a result of natural revcovery processes in the upper estuary. This is presumably due to either sediment deposition that provides a natural cap and containment barrier for PCBs, or contaminant loss due to erosion or degradation. If it is assumed that the flux decreases in proportion to $t^{-1/2}$ consistent with various models of contaminant release from stable sediments, the change in flux between two years, t_1 and t_2, is approximately given by

$$\% \ loss = \frac{Flux(t_1) - Flux(t_2)}{Flux(t_1)} \approx 1 - \sqrt{\frac{t_1 - t_0}{t_2 - t_0}} \qquad (1)$$

where t_0 is a curvefit "zero" time. Consistent with the observed differences is a zero time of about 1981 suggesting that the reduction in flux due to natural recovery at the present time, 19 years later, is about 3% per year. This is too small to be detected in measurements over just two years but as seen from the reduction in measured fluxes, may be significant over time.

Air Concentrations Observed During Dredging Operations

The air concentration data is a much larger data set and contains many dredging related events and complex meteorological factors that defy attempts at simple analysis. The measured air concentrations were likely dominated by the large exposed area of contaminated estuarine water and mudflats exposed at low tide. Let us consider the average or background levels air emissions and concentrations of PCBs from the water column. Ebb tide water concentrations of PCBs averaged 0.71 µg/L (standard deviation of 0.31 µg/L). On average 44% of the total PCBs were dissolved which may be available for evaporation (0.31 µg/L). Any PCB bound to dissolved organic matter was neglected. Given an estimated air-water mass transfer coefficient of 7 cm/hr (Thibodeaux et al., 1990) and using the models of Reible (1992) and Valsaraj and Reible (1991), this suggests an emission rate of 0.022 $mg \cdot m^{-2} \cdot hr^{-1}$. Reible (1995) provides a simple model of air concentrations that would be observed on or

immediately adjacent to large area sources of emissions. If we consider the range of air concentrations that would be expected above or near the source area (the upper estuary) under low wind conditions

$$
\begin{aligned}
C &= 27\ \frac{q}{u} \\
&= 27\ \frac{0.022\ mg{\cdot}m^{-2}{\cdot}hr^{-1}}{U} \qquad (2) \\
&= 41\ ng/m^3 \qquad if\ U = 4\ m/s\ (14{,}400\ m/hr)
\end{aligned}
$$

Where q represents the emission rate in $mg{\cdot}m^{-2}{\cdot}hr^{-1}$, U the wind speed in m/hr and C the observed air concentration above or near the source area (the upper estuary). The wind speed employed here is the average measured wind speed over the sampling days (9 mph or 4 m/s). The predicted value is remarkably close to the average off-site air concentration of 54 ng/m^3 (standard deviation of 41 ng/m^3). The consistency of the predicted and observed concentrations suggest that the emission models of Reible (1992) and Valsaraj and Reible (1993) are a reasonable depiction of the processes in the estuary and provides a confirmation of the conclusions of those works.

This rate of evaporation (0.022 $mg{\cdot}m^{-2}{\cdot}hr^{-1}$) will occur over at least the entire area of the upper estuary resulting in evaporation of a significant fraction of the PCBs that are present in the upper estuary over the 10 or more years required for the dredging to take place. With an upper estuary area of 800,000 m^2, the loss of PCBs per year is about 155 kg, essentially identical to the 141 kg loss annually by tidal flushing to the lower estuary (0.2 kg/cycle x 705 cycles/yr). Neither of these losses will be significantly reduced until the estuary is nearing complete remediation. And as indicated by the trends in air concentrations near the CDF (Table 3), the release to the air (and the resulting air concentration, exposure and risk) will likely increase during much of the dredging and CDF placement operation.

The high background concentrations resulting from PCB emissions throughout the estuary makes it difficult to differentiate between dredging related and other emissions. Nevertheless, some high (above 1000 mg/m^3) values cannot be dismissed as unrelated to dredging. For example, on June 16, 1994 a concentration of 1800 mg/m^3 was recorded at the Sawyer Street CDF site, a mile south of the dredging operation. Reviewers of the data (EPA Region 1 letter of Gayle Garman, July 7, 1994) suggested that "dredging operations were not the cause of the high value..". It is unclear, however, whether the dredged sediments were being placed in the nearby CDF giving rise to the elevated concentrations. If CDF placement was underway, the high concentrations could be associated with that source.

The identified cause, as detailed in the letter, was a windstorm on June 15 and 16 that stirred up the aquatic systems. It must be remembered, though, that dredging had been ongoing for 26 days prior to this storm. During this time bottom sediment in and around the dredging site had presumably been severely disturbed and were in a general unconsolidated

state. Fluffy materials existed in the dredged zone as well as beyond due to settling of resuspended solids. When this storm event occurred, this material was likely easily reentrained into the water column. This reentrainment could increase the concentration of PCB in the water and correspondingly the rate of vaporization. Thus the high levels may still be related to dredging although indirectly through destabilization of the sediment.

Conclusions

In summary it seems that the air and water monitoring data during hot-spot dredging have not been properly studied and evaluated to reveal the local impact/increased risk that may occur as a result of the planned remedy involving the removal of 450,000 yd^3 of contaminated sediment. The planned remedy will significantly disturb the long-consolidated bed-sediment and slow the currently observed rate of natural recovery of the sediment. After several years of dredging, the bottom sediments will have been disturbed to the degree that a fluffy layer exists throughout. Under these hypothesized events the contamination release and exposure may be as high or higher than any time previously. Recall that PCBs were placed into the estuary slowly (for 40+ years) and now are enjoying isolation due to being buried in consolidated sediment. Of course storm events over this 40+ year period were likely the cause of translocation of the sediment from the discharge point further afield in the upper and lower estuary. However these storm events were of short duration. After the storms, the particles re-settled and re-consolidated. With multiple dredges in operation, there is a continuous stirring of portions of the sediment, simulating storm events. The suggestion that PCB release while performing the planned remedy may be as high or higher than historic events is not unrealistic. All of the above underscores the fact that at this point in time there is not sufficient data to perform a credible risk analysis for the remedy. The lack of a clear, statistically significant reduction in air or water concentrations or water column fluxes either during or subsequent to the hot-spot dredging points to collection of either incomplete or inadequate data, or limited effectiveness of dredging as a remedial option. This uncertainty should be resolved before full implementation of the planned remedy.

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EPA 1996 Remedial Action Plan-New Bedford Harbor, Massachusetts
A Review

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I have reviewed materials provided Weldon S. Bosworth PhD of Dames and Moore, Salem, New Hampshire dealing with the latest proposed EPA Cleanup Plan for New Bedford Harbor and surrounding waters. These materials included the public announcement of the 1996 EPA Proposed Cleanup Plan, a variety of documents from the Administrative Record and other reports and papers referenced in the following discussion. Very briefly, this plan calls for hydraulic dredging of approximately 450,000 yds^3 of sediment and the placement of these materials in a series of four (4) shoreside diked containment areas (CDF's) sited along the western margin of the harbor. In the upper Harbor (the area north of the Coggeshall Street Bridge) subtidal dredging is to remove all sediments with PCB concentrations in excess of 10ppm. Dredging will extend into adjoining wetland areas removing marshlands with PCB concentrations in excess of 50 ppm. This higher action level will also be used in the lower harbor where dredging will remove all sediments with PCB concentrations in excess of 50 ppm. Waters associated with the proposed dredging will be treated before return to the harbor and each CDF will be surface sealed for subsequent commercial and/or recreational development. The proposed plan, with an estimated cost of at least $116,000,000 is said to have "broad local support".

With the materials available in the Administrative Record a critical scientific review of this plan cannot be developed. The memorandum of Richard Cavagnaro to the Remedy Review Board dated July 10,1996, and attached materials, represents the single most comprehensive presentation of this plan in my possession and it fails to provide a single reference in support of the variety of statements and conclusions. Hoping that this was due to the nature of the document (i.e. a summary memo) I initiated a search of the published and unpublished literature dealing with the New Bedford Superfund Site with particular emphasis on the past remedial dredging activities in the harbor(i.e.The Pilot Project and subsequent hotspot dredging). This search yielded reports summarizing pre-project monitoring results (Nelson,et.al.,1996) and a variety of papers concerning the Pilot Dredging project (Otis and Averett,1988), detailing sediment geochemistry (Pruell,et.al.,1990), public health effects (Miller,et.al.,1991), chemical and biological assessment criteria (Nelson and Hansen,1991) and the use of mussels as indicator organisms (Bergen,et.al.,1993; Nelson,et.al.,1995; Bergen,et.al.,1996) The search also yielded a variety of uninterpreted data from

monitoring conducted throughout the period of hot-spot dredging. Unfortunately, this search failed to provide indication of the existence of a single comprehensive report sufficient to support the proposed EPA plan. It appears therefore, that the plan presented in the Cavagnero memo is primarily a consenus product resulting from EPA predisposition and negotiations with the local community rather than a scientifically based optimum environmental remedial scheme. This conclusion is further supported by the variety of off-hand unsupported statements in the Cavagnero memo that are seemingly contradicted or at odds with the work of EPA's own scientists.

Perhaps the most glaring deficiency in the Cavagnero memo is the absence of any mention of the presence of other contaminants (with the possible exception of copper as a factor affecting ultimate project cost). In addition to PCBs, New Bedford Harbor sediments contain high concentrations of lead, mercury, cadmium, and other metals of concern (Nelson,et.al.,1996). The presence of these materials complicates the establishment of cause and effect relationships governing biotic survival and overall ecosystem health. Given the concentrations of these contaminants throughout New Bedford Harbor, it is not surprising that the benthic community is "stressed". It's likely that such stress would be evident absent the presence of PCBs. At the very least the stress would be modified by the presence of these metals and the associated synergy with PCB. This inference is supported by comparisons with Black Rock Harbor near Bridgeport, Connecticut. Sediments in this latter area also contains relatively high concentrations of trace metals but no PCBs. Field surveys of the biological community (Johnson,et.al.,1981) show benthic community characteristics essentially similar to New Bedford (Nelson,et.al.,1996). Given these similarities it seems possible that much of the benthic stress claimed for New Bedford Harbor may not be PCB related. Moreover, the similarities suggest that simple emphasis on PCBs without consideration of the factors affecting metal supplies and/or overall water quality (including nutrient inputs and dissolved oxygen levels) may do little to improve the environmental quality of New Bedford Harbor.

Beyond the matter of synergy with other contaminants, the treatment of public health in the Cavagnero memo appears simplistic and inflammatory. The EPA's own studies show no elevation in serum PCB in the population of the New Bedford area (Miller,et.al.,1991). This is despite the stated preference for seafoods (contaminated ?) and/or the potential for volatilization and associated airborne transport in the area. Even if this was the case there appears to be an increasing body of literature questioning some of the earlier research reporting PCB associated carcinogenicity (Abelson,1991). Together with the fact that tissue level concentrations of PCB in the commercially important lobster and flounder appear to be approaching the FDA standard (2ppm) in Buzzards Bay, these factors at least warrant some

mention in a reasoned discussion of project benefits.

With minor or no discussion of the above issues the Cavagnero memo concludes that immediate large scale dredging is the preferred approach. He states "The installation and preservation of a shallow water cap for this large area was considered "highly unreliable" and extremely damaging to the various harbor habitats..." but fails to provide any supporting documentation. Presumably "unreliable" means unstable and likely to be breached during storms while damaging refers to altered subtidal habitat due to sediment grain size modifications and depth associated changes in circulation. This is clearly a stretch. Cap disruption in this system protected by a hurricane barrier, shoreside sheltering and limited fetch is no more likely for a cap than for a CDF. As for the habitat, dredging can be expected to signficantly alter sediment-water interfacial conditions by reducing flow associated energies and disrupting what is now near-equilibrium conditions. Sedimentation rates in the dredged area will increase significantly relative to prevailing values resulting in a higher water content, generally unstable, deposit. These conditions, at best, favor mobile opportunistic species resulting in a substantial alteration in benthic community structure relative to existing conditions. From an ecosystem standpoint, it is not immediately apparent that such a shift is preferred to that associated with a cap.

The need for dredging is justified in large part in the Cavagnero memo by the fact that PCBs continue to migrate via water column transport from the upper harbor to the lower harbor and, presumably, on into adjoining Buzzards Bay. Again, the memo fails to discuss the time history of this flux or any modification that may have resulted from the hot spot dredging. A brief review of the available data indicates that over the past ten years, or so, this flux has been steadily decreasing from 1.55 kg/tidal cycle in 1988(tide corrected-Teeter,1988) to 0.432 kg/tc (range 0.067-1.28 kg/tc) in 1990 (ASA,1990) to approximately 0.13 kg/tc in 1994-5 (EPA-unpublished data). These latter data are particularly interesting since they were obtained by monitoring during the hot spot dredging and may even be elevated relative to ambient by dredge induced resuspension. This long-term trend indicating an order of magnitude decrease in PCB flux appears clear and raises questions concerning the need for and utility of the proposed dredging scheme.

In addition to the long-term trend, review of the EPA hot-spot monitoring data suggests a progressive decrease in PCB flux over the project period (Spaulding Environmental Associates (SEA),1997). This is consistent with the purpose of the project and seemingly should be considered in the development of the next phase of remediation. The Cavagnero memo makes no mention of this trend.

The experience provided by the hot-spot dredging apparently provided a basis for the continued and expanded use of dredging in the proposed remedial plan. Cavagnero states " the completion of hot-spot dredging provides a great deal of data about actual costs of air monitoring, dredge production rates/downtime...". Unfortunately, these data are scattered throughout the Administrative Record and, without benefit of careful analysis and summarization, are virtually impossible to use in review. In addition, the memo makes no mention of effects associated with the hot-spot dredging including resuspension, contaminant flux, biotic uptake, changes in circulation and/or overall water quality impacts and only contaminant flux data appear in the Adninistrative Record. Seemingly a careful review of all of these factors and a clearly presented summary of results would be a necessary part of the process leading to the development and presentation of optimum remediation plans.

Review of the PCB flux data provided by the monitoring effort indicates that the hot-spot dredging resulted in relatively minor secondary resuspension. The majority of the major perturbations in the record appear to be coincident with meteorological events, either winds or rainfall. This is not particularly surprising given the fact that the average production rate was approximately 50 yds^3/day (14-16,000 yds^3 over a 260 day period). Since maintenance of such a rate during the proposed project would require more than twenty years for completion it seems likely that resuspension will become more of a factor in the proposed project. Just how much more of a factor cannot be accurately specified, however, in the absence of more detailed data from the hot-spot project and specification of probable production rates for the proposed project. These data are seemingly available to the EPA and they should be required to quantitatively address this issue.

Beyond the matter of sediment resuspension and associated PCB flux, the proposed dredging has the potential to significantly alter circulation and sediment transport within the New Bedford Harbor system. Increasing average water depth will, as discussed above, tend to increase deposition rates altering the fabric of the sediment-water interface as well as water column turbidity. Both factors have the potential to adversely affect the benthic community and fisheries habitat. Given the high nutrient loads most probably associated with this harbor system the increased water depths also have the potential to facilitate stagnation and low water column dissolved oxygen levels. Such conditions can be expected to significantly "stress" the local biolgical community. Again, there was no mention of this issue in the Cavagnero memo.

Modifications of basin water depth will, in addition to the above effects, significantly alter the circulation patterns within the harbor. Such modifications will affect the extent of

salt water intrusion modifying water column density and mixing and impact local biota. Bathymetric changes also will alter residual circulation patterns in the harbor changing residence times and the routes and rates of material transport. Seemingly the extent of some of these potential changes could be addressed by the EPA using the extensive numerical modeling schemes they have developed for this project. If EPA has no confidence in these schemes most of these questions could be studied using one of a number of simpler and more reliable models that are available to the public.

In summary, my review indicates that the utility of and need for the proposed remedial scheme cannot be evaluated using available information. The absence of supporting documentation associated with the Cavgnero memo and the material available in the Administrative Record suggests that the proposed scheme is not based on scientific or engineering data but rather represents a political product developed in consultation with the community. This view is further supported by the number of contradictions or omissions evident in the presentation material. From a scientific standpoint there appears to be very little evidence in support of a project of this size.

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Review Comments on EPA's Proposed Cleanup Plan for New Bedford Harbor

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Introduction and Background

Spaulding Environmental Associates Inc (SEA) has performed a review of material provided to us by the Dames and Moore Group on the new remedial plan EPA has proposed for New Bedford Harbor. A list of the material provided is given in the bibliography at the end of this document. Our present review comments are given as a series of brief summaries that principally address EPA's evaluation of remedial alternatives using an integrated hydrodynamic, PCB transport and fate and food chain model system applied by Battelle (1990) to New Bedford Harbor. We have not repeated the extensive earlier critique of the hydrodynamic, PCB transport and fate, and food chain models that has been incorporated in prior comments prepared by AVX (Nutter, McClennen, and Fish et al, 1992) in response to EPA's earlier remedial plan for the harbor. Comments in this earlier critique are directly relevant here as EPA relies indirectly on the results of these model simulations to evaluate the impact of the new proposed remedial measures.

A review of the information provided suggests that EPA has not made any improvements to the model system nor have they performed any further simulations with the Battelle (1990) model. Interestingly for the selected remedial alternative, which is a hybrid of earlier alternatives, they have performed no simulations at all but instead have relied upon earlier simulations to bracket the expected impact of the remediation. In much of the new material EPA refers to Battelle's model system (which includes hydrodynamic, PCB transport and fate, and food chain modeling) as hydrodynamic modeling. This of course is technically incorrect and may lead to some confusion in reading the material. It may also point to a fundamental misunderstanding by EPA of the how the model actually works, the underlying assumptions, and what predictions it is capable of making and the associated uncertainties.

Review comments

SEA's review comments are given below. The section header provides a description of the issue being addressed.

Target cleanup level (TCL) for sediments

The new remedy was selected because EPA concluded it is more protective than the 1992 remedy. The present Phase 2 plan differs from the 1992 plan in two respects:

a. TCLs for sediments have been lowered from 50 ppm to 10 ppm in the upper Harbor and from 500 to 50 ppm in the upper Harbor saltmarshes.

b. Capping of contaminated sediments at the New Bedford waste water outfall has been eliminated. Two hot spots south of the hurricane barrier are still slated for dredging, but the TCL has been raised from 10 ppm to 50 ppm.

EPA notes that the change of plan reflects unspecified "comments" on the 1992 plan to the effect that a site wide TCL of 50 ppm is not sufficiently protective of the environment. EPA agrees with the comments and proposes therefore to lower the TCL for the upper Harbor to 10 ppm and the salt marsh TCL to 50 ppm in order to "provide an additional measure of risk reduction for both human health and ecological risks" (U.S. Environmental Protection Agency, Environmental News, 27 October 1996, p. 15). EPA notes that lowering the TCL further in the upper Harbor would be destructive of the saltmarsh and would not enhance human health. A TCL of 10 ppm was not applied to the lower Harbor because of its industrial/commercial character, which includes many point and non-point sources of (undefined) contamination which are likely to persist after cleanup. They do not discuss the industrial character of the upper harbor nor the likelihood that it will continue.

EPA prefers its proposed alternative because it balances the nine Superfund criteria and is protective, cost effective, and can be implemented using proven technology (U.S. Environmental Protection Agency, Environmental News, 27 November 1996, p. 18). The 10 ppm TCL (Alternative 3) also includes large areal contamination, sediment volume and costs, so is applied only to the upper Harbor, with the rationale that saltmarshes are important breeding, nursery and feeding grounds for marine biota. However, the proposed saltmarsh TCL is 50 ppm, not 10 ppm because further reduction in TCL would be destructive of the marshes.

EPA justifies its rejection of the 1992 plan (site-wide dredging and CDF disposal with a TCL of 50 ppm) on the basis that its new plan "achieves a high degree of sediment quality in the ecologically important upper Harbor, a degree which approaches that called for by the ecologic risk assessment" (U.S. Environmental Protection Agency, Environmental News, 27 October 1996, p. 13).

By EPA's own account (ibid., p.18) its ecological risk assessment concluded that a TCL of 0.1 to 1 ppm sediment PCB concentration is appropriate to protect the ecosystem. However, this solution is acknowledged to be costly, impossible to implement, and destructive of wetlands.

Battelle (1990) simulated various cleanup scenarios, summarized in their Figures 7.72, 7.73 and 7.74 (appended). Figures 7.72, 7.73 and 7.74 show results of the model simulations for each remedial action case in terms of the net PCB flux at selected locations; the mean water column PCB concentrations for the upper, lower and outer harbor; and the area averaged PCB sediment

concentrations in the upper, lower, and outer harbor, respectively. All results are shown 10 years after the remediation has been implemented. In Battelle's figures, the "Upper Estuary" and "Lower Harbor" scenarios have TCLs of 1 to 10 ppm in the location noted and the "Hot-Spot" scenario has a TCL of 10 ppm in the upper estuary (Battelle, 1990, pp. 7-42 - 7-43). The other three cases assume TCLs of 1, 50, and 500 ppm throughout the estuary. Setting aside the fact that the model is uncalibrated and unverified and has shown no predictive ability (Nutter et al, 1992) we note that in the two areas where they can be compared (i.e., the Hurricane Barrier and the Open Boundary) there is little difference in the net flux (kg/tidal cycle) of total PCBs under the 10 ppm (Upper Estuary) and 50 ppm scenarios after 10 years (Battelle's Figure 7.72). Similarly, there is virtually no difference in the predicted water column PCB concentration (ng/L) after 10 years in the upper, lower, and outer harbor areas under the 10 ppm (Upper Estuary) and 50 ppm scenarios (Battelle's Figure 7.73). The differences in the area averaged sediment PCB concentrations in the upper, lower, and outer harbor for the 10 and 50 ppm TCLs are similarly small.

Battelle (1990) did not explicitly evaluate the 10 ppm scenario in its food chain simulations, so EPA's assertion that the 10 ppm TCL is more protective of the environment appears to be undocumented. However, cleanup scenarios which were compared (No Action, 500 ppm, 50 ppm, and 1 ppm) revealed little predicted difference in biota body burdens of total PCBs except under the 1 ppm scenario, which EPA has rejected as un-implementable. EPA's choice of a 10 ppm TCL appears arbitrary. Even if we were to accept that Battelle's model could accurately simulate the dynamics of PCB transport, fate, and effects in New Bedford Harbor no clear advantage over the 50 ppm TCL is documented.

Battelle (EPA) model system

An in-depth critique of the Battelle model system has been presented in Nutter et al (1992). In this section an update to that critique is presented.

Hydrodynamics and PCB transport and fate model

As noted in SEA's earlier review the hydrodynamic and PCB transport and fate models Battelle employed to evaluate remedial alternatives for New Bedford Harbor are uncalibrated and unverified. The models show essentially no predictive ability when applied to simple tidal forcing and the stimulation of a dye release. The quality of the predictions was in fact so poor that the authors recommended repeatedly that the model predictions only be used in a comparative sense. The models have also evidently seen very limited use in other estuarine systems.

HydroQual food chain model:

* Use of the model. The HydroQual bioaccumulation model has not been used extensively in marine ecosytems. To SEA's knowledge, there have been only two published applications of the model which explicitly deal with PCBs in marine or estuarine ecosystems. One deals with striped bass (primarily a freshwater fish) in the Hudson River estuary (Thomann et al., 1988) and the other is Connolly's (1991) application to winter flounder and lobster in

New Bedford Harbor. SEA was unable to locate any new, published applications of the model.

* Lower trophic levels. The HydroQual model does not deal adequately with the lower trophic levels of the marine food chain. Numerous studies published during the past decade have established that the flow of energy and material in the lower trophic levels of pelagic ecosystems does not move directly from phytoplankton to zooplankton to fish and other higher order consumers. There are a number of intermediate steps through the "microbial loop", which may affect the quantity and quality of the material transferred. Revised models for target fish and crustacean species should include the role of the "microbial loop" (e.g., Azam, et al., 1983) in contaminant transfer.

* Spatio/temporal distributions of biota. EPA has recently performed improved mapping of benthic biota in New Bedford Harbor and environs (Nelson, et al. 1996). These data are a great improvement over Battelle's prior efforts. Nevertheless, SEA's (1992) contention that the substantial mobility of two of the most commercially significant apex consumers in the system, lobster and winter flounder, is ignored by the food chain model still stands. Because the organisms are highly motile, they will not be exposed to constant high levels of contaminants in New Bedford Harbor, and their body burdens of PCBs will be lower than predicted by the food chain model.

.* PCB distribution in upper Buzzards Bay. PCB distribution in upper Buzzard's Bay has now been better mapped by EPA (Nelson, et al. 1996, p. 14). Nevertheless, the scale of sampling (order ~1 km in the outer harbor) remains too coarse to unambiguously define sub-areas having high contaminant levels.

* Biota body burdens of PCB. Apex consumers in Buzzards Bay already meet the FDA standard and are predicted to approach the NCP standard within 10 years under the 50 ppm scenario. As of 1986, winter flounder and lobster collected from upper Buzzards Bay (the outer harbor) both had body burdens of total PCBs below the FDA limit of 2 ppm (Schwartz, 1988). That is, the two apex consumers of primary commercial importance already more than meet the FDA standard. It is likely that body burdens have decreased further since Schwartz's (1988) analysis of samples collected in 1986. Battelle's (1990) model indicates that both lobster and winter flounder will approach the NCP limit of 0.2 ppm PCB after 10 years under the 50 ppm scenario. Battelle did not perform a similar analysis for the 10 ppm case.

Literature search

In order to determine whether any of the results of EPA's New Bedford Harbor investigations were published and potentially contained new information a computer search of the ASFA (American Society of Fisheries Abstracts) abstracts through December 1996 was performed. The search located few new publications in the refereed literature. Keywords searched included New Bedford Harbor, PCB, and HydroQual. Several recent papers dealing with PCB contamination in

New Bedford Harbor and environs were located. One publication by Cullen et al. (1996) is of particular interest. In brief, elevated levels of PCB congeners were measured in tomatoes (but not other produce) grown downwind of the hot spot during dredging of the hot spot in 1994. The presence of contaminants in tomatoes was attributed to volatilization of PCBs and subsequent atmospheric transport.

PCB flux monitoring

EPA's Environmental Research Laboratory -Narragansett evidently performed PCB flux monitoring at the Coggeshall Street Bridge prior to, during and post the dredging of the hot spot in the upper harbor. Only data for the hot spot dredging period was provided. Based on this data EPA concludes that a "net seaward flux of approximately 0.23 kg (0.5 lbs) per day continues in the water column at the Coggeshall Street Bridge". This value is consistent with EPA's estimate of a cumulative total of 57.797 kg seaward flux of PCBs in 260 days of hot spot dredging (as reported on the last page of their table).

A review of the PCB flux data was performed to determine if EPA's conclusion was supported. First it is important to note that it has been impossible to determine what data was collected in the field and how the data was processed to estimate the PCB flux since no explanation is provided either on the tables or in an accompanying document. The values of the PCB flux were reported in kilograms. This of course is incorrect as flux measurements should be reported in mass per unit time (e.g. kg/day or kg/tidal cycle). Since the measurements appear to apply to the flux per dredging day we have assumed that the units of the flux are in kg/day. With these points noted we performed a preliminary analysis of the data.

A close study of the tabulated data shows that of the 260 days in which dredging was performed monitoring data were only available on 97 of those days or approximately 37 % of the time. In tabulating the data EPA substituted the mean values for all previous days when no monitoring data were collected. This procedure effectively substitutes a running value of the mean when no data is available. Figures 1 and 2 show a plot of the PCB flux in kg per day at Coggeshall Street Bridge versus dredging day with all data included and with only the actual observations, respectively. The "all data" case includes EPA's substitution of the running value of the mean when no data were collected. The plots show both daily data as well as a 30 day average of the data. The data shows very large day to day variations. The 30 day averaging removes this substantial day to day variability and attempts to determine the trend in the data. (The reader is cautioned that application of regression analysis to the daily data (without averaging) shows that there is no statistically significant trend in the data.This is principally attributable to the large variance in the data and the limited length of the record). While EPA's procedure (use of running average) to substitute for days when no measurements were made maintains the correct mean value over the record it gives a distorted view of the trend in the data, as clearly evidenced by comparing the two figures. As an example if we restrict our attention to the first 30 days of dredging we see that the average net seaward transport of PCB is approximately 0.265 kg/day. This holds for both cases; when only the observed values are used or if the entire record (using substituted values for days when no monitoring data are available) is employed. For the last 30

days of the record the PCB flux based on actual observations is about 0.085 kg/day. This compares to a mean value for the same period using all data in the table of 0.21 kg/day. We see that when only the observed data is employed there is a substantial decrease in the mean PCB flux from 0.265 kg/day at the beginning of the record to 0.085 kg/day at the end or a reduction of about 68 %. When the data presented in EPA's table is used directly the reduction is very modest from 0.265 to 0.21 kg/day or 20 %.

While EPA's estimate of the mean value of the PCB flux for the record period is essentially correct their statement that the mean flux continues at this rate is unsupported by their monitoring data. In fact a preliminary analysis of their data using a 30 day averaging procedure suggests that the net PCB flux at Coggeshall Street Bridge has indeed substantially decreased from the beginning to the end of the monitoring program. This result might be expected since dredging of the hot spot removed the most highly contaminated sediments in the upper harbor (according to EPA, accounting for over 50% of the total PCB's in the harbor).

EPA's use of the model results

In the report presenting the PCB transport and fate model and its application to New Bedford Harbor and various remedial measures (Battelle, 1990) the authors repeatedly remind the reader that the results of the model shouldn't be used in a strict quantitative sense; only comparatively. As examples in Volume II, Section 5, p 5-153 the authors state that:

".. Although these observations are in general agreement with field measurements, the estimated concentrations computed by the model should be used as a baseline to compare the relative effectiveness of the modeled remedial actions. The results should not be viewed in an absolute sense, because a rigorous validation of the model was not possible."

Similarly in Section 7, p 7-124

"As discussed earlier, due to the inherent uncertainties in performing modeling studies of this size and complexity, it is important to view the results in a comparative sense."

In R. Cavagnero's (EPA, Chief ,Technical and Support Branch Office of Site Remediation and Restoration, Region I) July 10, 1996 memo to the Remedy Review Board he says that " We certainly recognize the limitations of the model and do not view the results as absolute predictions, but we believe the model estimates are helpful for comparing alternatives and in assessing the qualitative impact of the various remedial alternatives." Unfortunately the memo repeatedly gives detailed quantitative comparisons between the model predictions for various alternatives and over time.

Verification of the model with monitoring data

While the poor predictive ability and lack of rigorous quantitative validation of the PCB transport fate and fate model has been described in AVX's earlier submission (Nutter el al, 1992) the availability of the EPA hot spot flux measurement data set collected at Coggeshall Street Bridge

provides another opportunity to assess the model's predictive ability (quantitative and comparative) for a data set that didn't exist at the time of the modeling study. According to the EPA model the PCB flux at Coggeshall Street Bridge for the " no action" case was predicted to decrease from 0.22 to 0.20 kg/tidal cycle (or 0.425 to 0.386 kg/day) over 10 years (Battelle, 1990, Table 7.1, p. 7-13).EPA's hot spot monitoring study, as summarized above, gives a value of 0.265 kg/day at the beginning of the record. We see that the model overpredicts the observed PCB net flux by almost a factor of two (on semi-diurnal tidal cycle has a period of 12.42 hrs). For the hot spot remediation case the flux was predicted to decrease from 0.21 to 0.18 kg/tidal cycle (0.405 to 0.348 kg/day) over the same 10 year period (Battelle, 1990, Table 7.19, p. 7-44). We see from a relative comparison of these simulation results that the hot spot remediation is predicted to have very little impact on the PCB flux either at year 0 or year 10. If we focus on the results for year 0 the model predicts a reduction of only 4.5 % in the PCB flux between the hot spot remediation and no action cases. We can compare this predicted change to that which was observed by EPA in their monitoring study for the hot spot remediation. To do this we will assume that data collected during the first 30 days of dredging represents the before (no action) case and that the last 30 days of dredging represents the hot spot remediation case. The 30 day averaging period has been selected to remove the considerable daily variability in the observed estimates of the flux. The data show a flux of 0.265 kg/day for the first 30 day period and 0.085 kg/day for the last 30 days. This is a decrease of almost 70 % in the flux. We can see that EPA's model not only incorrectly estimates the absolute values of the flux but their relative magnitudes as well. This analysis confirms the initial findings that EPA's model displays no predictive performance either in a qualitative (comparative) or quantitative sense.

We should also note that EPA/Battelle offers no analysis or verification to show that the model has any predictive ability in the long term (10 years). Given the lack of validation of the model, either in an absolute or comparative sense based on these short term comparisons, it is pure speculation that the models could provide any predictive capability in the long term.

Conclusions

The benefit associated with a 10 ppm TCL in the upper estuary is not documented and appears arbitrary. Considering EPA's own acknowledgment of problems with the HydroQual (food chain) and Battelle models and the poor performance of Battelle's model demonstrated above (using the hot spot monitoring) one cannot reliably estimate the impact of the various remedial measures considered.

EPA should have performed a more careful risk analysis to assess the appropriate TCL. The methodology for this is well developed and in fact publications showing the specific application of this type of strategy to New Bedford Harbor were available for EPA's use (Dakins et al, 1994). Dakins et al (1994) also address the impact of uncertainties on this analysis.

In summary EPA's evaluation of the impacts of its revised remedial action plan for New Bedford Harbor is critically flawed. It is based on a hodge-podge of speculation, guess work, and the application, interpretation, and extrapolation of results from a model system that has repeatedly

been shown to provide very poor quality predictions. Independent tests of the model predictions for the hot spot remediation case, contained here, show that the model substantially overestimates the flux of PCB from the upper harbor. EPA's selection of a 10 ppm TCL is unsupported by available model simulations and appears totally arbitrary.

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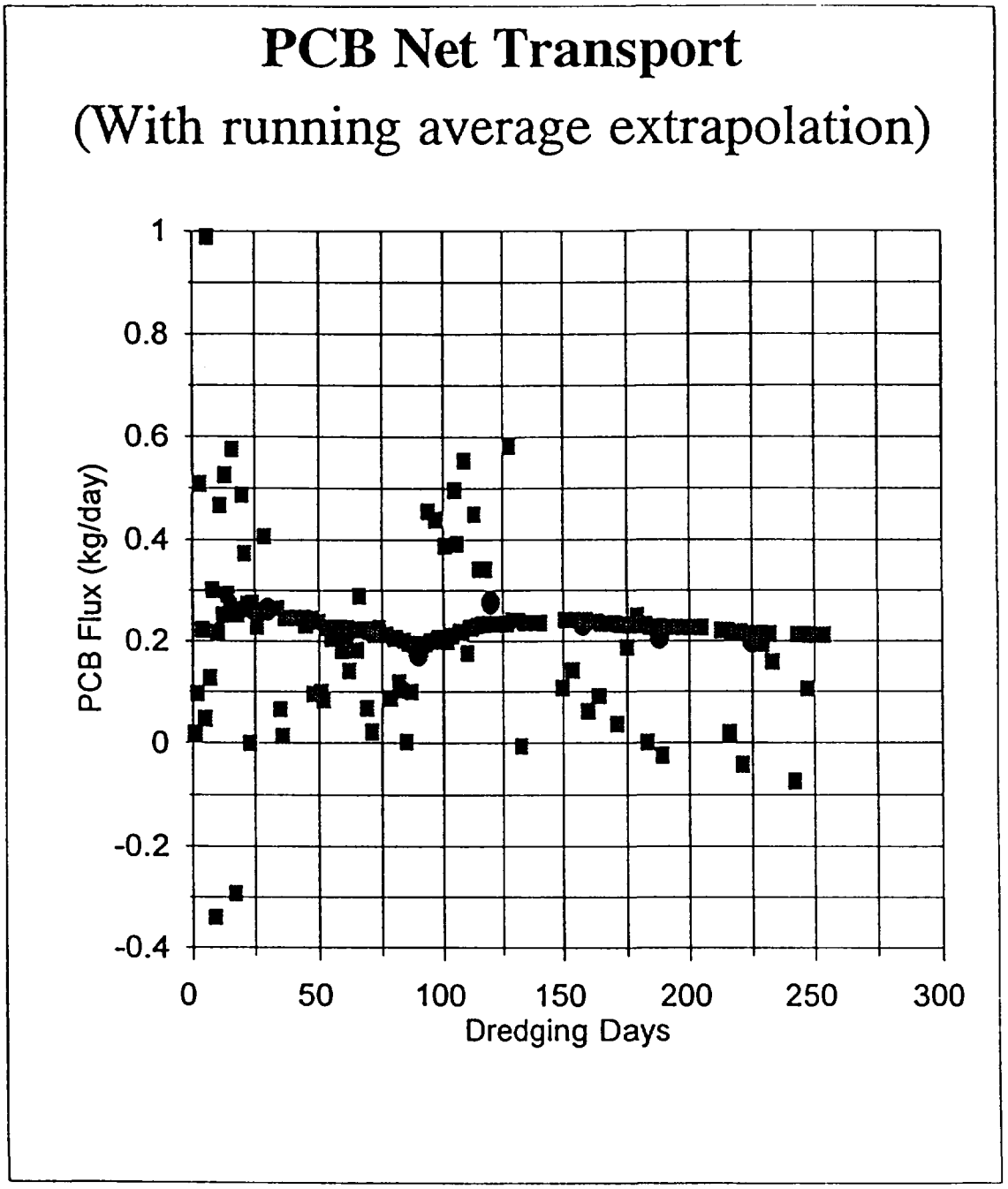
List of figures

Figure 1 Net PCB flux (kg/day) versus dredging day at Coggeshall Street Bridge collected by EPA-ERL Narragansett Laboratory during the hot spot monitoring study using all data available (including running averages when no data was collected). Positive indicates seaward transport. The filled squares represent daily values and the filled circles the 30 day averaged values.

Figure 2 Net PCB flux (kg/day) versus dredging day at Coggeshall Street Bridge collected by EPA-ERL Narragansett Laboratory during the hot spot monitoring study using only the observed values. Positive indicates seaward transport. The filled squares represent daily values and the filled circles the 30 day averaged values.



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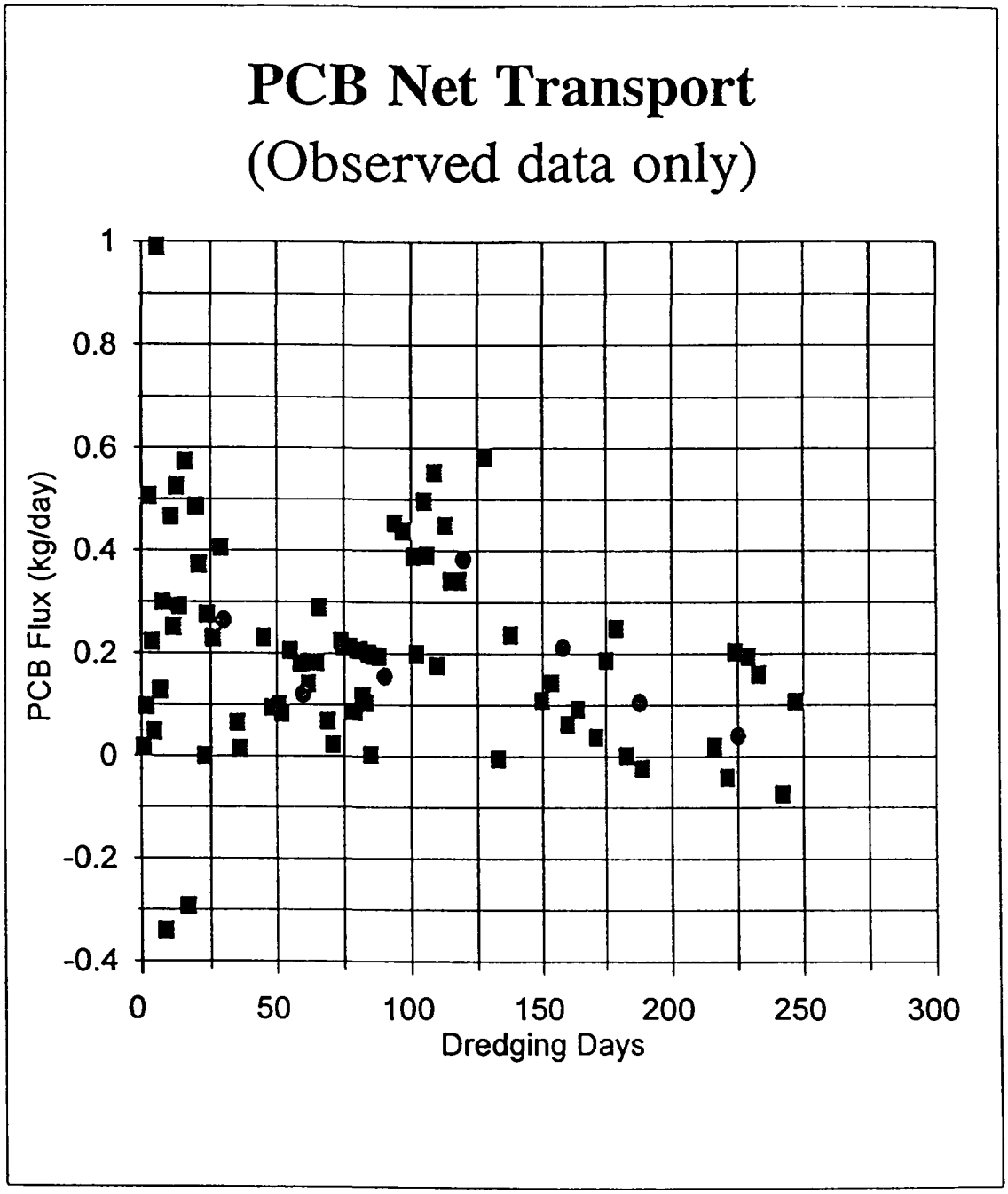

Figure 2 Net PCB flux (kg/day) versus dredging day at Coggeshall Street Bridge collected by EPA-ERL Narragansett Laboratory during the hot spot monitoring study using only the observed values. Positive indicates seaward transport. The filled squares represent daily values and the filled circles the 30 day averaged values.

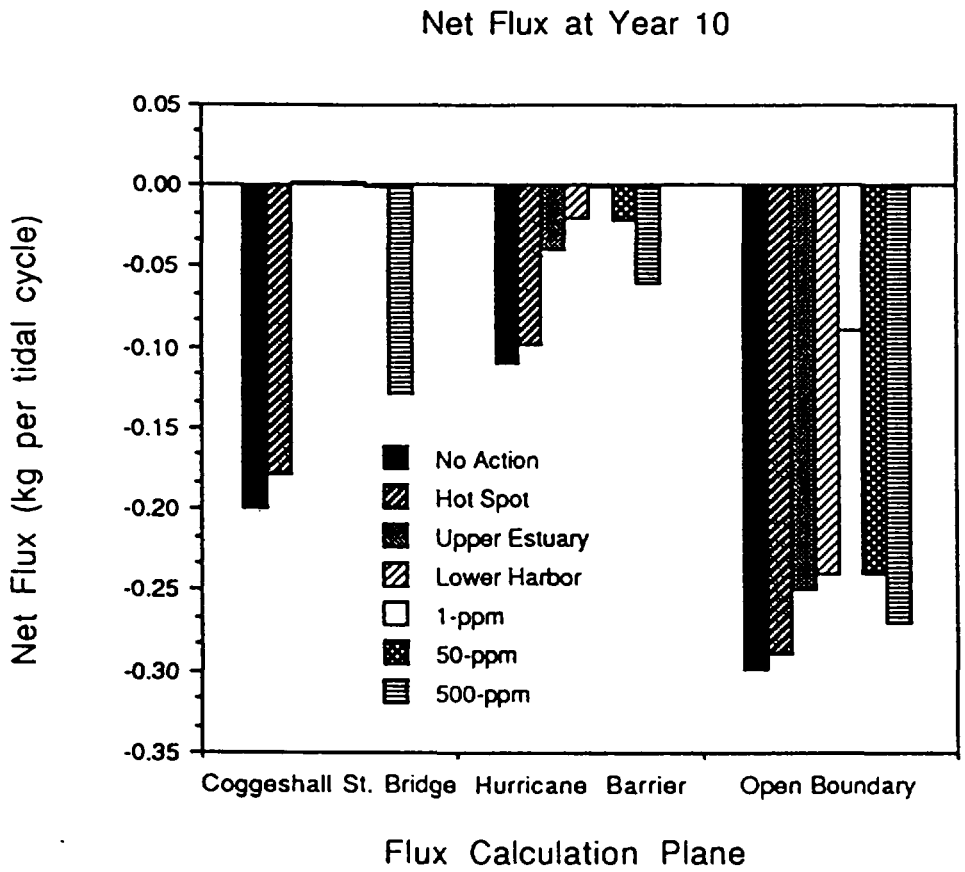

FIGURE 7.72. COMPARISON OF THE COMPUTED NET FLUX RESULTS AT YEAR 10 (kg/Tidal Cycle)

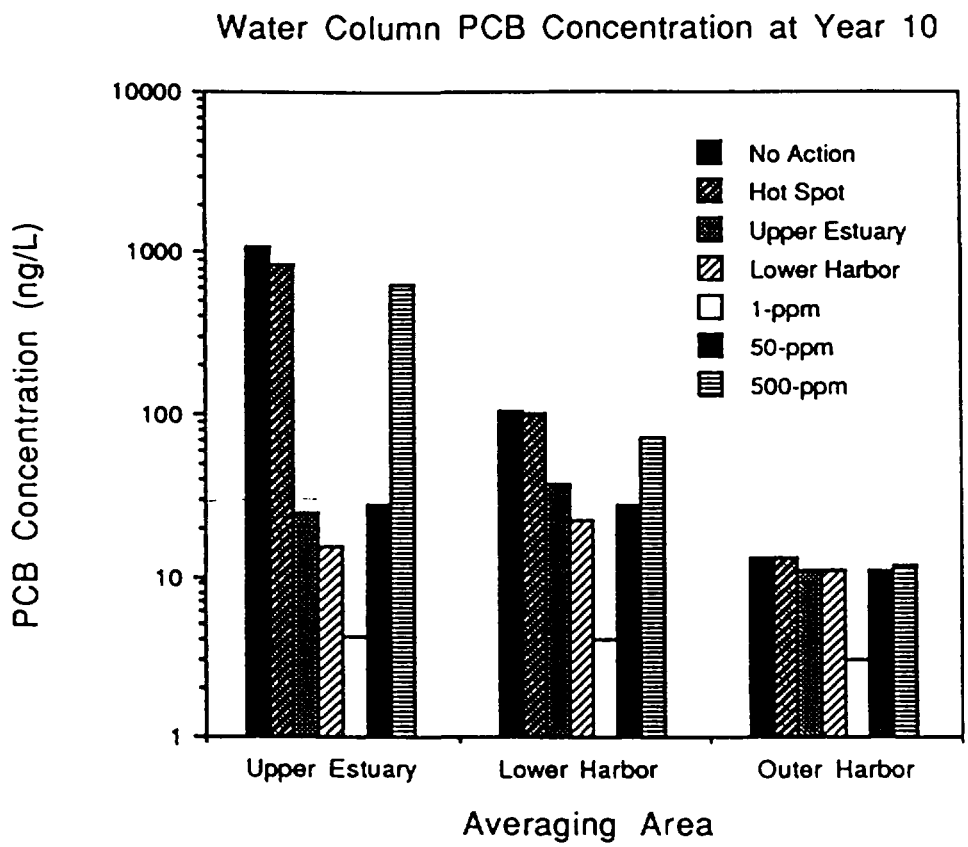

FIGURE 7.73. COMPARISON OF THE AREA AVERAGED WATER COLUMN PCB CONCENTRATION AT YEAR 10 (ng/L)

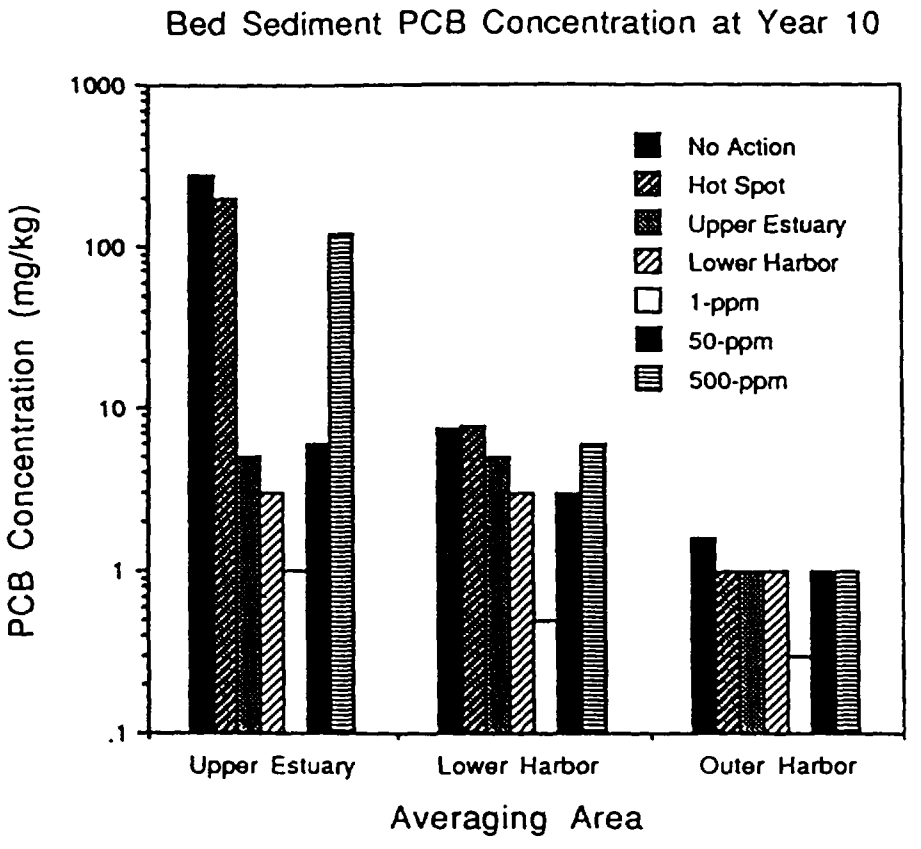

FIGURE 7.74. COMPARISON OF THE AREA AVERAGED BED SEDIMENT PCB CONCENTRATION AT YEAR 10 (mg/kg)

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NEW BEDFORD HARBOR
REVIEW OF 1996 PROPOSED PLAN
NEW BEDFORD, MASSACHUSETTS

NEW BEDFORD HARBOR
REVIEW OF 1996 PROPOSED PLAN
NEW BEDFORD, MASSACHUSETTS

This technical memorandum summarizes the results of a review of the engineering and cost estimate issues relative to the New Bedford Harbor, Operable Unit 2 Proposed Plan (1996 Plan). Given the short amount of time allowed by EPA for the comment period, only the most glaring concerns have been presented. There is little doubt that with additional time, a more thorough review could be accomplished. Such a review would certainly yield a more comprehensive list of deficiencies and contradictions that should be brought to the EPA's attention.

I. Summary and Relevance of Previous Comments

In January 1992, EPA issued a Proposed Plan (1992 Plan) for remediation of the Estuary and Lower Harbor/Bay Areas, with a Target Cleanup Level (TCL) of 50 ppm of PCBs in sediments. AVX prepared and submitted comments on the 1992 Plan in July of 1992, including comments on engineering feasibility and cost estimation. These 1992 engineering and cost comments, and their relevance to the 1996 Plan are summarized below.

A. Cost Associated with Dredging Will Be Greater Than Estimated

AVX commented that the dredging cost estimate did not reflect a realistic dredge rate and did not account for down time. EPA had predicted a production rate of 35 cy/hr, and 100% of available time utilized for dredging. AVX commented that the pilot study production rate was 26.5 cy/hr, and the pilot study dredged only 77% of the available time.

Since the 1992 comments, the Hot Spot dredging has been completed. As AVX predicted, significantly lower production rates and longer periods of down time were experienced. The Hot Spot dredging activities experienced a 75% operational time, and achieved a production rate of only 13.4 cy/hr. In the cost estimate backup for the 1996 Plan for the preferred alternative, EPA has applied the lower (13.4 cy/hr) rate and the 75% operational time to the upper third of the estuary portion of the dredging work. However, the cost estimates reflect an increase to the operational time to 80% and 85% for the middle third of the estuary and the southern third of the estuary/lower harbor respectively. The EPA cost estimates reference and use an Army Corps of Engineers (ACOE) assumption of an increased production rate of 20.1 cy/hr for the southern third of the estuary and lower harbor. There is no basis for this assumed added efficiency. If the Hot Spot production time and down time is used, an increase in the capital and operation and maintenance costs will occur.

Note that the ACOE documentation not only assumed a higher production rate of 20.1 cy/hr, but also assumed 8 hours/shift of actual dredge time for the southern third of the estuary and lower harbor. The ACOE also assumed 6 hours/shift of actual dredge time for the middle third of the estuary. By calculating out two shifts and two dredges, the ACOE claims the total daily production rate for the northern third to be 215 cy/day; and for the southern third and lower harbor to be 643 cy/day. In contrast, Foster Wheeler, the EPA contractor who prepared the cost estimates used in the 1996 plan, used a total daily production rate of 215 cy/day for both the northern and middle third of the estuary, and a rate of 320 cy/day for the southern third and lower harbor. The cost estimate documentation is therefore inconsistent, and no information is provided for why only some of the ACOE assumptions are utilized. Furthermore, the ACOE assumption for the southern third and lower harbor that "contamination levels are lower and water depths greater in this area so production rates can increase considerably" is incorrect. Levels of contamination do not affect the way a dredge works. Because the contamination levels are lower, it will be more difficult to chase the

contamination across a wider area. Multiple passes with the dredge will be required. In addition, these areas will contain more flotsam and sunken debris which will interfere with, and slow down, the dredging operation.

B. The Cost of Construction of the CDFs Does Not Account for the Material That Will Be Needed as a Result of Settlement.

AVX commented that the consolidation of the silts underlying the dike walls will result in the dikes settling 3 to 5 feet, and possibly failing. Several other geotechnical issues regarding the CDFs were raised, including the creation of a mud wave and resulting displacement of contaminants, the potential for sheet piling to damage the geomembrane, and differential settlement causing failure of the cover.

The CDFs in the 1996 Plan are different than the CDFs in the 1992 Plan in number (4 instead of 3), in location (CDF A has replaced 1B), and in construction (landside dikes have been replaced with sheetpile walls; CDF 7, now D, is enlarged). Neither the cost estimate documentation, nor the documents in the Administrative Record indicate if the 1996 changes address the geotechnical concerns raised by AVX. Although the 1996 Plan presents a temporary cap and three year period for settlement, the implication is that this is for settlement of the dredged sediments, and not intentionally for settlement of the underlying silts. No concrete evidence of the cost estimate or actual cost for the Hot Spot CDF could be found. An April 1996 ACOE estimate of construction and capping for the four 1996 Plan CDFs is provided, but the design upon which it is based is not. Because no documentation of the design revisions are provided, one can only assume that the issues raised by AVX concerning the original design are still valid.

C. The EPA Has Not Included Costs and Issues Associated With Locating the CDFs

AVX indicated that the cost of purchasing the land for the CDFs was not included in the cost estimate. The estimates for the 1996 Plan still do not show property purchases, so the comment is still valid. Furthermore, the area of the land that will need to be purchased has increased given that there will be an additional CDF and the size of CDF D has increased. EPA has added to the 1996 Plan language encouraging future reuse of the shoreline CDFs. Additional long term costs will be incurred in order to coordinate the development and reuse of the CDFs and ensure that monitoring and maintenance continue to occur.

D. The Costs for the Proposed Water Treatment System are Underestimated

AVX commented that the presence of organics in the CDF effluent may reduce the treatments system's ability, and that the ability of the system to treat seawater was not evaluated. AVX noted the deficiencies in the pilot water treatment study.

Since the 1992 Plan, the EPA has collected information and cost data from the Hot Spot CDF effluent treatment. Rather than use this information directly, however, the cost estimate documentation shows an <u>average</u> of the ACOE estimate for the Hot Spot treatment system, scaled up to handle the necessary volume, and the Operable Unit 2 FS (EPA 1989) estimate, scaled up to 1996 dollars, has been applied. The use of an average between two estimates that differ substantially, a $5.8 million capital cost for a 2 mm gpd plant from the FS vs. $11.5 million capital cost for a 1 mm gpd plant from the ACOE) is arbitrary and without technical basis. The fact that EPA, Foster Wheeler and the ACOE could not arrive at a single, technically based cost estimate confirms AVX's original comment that the water treatment costs are unknown.

In a September 1996 letter from David Dickerson to Foster Wheeler, Mr. Dickerson indicated that the Remedy Review Board questioned the water treatment costs, and that they were being revisited. The package provided to us that went from the Region to the Remedy Review Board, however, did not contain any information about cost or about the conceptual design of the water treatment plant. There also does not appear to be any documentation provided by EPA on the design or the performance of the plant built for Hot Spot. Either the public has not been provided all the pertinent documents regarding the water treatment system, or there is a serious lack of information on which to base the estimate. If the latter is true, then AVX's (1992) comment that "..the cost estimates for water treatment are just a guess..." is still valid.

II. Potential Improvements to the Dredging Efficiency

The Hot Spot dredging clearly showed that the original estimated dredging rate of 35 cy/hr was overly optimistic. The actual rate was 13.4 cy/hr. Because the dredging was dependent upon the tides, long stretches of time each day were lost. Given that dredging accounts for roughly 25% of the total project cost, further evaluation of measures to improve the efficiency of the dredging are warranted. In its Operable Unit 2 Feasibility Study, EBASCO (1990) noted in evaluating the capping alternative that " .. a hydraulic control system would need to be installed at the Coggeshall Street Bridge to ensure adequate water depth in the upper estuary for efficient installation of the cap." The same assertion is true for dredging, and the 1996 Plan should include a discussion of the use of hydraulic controls to maintain water depth and reduce the tidal limitations on dredging.

Note that the use of hydraulic controls is important not only to improve the efficiency of the dredging, but also to minimize the adverse environmental impacts. Limiting the effects of

tidal currents and maintaining a near steady depth of water will help reduce sediment resuspension and entrainment.

III. Comparison of Various Cost Estimates and Cost Escalation

Consistent and complete cost information apparently is unavailable, or has not been provided to the public in the administrative record to date. The amount of uncertainty in the costs for the alternatives overshadows the variability between alternatives. Therefore, cost comparisons between alternatives, and between the various cost estimates are sketchy at best and an analysis of the cost benefit of the preferred alternative is pure speculation. Table 1 presents a summary cost comparison.

A. Costs Based on Hot Spot Remedy

Perhaps the simplest, and most straightforward cost estimate for the 1996 Plan can be gained through a direct application on a unit cost basis, of the costs to complete the Hot Spot remedy. According to cost figures provided in a facsimile dated January 7, 1997, from C. Sallese of the ACOE to D. Dickerson, the revised cost for the Hot Spot remedial action totals $33,721,351. Deleting those items that are related to long term activities (monitoring) and to circumstances obviously unique to the Hot Spot remedy (soccer field, concessions stand, ash handling facility, mob/demob incineration, partial termination), the total capital cost is $26,693,175. The Hot Spot remedy dredged and stored 14,000 cubic yards of contaminated sediment, for a cubic yard unit price of $1907.

Given an estimated volume for the Estuary/Lower Harbor/Bay remedy of 450,000 cubic yards, the projected cost based on the Hot Spot experience would be $857,995,000. Certainly, there are efficiencies of scale (operating multiple shifts and multiple dredges), and

technical variations (lower levels of PCBs in sediments and effluent, larger CDFs) which would reduce this number, but this estimate does provide an upper bound of what could potentially happen. Having conceded this, however, a further consideration of the projected total capital cost for the preferred remedy is warranted. (Note that the comparison requires the use of capital costs, rather than the costs based on net present worth.) At $141,684,000 (capital cost) for dredging and storage of 450,000 cubic yards, the 1996 Plan preferred remedy yields a unit cost of $315 per cubic yard. Are there truly significant enough differences in efficiency and technical variability to warrant the conclusion that excavation and storage of sediments under the 1996 Plan would cost <u>six times less</u> than the work already accomplished? Even if assuming that savings of 50% due to efficiency of scale (as Foster Wheeler did in scaling up the FS cost for water treatment), there is still a potential capital cost of $429,075,000. This actual cost/unit cost approach is undeniably simplistic, but it highlights the uncertainty involved in an overly optimistic cost estimate that is poorly documented and that selectively chooses only some of pieces of the actual Hot Spot costs for application to the 1996 Plan.

B. Cost Estimate for Preferred Alternative

Further details regarding the cost estimate for the preferred alternative are required. The assumptions used to determine the operating costs for dredging are not presented. In the Foster Wheeler estimate, an operating cost of $9,600 per day is used for two dredges and two eight-hour shifts. This is based on ACOE calculation sheets by M. Otis (4 pages titled "Hot Spot Dredging Summary"), which show an operating cost including labor of $2,400/shift. However, the same calculation sheets by M. Otis indicate that for the Hot Spot dredging, the actual costs were 80 hours at $525/hour and 1211.5 hours at $569.19/hour. Using these rates, the operating costs for an eight-hour shift would be $4,200 or $4,553, and for two dredges and two shifts would be $16,800/day to $18,214/day, nearly double the rate that was used.

What basis does EPA have for assuming that dredging for the 1996 Plan will cost half as much as the Hot Spot dredging? The setting, conditions, equipment and labor requirements would be the same.

The cost estimate for the preferred alternative also omits various required costs for long-term monitoring. The only monitoring of the CDFs is for inspection and erosion control. There is no ground water or long-term air monitoring. The only environmental monitoring is for water, sediment and biota sampling at 50 locations 4 times a year. What is the relationship between this environmental monitoring and the long-term monitoring study which includes some 90 stations? There is no monitoring for performance of the wetland restoration or for resedimentation of the excavated mudflats.

C. Cost Revision After Remedy Review

In his September 11, 1996 letter to Foster Wheeler, D. Dickerson noted that the National Remedy Review Board "did have specific concerns about the disproportionate costs for water treatment ($27.1 m) and air monitoring ($10.5 m)." EPA then directed Foster Wheeler to reduce the number of air monitoring stations, and to significantly reduce the monitoring frequency. The end result was an 80% drop in the estimated cost, from $10.5 m down to $2.1 m. No adjustment to the water treatment cost has been made.

How can EPA certify that the most <u>cost effective</u> remedy that protects human health and the environment is being selected, when cost items can vary as widely as 80%? The lack of confidence in the costs as presented makes any comparison of alternatives on the basis of cost a subjective and arbitrary exercise.

IV. Relationship of CDFs and Navigational Dredging

The 1996 Plan includes an enhancement to dredge some 1,000,000 cubic yards of sediment for navigational purposes. The remedy enhancement was formally requested in a letter from DEP Commissioner David Struhs to EPA Regional Administrator John DeVillars, dated October 10, 1996. In this letter, Commissioner Struhs notes that the navigational dredging is dependent upon state bonded funding for port dredging.

In the package provided to the EPA Remedy Review Board, the summary of the 1996 Plan indicates for the Lower Harbor portion of the Site that the EPA will "build a CDF above contaminated sediments in area 7 in the North Marine Terminal area...for containment of dredged sediments. This CDF would be constructed for potential future use as a docking facility, and for future expansion to store some of New Bedford's maintenance dredge material." The same information package, in response to a question on the navigational dredging, indicates that "While the full details have yet to be worked out, it is envisioned that the state DEP would be the lead agency for this effort. The DEP would use state funds to cover the costs of the enhancement. Conceptually, the DEP would contract directly with the Army Corps to design and build the necessary CDF(s), and to manage the dredging of the federal navigational channels. At the same time, EPA would be using the Corps to implement ROD 2, with the expectation that the two efforts could be coordinated to improve the logistics and efficiency of certain operations. For example, the less contaminated navigational sediments could be used as preliminary cap material at CDF D, and at least a portion of the design effort for the remedial CDFs could be transferred to the design for the navigational CDFs." The 1996 Proposed Plan itself indicates that a large navigational dredging CDF is proposed for north of the hurricane barrier, and that the sediments from the remedial dredging south of the barrier may go into this navigational CDF. Further details on implementation of the navigational dredging were not provided in the administrative record.

There appears to be a large potential for overlap between the navigational dredging and remedial dredging. Navigational spoils may be placed in an expanded remedial CDF (CDF D, formerly 7), and sediments from outside the hurricane barrier dredged during remedial action may be placed in a navigational CDF. The cost estimates provided do not separate out any costs for the remedy enhancement, or any cost savings attributable to the "improved logistics and efficiency of certain operations".

Close scrutiny of such a combined implementation will be required to ensure that the New Bedford Harbor account and Superfund do not pay for this additional work. Any acceptance of the remedy enhancement must address this separation of costs. The acceptance of the enhancement must include contingencies to protect the funds earmarked for remediation only. For example, if the remedial design is revised or enhanced to incorporate the navigational dredging, and the state subsequently does not fund the dredging work, then the state will need to pay for any required design modifications.

V. Monitoring CDF Performance

Although significant comments were raised at Community Forum meetings regarding the long term effectiveness of the CDFs and their potential for leaching, there does not appear to be any additional documentation of the requirements for long term monitoring of the CDFs. The 1990 FS indicates that monitoring will consist of annual inspections to ensure cap and dike integrity, harbor side stone replacement every 10 years, and maintenance of vegetative cover. The cost documentation in the administrative record is in agreement with this maintenance protocol. No provisions have been made for long term environmental monitoring of the CDFs. The 1996 Plan indicates that "Each CDF will include perimeter groundwater monitoring wells in order to verify that they are operating safely," but the associated costs do not include the long term monitoring for leachate and groundwater quality around what are

essentially four RCRA/TSCA landfills. Long term operation and maintenance of the CDFs as landfills must be addressed in the evaluation of the long term effectiveness of the remedy, or the EPA's intention to waive these requirements should be communicated to the public. This has not been done.

Further questions regarding the CDF performance should also be raised. The excavation of estuary and harbor sediments, will undoubtedly include organic material. Biological activity after disposal in the CDFs will generate typical landfill type off gasses. The cover system is designed to be impermeable, and does not account for any gas collection or treatment after capping. Does EPA believe that the cover system for the CDFs will be the functional equivalent to the cover required for a RCRA/TSCA landfill. Does EPA plan to waive the Land Disposal Restrictions that should apply to the sediment?

VI. The 5 - Year Review

EPA acknowledges in the 1996 Plan that the entire site, including the CDFs will be the subject of five year reviews in accordance with the requirements of the Superfund laws. EPA goes beyond the requirement to "assure that human health and the environment are being protected" (42 USC 9601 § 121 (c)) and has promised in the 1996 Plan and to the Community Forum that it will also review treatment alternatives for potential use on materials in the CDFs.

Given the high priority within the research community for development of a treatment for PCBs, it is not only possible, but likely that within the near future a treatment technology will be developed that is applicable to the New Bedford sediments and acceptable to the community. By continuing to approach the New Bedford sediments with the idea that they will at some point undergo treatment, the EPA has made the 1996 Plan in effect an interim

remedy. The EPA will spend hundreds of millions of dollars over the next ten years to dredge and temporarily landfill the sediments, only to reopen the disposal sites and handle the material a second time for treatment.

The potential ultimate costs for such an approach are staggering. Accepting for the moment the underestimated costs in the 1996 Plan, the total costs for this interim action, followed by sediment treatment could approach $215,000,000, an increase of 46%! Table 2, attached, presents a very general basis for this estimate. Beyond cost, however, the potential threat to human health and the environment associated with excavation of the sediments from the CDFs, transportation and redisposal/treatment are enormous.

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TABLE 1
COMPARISON OF COST ESTIMATES
FOR PROPOSED REMEDIAL ACTIONS
NEW BEDFORD HARBOR

REMEDIAL ACTION	Original FS Estimate	FS Estimate 1996 Dollars	AVX FS Estimate For 1992 Plan 1996 Dollars	Actual Cost	Estimate Based on Hot Spot	Current Estimate
Hot Spot Remedy	$14,397,300 [1]	$23,119,184	na	$33,721,350 [2]	na	na
1992 Preferred Alternative Operable Unit 2	$33,274,000	$49,934,292	$54,493,580 [3]	na	na	$117,751,570
1996 Preferred Alternative Operable Unit 2	na	na	na	na	$429,000,000 [4]	$115,545,872

Notes:

1. FS estimate for Hot Spot includes incineration.
2. Actual cost for Hot Spot is without incineration. Treatment is estimated at $10,000,000 to $15,000,000 (Memo from D. Dickerson to file June 5, 1995).
3. AVX estimate is in 1996 dollars.
4. Low estimate based on Hot Spot costs and assumed 50% efficiency in dredging.

TABLE 2
COST ESTIMATE INCLUDING
FUTURE SEDIMENT TREATMENT
NEW BEDFORD HARBOR

Estimated Cost to Implement the 1996 Plan Based on 1996 total capital cost Excludes O&M and Monitoring		$141,684,331
Material Handling Cost to Excavate Sediment Based on $1.97/cy to haul and $2.73/cy to load per Foster-Wheeler Estimate in Alt 4	$2,115,000	
***Material Handling Cost to Excavate Dike & Cap Soils** Assumes on site disposal without treatment Based on same price to haul and load, plus additional $3.35/cy to place and grade Total of 585,365 cy of soil from ACOE estimate	$4,712,188	
Material Handling Cost to Remove/Dispose of Geotextiles Assumes 618,370 sy of geotextile/membrane from ACOE estimate Based on $2.75 to remove and dispose	$1,700,518	
Cost to Restore Shoreline After CDF Removal Assumes 10 acres @ $15,000 per acre	$150,000	
***Cost to Treat Sediment** Assumes treatment would be 50% less than incineration price in 1996 Plan	$31,050,000	
TOTAL DIRECT COST	$39,727,706	
TOTAL CAPITAL COST WITH INDIRECT & CONTINGENCY		$71,509,871
TOTAL COST OF 1996 PLAN WITH SUBSEQUENT TREATMENT		$213,194,202

*These costs assume that the CDF cap soils do <u>not</u> need treatment. However, the proposal is to use PCB-contaminated sediments for the cap materials, which may result in increased costs.

TABLE RELEVANT REMEDIAL DREDGING EXPERIENCE

Project	Target	Vol (cy) removed	Total Cost ($) (million)	Total Unit Cost ($/cy)	Disposition of Dredged Sediments
Alcoa (Grasse R.) NY[1]	10 ppm PCBs	3100	4.9	1670	Onsite TSCA landfill
Sheboygan River, WI	10 ppm PCBs	5900	--	>600	Temporary onsite storage in tank and bio-treatment facility
Ruck Pond, WI[1] (Cedar Creek)	Removal of 95-99% of PCB-contaminated sediments	8000	7	925	Commercial landfills: TSCA (30%) and non-TSCA (70%)
New Bedford, MA	4000 ppm PCBs	14,000	20.1	1430	Nearshore CDF, pending treatment
GM (Massena), NY	1 ppm PCBs	15,000[2]	10	670	On-site holding basin, pending treatment
Waukegan Harbor, IL	50 ppm PCBs	32,000	15-21	300-420[3]	Into abandoned slip, and capped
Black River, OH[1]	Removal down to natural till (targeting PAHs and metals)	60,000	5	83	Into dedicated onsite landfill, and capped
Marathon Battery, NY	10-20 ppm Cd	77,000	9-11	115-140	Chemical fixation, then to out of state non-hazardous landfill
Bayou Bonfouca, LA	1300 ppm PAHs	159,000	115	725	Onsite incineration

1. Not an NPL site.

2. Also, 10,000 cy of rocks, in addition

3. Based on 50,000 cy soils/ sediments total.

PRECEDENTIAL SEDIMENT REMOVAL SITES IN PROGRESS

	Target Level (ppm)	Target Vol. (cy)	Projected Completion
Lipari Landfill (NJ)	VOCs (--)	154,000 (WE)	1996
LTV Steel (IN)	PAHs (--)	140,000 (D)	1996
Manistique River (MI)	PCB (10)	121,000 (D)	1997-98
United Heckathorn (CA)	DDT (--)	65,000 (D)	1997
Willow Run Creek (MI)	PCB (1)	145,000 (WE)	1997 (Phase I)

WE = wet excavation
D = dredging
-- = depth target

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- Tables 1a and 1c summarize characteristics, target levels, objectives, and results for the ten sites that have completed major sediment remediation. Two of these sites, New Bedford Harbor and the Black River, may also require additional sediment remediation in the future, over and above that which is listed. Two of the sites, Sangamo-Weston/Twelvemile Creek and the James River, are "natural recovery" sites. Two sites for which full-scale pilot sediment remediation has been performed, Aloca (Massena) and the Sheboygan River, are not included in these tables.

For the seven sites for which major sediment removal has been performed, please note the following:

- None were in an extended river; all seven sites were in readily accessible focused areas; 4000' maximum extent;

- Six of the seven involved remediation of relatively "small" volumes, less than 100,000 cy;

- Five of seven were able to use the adjacent PRP site as a "beach-head" and for sediment staging, dewatering, and disposal;

- Treatment of the sediment, for final disposal, was performed at only one of the seven sites (incineration at Bayou Bonfouca);

- High overall unit costs were realized for the six sites for which final costs are available: $115 - $1430 per cubic yard;

- One of seven failed to meet target levels; four others did not verify; one met an interim target of 4000 ppm; one met an informal target level of 20 ppm Cd (Marathon Battery);

- All seven were mass removal projects, with no clear post-dredging measure of success; and

- No final summary report is identified/available for any (i.e., documentation after remediation ranges from poor to non-existent).

TABLE 1a: MAJOR U. S. SEDIMENT CONTAMINATION SITES COMPLETED: CHARACTERISTICS/TARGET

Site	Characteristics	Contaminant	Fishing Advisory	Target Sediment Cleanup Level
James River, VA	81-mile estuary; 0.6 to seven miles in width	Kepone	1975-1988	Fish action level (0.3 ppm) and blue crab action level (0.4 ppm); no sediment Kepone level
Triana / Tennessee River, AL	11-mile stretch of two tributaries which discharge to the Tennessee River	DDT	Since 1978	Interim fish level and surface water goals established for DDT, as well as final fish level goals (5 ppm DDT); no sediment DDT level
Waukegan Harbor, IL	37-acre harbor in Lake Michigan	PCBs	Since 1981, for both lake and harbor	50 ppm
Marathon Battery, NY	one acre cove in Lower Hudson River and 43 acres of shallow inland cove	Cd	No	10-20 ppm
New Bedford Harbor, MA	five acres of hot spots in mud flat area (interim measure); 177 acres to be targeted in estuary, lower harbor, and upper bay (final)	PCBs; metals	Since 1979	4000 ppm PCBs (interim); 10 and 50 ppm proposed for final
Bayou Bonfouca, LA	4000 foot length of bayou in turning basin	PAHs	Since 1987	1300 ppm
GM Central Foundry, NY	ten-acre, 2500 ft. long near-shore area on St. Lawrence River	PCBs	Yes (limited)	1 ppm
Sangamo-Weston / Twelvemile Creek / Lake Hartwell, SC	24-mile creek and 56,000 acre lake; 730 PCB-contaminated acres	PCBs	Since 1976	1 ppm

TABLE 1a: MAJOR U. S. SEDIMENT CONTAMINATION SITES COMPLETED: CHARACTERISTICS/TARGET

Site	Characteristics	Contaminant	Fishing Advisory	Target Sediment Cleanup Level
Ruck Pond, WI	1000' length of Cedar Creek, between two dams	PCBs	Yes	Remove 95-99% of sediment; no sediment PCB level
Black River, OH	15 miles of Black River, which discharges into Lake Erie	metals, PAHs	Since 1983	Awaiting information. Target believed to be removal of sediment down to natural till; sediment target level not known

TABLE 1c: MAJOR U. S. SEDIMENT CONTAMINATION SITES COMPLETED: RAOs / MEASURES OF SUCCESS

Site	Remedial Action Objectives	Original Est. Cost and Time to Implement vs Actual	Measures of Success Used
James River, VA	EPA reviewed remedial techniques in 1978; concluded " leave alone"; natural recovery (slow burial by natural sedimentation) evolved as solution.	---	Fish and crab Kepone levels.
Triana / Tennessee River, AL	5 ppm or less DDT in three species of fish within 10 years and demonstrated for 3 consecutive years thereafter.	Not available.	Biennial fish and surface water sampling by the PRP; GW monitoring in 12 wells near or in the filled channel in years 1 and 10; ongoing inspecting and maintaining of the filled stretch. Five-year review performed in 1992. No deficiences or changes noted.
Waukegan Harbor, IL	None. Modeling concluded that residual PCBs between 100 and 10 ppm left after dredging would result in a PCB influx to Lake Michigan near zero. Based on this, EPA set 50 ppm PCB cleanup level. EPA calculated 96 % PCB mass removal if 50 ppm met.	Original $21.3 million and 2.5 years; actual about $21 million and about 3 years.	Committee reviews PCB levels in six species of fish annually for both Lake Michigan and the harbor.
Marathon Battery, NY	Remove contaminated sediments to levels consistent with state and Federal ARARs and to ensure protection of the environment . . . Since no ARARs exist for sediments, Cd action levels of 220 ppm for human and 10 ppm for eco protection were set by a site-specific risk analysis. Dredging to the action levels was judged infeasible; instead, dredging targeted the top layer of sediments (predicted 95 % Cd removal)	Not available.	First round of post-monitoring sampling of sediments and surface water conducted in Nov '95. No biota sampling yet. EPA may tabulate and review data for 5 years and determine trends. EPA unsure how to apply input from Constitution Marsh and West Foundry Cove, which were not remediated based on "more harm than good."

TABLE 1c: MAJOR U. S. SEDIMENT CONTAMINATION SITES COMPLETED: RAOs / MEASURES OF SUCCESS

Site	Remedial Action Objectives	Original Est. Cost and Time to Implement vs Actual	Measures of Success Used
New Bedford Harbor, MA	For Hot Spot area: (1) significantly reduce PCB migration and the mass of PCBs needing to be remediated in the overall harbor and (2) protect public health and marine life by preventing direct contact with hot spot sediments. For Estuary and Lower / Upper Harbor : (1) reduce human and ecological exposure to PCB-contaminated sediments and (2) reduce water column and biota PCB concentrations by reducing PCB sediment concentrations.	Original cost bid for hot spot area of $19.4 million included construction of WWTP, dredging for four months, and incineration. Final cost was $20.1 million and included both the construction of WWTP and dredging for 16.5 months, with incineration and CDF capping deleted. Dredging only costs as bid (10,000 cy, 4 months) were $650,000 and actual (14,000 cy, 16.5 months) were $1.74 million.	Post dredging sediment verification samples collected in dredged areas. Fifteen final composite samples were used to document post dredge PCB levels in the 5 hot spot areas. The 15 samples ranged from 67 to 2068 ppm PCBs with a median of 707 ppm. Since it's an Interim Measure, no additional monitoring is defined.
Bayou Bonfouca, LA	Reduce or eliminate the potential for ingestion of carcinogens in groundwater, surface soils, and shellfish; control the migration of PNAs in the groundwater aquifers; and reduce or eliminate the direct contact threat posed by Bayou sediments . . . A PNA action level of 1300 ppm in sediments was set by a site-specific risk assessment, and met 10^{-4} risk.	Original estimate was 150,000 cy, $90 million, and 5.5 years. Final values were 159,000 cy, $115 million, and 21 months. Dredging only final cost was $133 per cy.	No post dredging sediment verification sampling or fish sampling. No fish sampling planned until after Southern Shipbuilding remediation is completed, one mile downstream.

TABLE 1c: MAJOR U. S. SEDIMENT CONTAMINATION SITES COMPLETED: RAOs / MEASURES OF SUCCESS

Site	Remedial Action Objectives	Original Est. Cost and Time to Implement vs Actual	Measures of Success Used
GM Central Foundry, NY	None. EPA chose a cleanup level of 1 ppm for PCBs in sediments in the St. Lawrence and Raquette Rivers. NYSDEC and the St. Regis Mohawk Tribe objected and concluded that the ROD may only partially address the risks to the environment.	ROD projected dredging / treatment / disposal of 62,000 cy of sediments at $21.5 million. Actual effort was more focused. After one abortive start (cancelled in 1994 and rebid), 15,000 cy of sediments and 10,000 cy of rocks were dredged from a nearshore area in the St Lawrence River over six months for $10 million.	Post dredging sediment verification samples. In 5 of 6 quadrants, all discrete verification samples were less than 10 ppm PCBs. In one 250' x 300' quadrant, samples were higher, only less than 100 ppm despite multiple passes, with one hit at 6000 ppm. This quadrant was capped with 18" of sand, gravel, and stone. None of the 6 quadrants were able to be remediated to 1 ppm.
Sangamo-Weston / Twelvemile Creek / Lake Hartwell, SC	None. EPA chose cleanup goals. A sediment PCB concentration of 1 ppm was selected based upon technical feasibility. Represents 4.7 million cy over 730 acres. For fish, the FDA level of 2 ppm was selected based on technical feasibility (since a fish tissue concentration of 0.036 ppm was calculated for the 10^{-4} risk level and judged to be unattainable).	Natural recovery in-progress, along with (1) continuation of the fish advisory, (2) annual monitoring, and (3) more controls on the periodic flushing of sediments from behind three impoundments. Modeling predicts FDA levels in fish will be reached in 12 years.	Annual sediment (20 locations) and fish monitoring (six stations) for 15 years minimum. PCB data trends will be used to support decisions to modify the fish advisory.
Ruck Pond, WI	None. Remove sediments to the maximum extent practical, based on visual. These were considered to be a major upstream source. PCB levels in the 1000s of ppm.	Not available.	None. Ongoing study of next 6 miles of Cedar Creek (downstream) may eventually show if improvement occurs.

TABLE 1c: MAJOR U. S. SEDIMENT CONTAMINATION SITES COMPLETED: RAOs / MEASURES OF SUCCESS

Site	Remedial Action Objectives	Original Est. Cost and Time to Implement vs Actual	Measures of Success Used
Black River, OH	None known. USX tasked to remove contaminated sediments in the Black River near their outfall, pursuant to a 1985 Consent Decree.	$1.5 million. Estimated time to implement not known.	Some upstream/downstream testing done during dredging. Ohio EPA completed an extensive fish survey in 1992, with one goal being to evaluate the effect of the sediment removal. Attempting to obtain the data.