HUDSON RIVER PCBs REASSESSMENT RI/FS
PHASE 3 REPORT: FEASIBILITY STUDY

DECEMBER 2000

For

U.S. Environmental Protection Agency
Region 2
and
U.S. Army Corps of Engineers
Kansas City District

Book 5 of 6
Appendix D through Appendix H

TAMS Consultants, Inc.

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MODEL INTERPRETATION, SPECIFICATIONS AND RESULTS

D.1 Use of Data Trends and Models in Evaluating Remedial Alternatives

Use of Data Trends and Models in Evaluating Remedial Alternatives

The evaluation of remedial alternatives for the Hudson River PCBs site utilized a number of analytical tools. The first and foremost among these tools are the quantitative models developed for the Reassessment RI/FS. The models predict water, sediment and fish PCB concentrations, and make it possible to compare remedial alternatives. However, the model predictions alone do not provide a complete basis for decision. The uncertainty associated with the predictions should also be taken into account. In addition to the models, it is also valuable to utilize a separate set of tools; the analysis of trends in the data.

The HUDTOX mass balance fate and transport model is the quantitative foundation for the Feasibility Study. HUDTOX provides a best-estimate interpretation of the 1977–97 history of observed PCB fate and transport in the Upper Hudson River, at a model segment-averaged spatial scale. FISHRAND similarly provides a best-estimate interpretation of the history of observed PCB concentrations in fish, conditional on the HUDTOX interpretation of PCB fate and transport. While these models are calibrated to provide best-estimate interpretations of data, the interpretations are not necessarily exact. First, the calibrated models are limited by the quality of available calibration data. In some key areas, the calibration data are limited (e.g., there are only very limited data on surface-layer sediment PCB concentrations over time). Second, the models cannot capture all the details of PCB fate and transport at the local scale at which the biota actually uptake PCBs from sediment and water.

The models are, of necessity, simplifications of reality. Coupled with the fact that calibration data are imperfect, this means that there is inevitable uncertainty associated with model forecasts. Further, deficiencies in the calibration data could result in a model that is biased—in the sense that causal relationships are not perfectly captured–which may result in inaccuracies when the model is used in a forecast mode. Bias might also be introduced if there has been a qualitative change in the nature of PCB fate and transport in the river relative to the model calibration period. Finally, the model has been built and calibrated at the scale of model segments and river reaches. These relatively broad spatial scales do not necessarily reflect what happens at local spatial scales smaller than model segments. All of these considerations suggest that model predictions alone do not provide sufficient and complete evidence on which to evaluated remedial alternatives.

Potential uncertainty and bias in the models are of particular importance for evaluating the No Action and Monitored Natural Attenuation alternatives, as the interpretation of risks associated with these alternatives relies on model predictions that a certain fraction of the mass of PCBs in river sediments will remain isolated from the food chain in the river. Forecasts associated with significant removal or capping of contaminated sediments have relatively less uncertainty, at least in terms of long-term impact, as the isolation from the river of a portion of the PCBs is assured by the remedial action.

This Appendix discusses a variety of analytical tools that address the fate and transport (and availability for bioaccumulation) of PCBs in the Hudson, including, but not limited to the quantitative models. The first section summarizes the quantitative fate and transport and bioaccumulation models. The second section provides an analysis of trends in recent data. This has two purposes: First, the trend analysis provides a purely data-based, empirical estimate of the potential future status of the river given No Action. Second, comparison of trends in data and the models helps provide insight into the potential uncertainty and/or bias associated with model forecasts. The next three sections provide tools that relate to interpretation of modeling results, addressing model uncertainty, potential model bias, and model scale issues. The sixth and final section documents the development of an alternative, bounding calculation of the No Action and Monitored Natural Attenuation alternatives.

1. Quantitative Models

The primary criterion for screening the effectiveness of a remedial alternative is its ability to protect human health and the environment. Evaluation of this criterion is based on forecasts of exposure concentrations and resulting risks associated with each remedial alternative. Quantitative models aid in the evaluation of this criterion; however, the forecasts should be evaluated using a weight-of-evidence approach.

Quantitative modeling forecasts are provided by a series of coupled mathematical models, developed to aid understanding of PCB fate and transport and PCB bioaccumulation in the Upper Hudson River. The backbone of the modeling effort is the Upper Hudson River Toxic Chemical Model (HUDTOX). HUDTOX is a modified version of USEPA's widely-used WASP5 model, and was used to simulate PCB fate and transport for the 40 miles of the Upper Hudson River from Fort Edward to the Federal Dam at Troy, New York. This model is based on the principle of conservation of mass, and balances inputs, outputs, and internal sources and sinks for PCBs in the sediments and the water column. Mass balances are constructed first for water, then solids and bottom sediment, and finally PCBs.

HUDTOX is augmented by a hydraulic model of the Thompson Island Pool, a sediment scour model, and a bioaccumulation model. Hydrodynamic behavior of the Thompson Island Pool was simulated with the US Army Corps of Engineers RMA-2V model, which estimates velocities and shear stresses on a two-dimensional grid. The Depth of Scour Model (DOSM) was principally developed to provide spatially-refined information on sediment erosion depths in response to high-flow events such as a 100-year peak flow. DOSM is linked with a hydrodynamic model that predicts the velocity and shear stress (force of the water acting on the sediment surface) during high flows. DOSM results are also fed forward into HUDTOX through relationships that represent area-average rates of flow-dependent resuspension of cohesive sediments for HUDTOX segments. Model calculations of forecast PCB concentrations in the water column and sediment from HUDTOX are used as inputs to the bioaccumulation model (FISHRAND) to predict PCB concentrations in the fish. These models are described in greater detail in the Revised Baseline Modeling Report (USEPA, 2000a).

As constructed and calibrated, the mass balance modeling shows the following key characteristics over the 70-year forecast period:

- The river is net depositional in the TI Pool (River Section 1), and apparently also in the downstream sections (River Sections 2 and 3).

- Solids loads are dominated by the tributary inputs (downstream of the TI Pool). Assumptions regarding solids loads exert an important control on long-term predictions of the environmental distribution and availability of PCBs to the food chain.

- PCB (Tri+) loads to the water column are dominated by the sediment to water mass transfer under non-scouring flow conditions. In recent years (post 1993), water column and PCB (Tri+) surface sediment concentrations are gradually declining due to reduced input loads from the GE facilities and natural attenuation processes.

- For the first two to three decades of the model forecast, depending on location, the in-place PCB (Tri+) reservoir in the sediments and sediment-water transfer processes control responses of surface sediment concentrations and associated flux to the water column.

- Reach-averaged PCB (Tri+) concentrations in the surface sediment are forecast to decline at annual rates of approximately seven to nine percent over the next two decades, consistent with long-term historical trends.

- PCB (Tri+) loads from upstream of the model boundary at Fort Edward control the long-term responses of reach-average PCB (Tri+) concentrations in the water column and surface sediments, and accordingly, reach-averaged exposures to fish. Sediment-derived PCB exposure to fish at the local scale may, however, differ significantly from reach-average forecasts.

- The rate at which reach-averaged exposure concentrations approach an asymptote depends upon the assumed magnitude of the upstream boundary load and location within the river.

- Over the long term, PCB (Tri+) fish body burdens will also asymptotically approach steady-state concentrations. These concentrations are species-specific, depending on the relative influence of sediment versus water sources, and reflect the upstream boundary loading assumption.

When applied in a forecast mode, the models suggest that active remediation of sediments can have a significant benefit in reducing exposure concentrations and fish body burdens of PCBs. The models also suggest that the relative risk reduction associated with sediment remediation may only last for several decades relative to No Action and Monitored Natural Attenuation (MNA). This results primarily from model predictions of relatively rapid reductions in exposure due to natural processes. (Note: Natural processes that reduce PCB exposures occur in both the No Action and the Monitored Natural Attenuation alternatives; the primary difference between these alternatives for the purposes of this Appendix is that the No Action alternative does not assume upstream source control, whereas the Monitored Natural Attenuation alternative does.)

Active remediation scenarios are distinguished from No Action and MNA by accomplishing a step function movement (representing remediation) rather than gradual decline toward asymptotic sediment concentrations in equilibrium with the upstream boundary concentration. The apparent benefits of remediation (as compared to No Action or MNA) are constrained by the trajectory of the No Action or MNA alternatives. The No Action and MNA trajectory is controlled by the model assumptions that represent "natural" attenuation.

The ability of the model to distinguish among remedial scenarios and to contrast remediation against the No Action and Monitored Natural Attenuation alternatives depends on the accuracy of the model calibration and the model's spatial segmentation. These issues are discussed in detail in subsequent sections of this Appendix. Uncertainties associated with model calibration and spatial segmentation, as well as an empirical analysis of recent data-based trends, raise the distinct possibility of a slower rate of decline in exposure concentrations than predicted by the HUDTOX model, particularly at the localized spatial scales associated with the foraging range of resident fish. This would result in underestimation of the benefits of active remediation.

2. Analysis of Trends

The analysis of trends was developed as a secondary line of evidence for use in conjunction with the quantitative models. The analysis compares the time course of predicted and observed PCB concentrations and loads in various media, with particular attention to apparent half-lives. Half-lives are not an ideal metric for evaluating the general quality of model fit, as small changes in model parameters can lead to large changes in apparent half-lives without having a large effect on the quality of fit to observed data. For the Hudson River Reassessment RI/FS, however, the time required to reach a specific concentration target is an important factor in the evaluation of remedial alternatives. Therefore, half-lives provide an important diagnostic for the decision support uses of the HUDTOX model.

Many of the PCB trends in the Hudson River resemble exponential declines, albeit trends that have been interrupted or reset at various times (e.g., the increased upstream loading following the Allen Mill gate structure failure in Fall 1991). An exponential decline may be characterized by a half-life, or the time required for a metric to reach one-half of its starting value. If the model accounts for the mechanisms controlling the system correctly, half-lives predicted by the model should match those seen in observations.

PCB trends in the Hudson since the start of monitoring are not well characterized as a *single, consistent* exponential decline. Most notably, conditions were partially reset in 1991 by the Allen Mill gate structure failure at Hudson Falls, and other perturbations probably have occurred, including those associated with unusual hydrology (e.g., high flow events). Further, it is reasonable to guess that rates of decline may have changed over time, as the contaminated sediment released by the Fort Edward Dam removal washed out or stabilized and as the relative importance of different physical processes changed. Therefore, the available time series are broken into subsets to capture these potential changes in trend. The following time spans were selected as the primary basis for comparison:

1977 - 1985	(early period of decline following the Fort Edward Dam removal)
1985 - Sept. 1991	(subsequent period of decline up to the Allen Mill event)
1985 - 1999	(net trend for the past 15 years)
1995 - 1999	(period after the stabilization of the Hudson Falls source)

The breakpoints among these time intervals appear to capture the major potential changes in trend. The time periods of 1999-2004 and 1999-2020 were examined to evaluate the consistency of model forecasts with recent data. Forecasts for the No Action alternative were evaluated under an assumed constant load upstream boundary concentration condition. A consequence of the assumption of constant upstream loads in the forecast is that all half-lives will gradually increase as concentrations in the various media gradually approach equilibrium with the upstream boundary.

2.1 PCB Concentration Trends in Fish

Concentration trends in fish potentially provide one of the most rigorous tests of the joint performance of HUDTOX and FISHRAND, as the fish response integrates many geochemical processes. Long time series of concentrations in various species at various locations are available from NYSDEC, and these biotic concentrations should integrate or smooth out short term or spatial variability seen in other media. Several caveats should, however, be noted. Most importantly, changes in analytical methods over time may serve to introduce spurious step changes into the fish concentration record. This problem is reduced by attempts to convert the NYSDEC data to a consistent Tri+ PCB basis, although the conversions themselves are subject to uncertainty. In addition, concentrations in fish in a given year may be influenced by factors such as weather, food availability, and the distribution of age and sex in a given year's data set.

It is also important to remember that calibration of the FISHRAND model was conducted using environmental concentration estimates from HUDTOX as the forcing function. Thus, any shortcomings in HUDTOX will also propagate into the FISHRAND calibration. Trends in brown bullhead should generally follow HUDTOX predicted trends in surface sediment concentration, while trends in pumpkinseed should generally follow predicted trends in water column concentration (particularly summer concentrations), and largemouth bass should depend on both sediment and water (see Table 6-7 in the RBMR, USEPA, 2000a).

Concentration trends in fish are evaluated here as lipid-based concentrations, on the assumption that conversion to a lipid basis better reflects actual uptake processes and helps to smooth out some of the year-to-year and sample-to-sample variability. A comparison of FISHRAND model median predictions to observed (corrected) Tri+ PCB data in fish lipid is shown for three species in the lower Thompson Island Pool and the Stillwater reach in Figures 1 and 2. These results use actual (observed) upstream boundary conditions for the 1998–99 validation period.

Figure 1 shows results for fish collected by NYSDEC near Griffin Island at RM 189 in the TI Pool. While the general fit seems acceptable, there are some discrepancies between model and data. For the largemouth bass, the model appears to underpredict recent 1998 and 1999 concentrations. High concentrations observed in 1990–91 are also not predicted by the model.

For brown bullhead, the general model trend in the TI Pool appears to fit better than for largemouth bass. It is noted, however, that the model predicts a gradual decreasing trend from 1995–1999, while the data show what appear to be nearly constant concentrations, with a slight increase in 1999. Given the dependence of bullhead concentrations on surface sediment, this result suggests that the modeled trend in surface sediment concentrations for this period might differ from the trend in sediment-driven exposure experienced by the sampled fish. This could occur either because the modeled trend is incorrect or because the exposure to the fish occurs at a local spatial scale that is smaller than that simulated by the model in which sediment concentration trends differ from the reach-averaged trend. Alternative explanations are that FISHRAND itself does not provide a valid translation from exposure concentrations to fish body burdens for the environmental conditions present in the late 1990's, or that the trend in the observed fish data is obscured by random variability in the sample results.

Pumpkinseed body burdens should provide a diagnostic of model ability to reproduce summer water column concentration trends. For pumpkinseed, the general trend in TI Pool is fit by the model (although 1999 data are not yet available). Notable here is the failure to predict elevated concentrations in 1989 – which could in turn be a source of the elevated concentrations seen in largemouth bass in 1990 and 1991. The year 1989 is one in which the data to characterize the upstream boundary loads are very sparse, so this could indicate a failure to capture pulse loading from upstream and consequent underestimation of summer water column concentrations.

The 1995–1999 data from the Thompson Island Pool suggest that the models could be predicting a rate of decline in fish tissue concentration that is more rapid than seen in the environment for the period since the upstream source was largely controlled. Small changes in trend at this end of the distribution could have large effects on the rate of natural decline during the forecast period. The interpretation of the Thompson Island Pool results must be made with caution, however, due to the locations used for sampling. The fall samples of yearling pumpkinseed are generally collected on the east side of the main channel, opposite Griffin Island and just south of *Hot Spot* 14. The spring samples of largemouth bass and brown bullhead are, however, collected in the backwater channel *behind* Griffin Island (because this is an area in which the bass congregate in the spring). Because this channel is somewhat isolated from the main river, the relevance of trends in these data to overall conditions in the lower Thompson Island Pool is uncertain.

The model and data for the Stillwater reach (Figure 2) are generally in closer agreement for brown bullhead and largemouth bass in the 1990's relative to the TI Pool. The pumpkinseed calibration misses the error bars on observed lipid-based concentrations in most years up through 1993, which could indicate a failure to accurately represent summer water column concentrations in HUDTOX. More notable at this location is a divergence between model and observations between 1977 and 1982. For all three species, the data suggest that initial concentrations were higher, with a more rapid decline, than is indicated by the FISHRAND model. For this period, the data to constrain water column concentrations in the modeling are very sparse. There are also significant uncertainties regarding the interpretation of analytical methods for the earlier data.

Table 1 summarizes half-life data for the three species discussed above, plus yellow perch. The consistent Tri+ data includes both Aroclor-based data reported by NYSDEC and direct estimates of Tri+ from homologue-based analyses from NEA included in the NYSDEC database. In addition to the model and consistent PCB Tri+ data, the table also includes the trends from annual means of NYSDEC-reported lipid-based total PCBs (NYSDEC-collected data only) and Aroclor 1254 concentrations without correction to a consistent Tri+ basis. These data are included for comparison; however, it is believed that analytical changes in 1990 and ca. 1992 may distort the interpretation of trends.

Across the period 1985-1999, trends in model and data (consistent Tri+ PCBs) are generally quite close. This reflects the fact that FISHRAND is calibrated to data that span this period, and the general fit of the model is quite good. For the 1985-91 period of declining concentrations, model and data are again close in the

Stillwater reach; however, the data-based trends in the TI Pool show both largemouth bass and pumpkinseed increasing, whereas the model predicts declines.

In general, the model does a good job of reproducing observed fish concentrations over the period of record when examined as an annualized lipid-based average concentration. But, the model does not seem to reproduce the trend in observed concentrations since 1995. For the recent 1995-99 period following substantial control of the upstream source the trends in the model and data appear to diverge. In the TI Pool, the model predicts continuing steady declines in fish concentration, but the data show either increasing or very slowly decreasing concentrations. For brown bullhead, the 1995-99 data-based half-life is 50 years versus a model estimate of 8.73 years, while largemouth bass have an increasing trend versus a model estimated half-life of 4.10 years. The rate of decline in the Stillwater reach also appears to be over-predicted for brown bullhead and largemouth bass.

In evaluating these trends it is important to keep in mind that the observed data are variable and subject to uncertainty. Reported trends are based on annual means. The 95-percent confidence limits on the observed means for 1995-99 are consistent with half-lives as short as 4.1 years for brown bullhead and as short as 6.7 years for largemouth bass. The FISHRAND output provides 1995-99 half-lives that are outside (shorter than) the range for largemouth bass, suggesting that a discrepancy is present—but the magnitude of this discrepancy could well be small. For brown bullhead, the central-tendency best estimates of trend appear quite different between model and data, but the range about the bullhead data covers the modeled trend for this period.

2.2 Water Column Load and Concentration

Long time series also exist for PCB concentrations in water. Interpretation of these data is uncertain, however, for years before 1991, due to the presence of sparse data and high temporal variability. The situation is better after 1991 due to the presence of GE monitoring, although a high degree of measurement-to-measurement variability is still present. The analyses presented here combine the USGS and GE results, where available, after conversion to a consistent Tri+ PCBs basis.

The water column data may be examined in terms of both loads and concentrations. Loads, as a more integrative measure, are examined first. Ratio estimators are used to convert from concentration and flow to continuous loads, as described in the DEIR.

Figure 3 compares annual Tri+ loads calculated from the concentration and flow output of the HUDTOX model with loads estimated from USGS monitoring data at Fort Edward and Waterford, approximately representing the upstream and downstream ends of the HUDTOX model grid.

At Fort Edward, the model representation of the upstream boundary condition seems to be biased low for 1985 through 1995 relative to the ratio estimator. This likely reflects the fact that the boundary condition was interpolated between observed data points for entry into the model, which can potentially bias estimates of load.

At Waterford, a result opposite to that at Fort Edward is seen: the model predictions seem to decline more slowly than loads calculated from observed data, and appear to *over*-predict loads past Waterford after 1985.

Based on this comparison, if the model underestimates the upstream boundary load and over-estimates the downstream load exiting the system, then the model must predict too much removal of PCBs (or not enough storage of PCBs) in the intervening reaches. This could in turn result in an over-estimate of the rate of depletion of PCBs in surface sediments.

Table 2 summarizes model-estimated half-lives for PCB Tri+ annual load between 1985 and 2020. Half-lives appear relatively long for the 1985–1990 period, but this is due to hydrologically-driven load increases in 1990; half-lives for 1985-1999 are much shorter. Half-lives after 1999 increase as the load asymptotes toward the assumed constant load upstream boundary specification.

Only limited data are available against which to compare recent load predictions. The best concentration data are those for the Thompson Island Dam, collected by GE since 1991. For the 1995-1999 period, loads calculated directly from these data show a half-life of 46 years, because the 1995 estimate is relatively low, versus a model estimate of 9.1 years. For 1994-1999 the data-based estimate is 10.0 years, while the model estimate is 5.9 years. While these results suggest a discrepancy, the data-based loads are calculated from concentrations at the TID-West nearshore station. Concentrations at this station are believed to be biased high relative to the average transport in the river during low flow conditions with reduced lateral mixing. This could result in an apparent discrepancy in load half-lives as the importance of TI Pool sediment-generated PCB loads has increased relative to the upstream load. Insufficient data are available from center channel observations at Thompson Island Dam, however, to estimate load trends over time.

At Waterford, loads calculated from USGS data provide estimated half-lives of 7.4 years for 1985–1990 and 1.8 years for 1985–1989, both shorter than the model estimates. As with the fish data, the estimated half-lives are subject to considerable uncertainty. Figure 4 provides a detail of Tri+ loads at the USGS Stillwater station (now discontinued). As at Waterford, the HUDTOX model appears to over-predict PCB loads at this station, and the actual loads appear to have declined faster than predicted by the model. It is possible that the USGS data may have a consistent bias relative to GE data as estimators of Tri+; however, this should not effect the estimation of trends.

Model and data may also be compared on a concentration basis. Figure 7-20 in the RBMR suggests that HUDTOX predicts more stable water column concentrations, with a slower rate of decline from peak concentration years than is seen in the data for stations downstream of TI Dam. This is supported by a half-life analysis. Results are similar for annual average and summer water column concentrations.

Figure 5 shows water column results on an annual average concentration basis – *i.e.*, a direct, non flow-weighted average concentration. The model upstream boundary condition and Fort Edward data agree quite well, as expected, as the boundary condition is specified by interpolating on the observed data. At Stillwater and Waterford, however, the model predictions are flatter than observations, and the model appears to over-estimate concentrations from about 1984 to 1996.

Table 3 summarizes half-lives for Tri+ PCB in the HUDTOX model output, using observed validation data for 1998-1999 upstream concentrations and the constant load boundary condition for the forecast period. Both annual average and summer average (May-September) results are shown; in general, the summer average concentrations have a slightly shorter half-life than the annual results. Recent data for comparison are again limited; however, the half-lives for 1995-1999 in the GE TID-West monitoring are 23.1 years for annual average and 17.3 years for summer average concentrations. These rates of decline are much slower than those attributed by the model for this period; however, the model quickly jumps to a longer half-life during the early forecast period due to the imposition of the constant load upstream boundary condition, which is forecast to account for two-thirds of the concentration present at Thompson Island Dam by 2005.

Despite some apparent discrepancies between short-term trends in model and data, by the end of the calibration period the model and data converge to similar concentration values. The No Action forecast then imposes a slow decline (long half-life) on future water column concentrations. As a result, model forecasts of water column concentrations are unlikely to result in a low bias in future exposure concentrations at the reach-averaged scale. Localized areas of elevated water concentrations in the neighborhood of exposed *hot spots* are not, however, represented at the larger spatial scale in the HUDTOX model.

2.3 Surface Sediment Data

Concentrations of PCBs in biota are driven by a combination of water column and surface sediment PCB concentrations. The relative importance of sediment-driven pathways varies by species, and, among the species studied, should be most important for brown bullhead.

Unfortunately, it is very difficult to evaluate concentration trends in surface sediment from the data, for three reasons:

1. Sediment PCB data have been collected at only a few points in time,
2. Concentrations in sediment are known to exhibit a high degree of spatial variability, which introduces a high level of uncertainty in any comparison across time based on limited sampling,
3. Much of the available sediment sampling has used rather large vertical segmentation, which makes it difficult or impossible to estimate data-based trends in concentration in the upper few centimeters of sediment that are likely to have the greatest influence on concentrations in biota.

Reach-averaged means of observed sediment concentrations provided the key calibration targets for the HUDTOX model, as described in the RBMR (USEPA, 2000a). In general, the model appears to do a fairly good job of starting with the 1976/78 sediment conditions and predicting forward through 1984 NYSDEC samples in the TI Pool, 1991 GE samples for the Upper Hudson, and 1998 GE samples for the Thompson Island Pool, when summarized at a reach-averaged scale. This is accompanied by a reasonable fit between modeled and apparent observed half-lives for sediment; however, the observed half-lives are highly uncertain. But, neither the 1976/78 or 1984 NYSDEC samples provide sufficient vertical resolution to identify PCB concentrations in the top few centimeters of sediment, so the model has not really been constrained to reproduce trends in the layer of sediment most likely to support bioaccumulation.

HUDTOX model predictions of the half-life of Tri+ PCB concentrations in the surface sediment layer are shown for selected locations in Table 4 (for HUDTOX runs that incorporate the observed upstream boundary conditions for 1998 and use a reinitialization to observed sediment concentrations in 1991.) Results are presented for averages across the TI Pool and three locations corresponding to the averaged model segments used to drive the FISHRAND model.

For cohesive sediments near the TI Dam and non-cohesive sediments above Federal Dam, half-lives for surface sediment concentration predicted by HUDTOX are relatively consistent over time, but appear to have been "reset" to longer values during the 1991-1993 time period due to model-predicted additions of PCB mass from increased upstream water-column loads. Significant addition of PCB mass to the surface sediments has *not* been confirmed by direct sediment sampling (discussed more below). Half-lives for the near-term forecast period are consistent with those seen prior to 1990, but shorter than those estimated by the model for 1995-1999. The model thus predicts that the rate of decline in surface sediment concentrations will increase over the next few years as the effects of the Allen Mill event wash out of the system. While this interpretation is not unreasonable, neither is it certain.

The ability of the model to reflect surface sediment concentration trends can be tested to some extent by comparing the 1991 GE sediment survey data (collected prior to the Allen Mill event) with more limited GE data for 1998. Unfortunately, the method of compositing used by GE in 1991 makes it difficult to exactly match samples between 1991 and 1998. It appears, however, that 1998 broad scale sampling at nine locations within the TI Pool and fine scale sample groups at two locations below Thompson Island Dam can be reasonably matched to 1991 composites. The comparison is shown in Table 5.

Of the eleven approximately co-located composite samples, average concentrations in the top 5 cm appear to have declined at eight locations between 1991 and 1998. Within the TI Pool, observed changes in surface sediment concentration between 1991 and 1998 range from -61.6% to +82.0%, suggesting a significant amount of local variability. The median change in the Tri+ PCB concentration in the top 5 cm of cohesive sediments in the TI Pool over this seven year period is approximately -33%. This equates to a 12.1-year half-life, or about a 40 percent greater halving time than is predicted by the HUDTOX model, which estimates that surface concentration (as a pool-wide average) should have declined by 43% in cohesive sediments and 42% in non-cohesive sediments between 1991 and 1998. The available samples for comparison are few, however, and difficult to generalize to a reach basis. Observed decline at several locations does closely approximate the rate of decline predicted by the model.

Statistical tests may be applied to these data under the assumption that sediment concentration should decline along according to an exponential trend. Given this assumption, the differences between 1991 and 1998 samples should be scale independent when expressed on a logarithmic scale. The 95-percent confidence limits on the average 7-year change in surface sediment concentrations range from a decline of 60 percent (5.3 year half life) to an increase of 1.3 %. Application of a two-tailed paired t-test to the natural logarithms of all 9 data points from the Thompson Island Pool does not reject the null hypothesis that the decline between 1991 to 1998 is equal to zero at the 95% significance level. Application of a stronger, one-tailed paired t-test, however, does result in a rejection of the null hypothesis that no decline has occurred at the 95% significance level. In other words, the data support a conclusion that a net decline in surface sediment concentration has occurred between 1991 and 1998, but the magnitude of this decline is subject to considerable uncertainty. When the same one-tailed test is applied to the smaller data set from cohesive sediments (7 observations; "fine" and "mixed" samples), the null hypothesis cannot be rejected at the 95% significance level. In other words, the data do not prove a significant decline in cohesive sediment surface concentrations between 1991 and 1998. But, neither are they incompatible with the model-estimated average rate of decline of 43 percent.

In fact, it is likely that cohesive sediments in the TI Pool have, on average, experienced some decline in surface concentrations between 1991 and 1998, but one that varies by location. Of particular interest are the results from *hot spot* 14, where only a small decline of 9.5% is estimated. This is one of the areas of the TI Pool that has the highest surface concentrations, and where little burial appears to be occurring. It is also near the NYSDEC fish sampling location. The estimated percent decline in surface sediment concentrations at *hot spot* 14 is almost identical to the decline associated with a 50-year half-life over a 7-year period (9.2%), which is the half-life estimated for recent (1995–1999) brown bullhead concentrations in the lower Thompson Island Pool. While these fish were not collected directly at *hot spot* 14, they could well be exposed to surface sediment concentrations that are declining at a similar, slow rate.

There is thus a possibility that the model may overestimate the rate of recent declines in surface layer sediment PCB concentrations. In addition, pool-wide trends may not be applicable at the smaller spatial scale at which fish feed. Further, it is likely that some PCBs from depths greater than 5 cm (*e.g.*, up to 10 cm depth) are mobilized into the food chain by benthic burrowers. While the HUDTOX model simulates vertical mixing of the sediment down to 10 cm depth in cohesive sediments, only the top 5 cm are subsequently utilized by the FISHRAND model. The deeper sediments below 5 cm are likely to show even slower rates of decline as they cannot readily exchange PCBs with the water column. Unfortunately, the GE broad-scale sampling in 1998 did not extend below 5 cm.

If the model over-estimates the rate of decline of bioavailable sediment PCB concentrations, this would in turn have important implications for the prediction of fish concentrations in those species with a significant benthic food chain pathway (*e.g.*, brown bullhead and largemouth bass). Indeed, the observation that concentrations in brown bullhead appear to have declined only slowly, if at all, since 1995 supports the possibility that the rates of decline of sediment exposure concentrations predicted by the model may be too fast, at least in the sediment forage areas associated with the NYSDEC fish sampling locations.

2.4 Summary of Trend Analysis

Observed trends and apparent half-lives in recent data provide useful diagnostic tools for examining potential model performance relative to the forecast period. The interpretation of trends is, however, complicated by a number of factors, including the Allen Mill gate failure event, normal year-to-year variability in flow patterns, and limited and uncertain data. For these reasons, it is not advisable to forecast future conditions based solely on recent trends. The examination of trends can, however, be used to aid in constructing a bounding calculation with the models.

The HUDTOX model has been demonstrated to provide an excellent fit to PCB concentrations in the water column at the reach scale, and the trend analysis does not suggest any major concerns with this component of the model. On the other hand, the data to constrain model predictions of surface and near-surface bioavailable PCB concentrations are quite limited. The trend analysis suggests the possibility that the model-predicted rate of decline of surface sediment Tri+ concentration in locations associated with NYSDEC fish sample collection, and, as a result, the rate of decline of fish concentrations driven by sediment exposures, may be too fast. The discrepancy is most likely due to cohesive sediments, as these sediments provide the main route of exposure to fish. This in turn suggests that a bounding forecast for No Action should be constructed using a slower rate of decline in cohesive sediment concentrations. The construction of such a bounding forecast is addressed in Section 5.

3. Model Uncertainty

The HUDTOX model was developed to estimate the future levels of PCBs in the sediments and water of the Upper Hudson. The model and its output are based on various analyses of the data that are used in turn to estimate the calibration targets that the model must satisfy. The HUDTOX model represents a credible best estimate of the processes controlling PCB dynamics in the Hudson River, given the availability of calibration data. Similarly, model predictions are the best estimates available consistent with the assumptions of the model calibration. It is important to note that the model forecasts are based on the model calibration and a range of assumed forcing functions (*e.g.*, boundary conditions). As a result, no conservative safety factors are incorporated into the forecasts. Use of the model predictions in evaluating remedial alternatives, however, should recognize the uncertainties in the predictions, thereby resulting in a remedial action that provides reasonable assurances of meeting risk targets. Of particular importance in this regard is evaluation of the possibility that the model predictions may overestimate the benefits of natural attenuation in the system. This may result in a more favorable comparison of No Action or MNA to active remedies than is warranted, when, in fact, it may not yield acceptable levels within an appropriate time frame.

As in any analysis of this magnitude, there are unavoidable uncertainties in the data and the related assumptions. In particular, there are several sources of model uncertainty that stem from lack of data or, more often, from the inability to directly measure the process represented in the model. Due to the complexity of the models, and the many potential sources of uncertainty, a single, quantitative estimate of the uncertainty in model predictions has not been produced. Rather, the RBMR (USEPA, 2000a) and subsequent evaluations (e.g., experimental modeling runs during development of the FS) include a variety of sensitivity analyses that measure the response of model predictions to changes in model parameters and forcing functions. In particular, Section 8.6 of the RBMR examines sensitivity of forecast results and concludes that the model forecasts are highly sensitive to specification of the upstream boundary PCB load, tributary solids loading, and vertical particle mixing. These sensitivity analyses provide a tool for considering the model uncertainties in the evaluation of remedial alternatives.

Small uncertainties in model calibration can have major ramifications in the evaluation of forecasts. For instance, the surface sediment data discussed in Section 1.3 of this Appendix have a median half-life of 12.1 years over the period 1991–1998, versus a HUDTOX estimate of about 8.6 years. The model estimate is well within the range of uncertainty on the observed data. With an exponential decay response, however, small changes in half life can produce a large change in time to reach a target. For example, to reach sediment exposure concentrations one-tenth of those now existing would require 28.6 years with an 8.6 year half life, but would take 40.2 years with a 12.1 year half life. Because the modeled rate of decline in exposure concentrations is uncertain, the models are more properly used to evaluate relative effects of different remedial options than to provide quantitative estimates of risk reduction based on time to reach a specific target, consistent with the recommendations of the Peer Review of the RBMR.

4. Potential Model Bias

The HUDTOX model represents a credible best estimate of the processes controlling PCB dynamics in the Hudson River, given the availability of calibration data. But, the possibility exists that the calibrated model is biased relative to future conditions in the Hudson River. Of particular importance is the possibility that the model predictions may over-estimate the benefits of natural attenuation in the system. Only a small degree of bias during the model hindcast period is sufficient to cause large variability in the estimated time to reach a specified remedial target, given the asymptotic character of model predictions. This section focuses on the potential for model calibration biases, and examines the following topics related to model behavior and supporting evidence:

1. Model calibration and the estimation of several sediment-water exchange parameters,

2. The apparent lack of recovery in summer water column conditions (despite the decline in the upstream loads originating from the Hudson Falls plant),

3. The lack of consistent decline in surface sediment conditions (again, despite the decline in the upstream loads originating from the Hudson Falls plant), and

4. Findings from the Low Resolution Sediment Coring Report, and sediment coring data collected by GE in 1999 that support the findings.

In the discussion that follows, it is important to note that the assumptions and parameters developed for the model are only as reliable as the available data. These data frequently provide the only numerical basis on which to estimate the model parameters. In many instances, circumstantial evidence suggests that these parameter estimates may be biased in one direction or another but do not provide a direct basis on which to numerically estimate an alternate parameter value. Thus the model will contain the best numerical value that can be obtained but circumstantial evidence suggests that the model output may be biased. The end result of the discussions that follow will indicate that, although the model forecast is within the range of uncertainty, it is likely that the forecast represents an optimistic rate of recovery for the Upper Hudson.

4.1 Model Calibration

The primary reason that model predictions of rates of natural attenuation are highly uncertain is the limited amount of temporal sediment calibration data available. The HUDTOX model uses reach-averaged concentrations in surficial cohesive and non-cohesive sediments as its main calibration target. Water column concentrations alone cannot constrain the calibration because they are highly variable and driven in large part by the incompletely known upstream background load. Downstream of the Thompson Island Dam, there were only two temporal data points in the sediment, for 1977 and 1991, available for model calibration, and only the 1991 data directly resolve the surficial (0-5 cm) sediment concentrations. There are a variety of attenuation curves that can be fit between two points. Within the TI Pool, there are also 1998 GE data that became available at the end of the model calibration effort. Surface sediment concentrations in 1998 appear, on average, to be lower than the 1991 results, but the confidence limits generally overlap. Thus, the model fit for the TI Pool also is driven by the relationship between 1977 and 1991 results. The problem is that the 1977 results are highly uncertain, do not provide a fine vertical resolution, and have wide confidence ranges. Starting the model with an initial condition at a value other than the median estimate for 1977 could yield a calibration with a very different attenuation rate. Some supplemental evidence for calibration is provided by depth-composited sediment data from 1984 (TI Pool only) and 1994, but the model does not fit these that well, appearing to yield a consistent over-prediction of non-cohesive sediment concentrations (0-23 cm composites), while under-predicting cohesive sediment concentrations in reaches below Thompson Island Dam.

Among the more important issues addressed by the model are those related to the size of the sediment PCB inventory available for re-release to the water column and the rate at which this inventory is sequestered by deposition. These assumptions are largely embedded within the parameterization of the model since there are no direct measures of available inventory. Indeed given the highly variable nature of sediment deposition and resuspension seen in sediment cores (as discussed in the Low Resolution Sediment Coring Report [USEPA, 1998b]), the direct measurement and integration of these processes over a long period is nearly impossible. However, the parameterization of the model involves several factors that are intended to integrate these processes via a simplified representation. These factors (or parameters) are constrained by little more than the model calibration itself. That is, these parameters are constrained only to the extent that the model is able to reproduce the various monitoring data trends (*i.e.*, water column concentrations at TI Dam, surface sediment concentrations, etc.). The net result of their assigned values must yield a result that closely matches the available data trends.

The model calibration approach does not necessarily yield a unique set of values for the model parameters and indeed there may be several combinations of these values which are capable of meeting the limited data-based criteria, as noted in the RBMR (USEPA, 2000a). The parameters of greatest concern in this regard include the sediment-water exchange coefficient(s), the vertical mixing depth and the vertical mixing velocity. It is likely that these factors vary significantly between cohesive and non-cohesive sediment zones as well as by river mile, but data are lacking to specifically estimate these values by region or sediment domain. Related factors, specifically the deposition rates for cohesive and non-cohesive sediments are also poorly constrained and are largely based on the results of QEA's sediment transport model (SEDZL) which is in turn based on a very limited data set as well.

4.1.1 Vertical Mixing Rates

Comparison of the model results to the 1991 sediment data suggests that the vertical profile of PCB concentrations in cohesive sediments has a lower gradient than is predicted by the model, perhaps due to an underestimate of vertical mixing (USEPA, 2000a [RBMR] Figures 7-17 to 7-19). Other contributing factors may include a lack of explicit representation of groundwater advection, uncertainty in initial sediment conditions, and too high a burial rate. Greater vertical mixing in the cohesive sediments, which contain the highest concentrations of PCBs, would tend to keep the surface concentrations in both cohesive and non-cohesive sediments replenished and thus slow the predicted rate of natural attenuation within those locations. The Low Resolution Sediment Coring Report found a loss of PCB mass from areas with high PCB concentrations that is greater than that implied by HUDTOX at the reach-averaged scale, suggesting that the rate of mixing of vertical mixing in HUDTOX may be low.

It is important to note that the vertical mixing velocity and the vertical mixing depth represented in the model are not "real" constants or parameters that can be measured directly, but rather are part of the necessary simplification of the sediment mixing and exchange processes which must be represented by the model. As part of this simplification, the sediment portion of the model has been constructed as a series of thin layers representing various areas of the river with associated exchange rates. This construction is designed as a manageable means to estimate and integrate the net effects of the highly complex processes of sediment resuspension and settling, biological mixing (bioturbation), sediment bedload transport, anthropogenic disturbances such as boat traffic, storm events, ice scour, and other related processes. While some of these processes are directly represented in the model (*e.g.*, flow-driven resuspension), the model still represents a great simplification of the transport, placement and removal of sediments on the river bottom. Indeed, the PCB contamination of the sediments has been extensively documented and shows conditions that have much greater spatial variability than can be represented in the model.(Brown *et al.*, 1988; USEPA, 1998).

The horizontal scales of the model segment are much greater than the scales of local homogeneity documented by the kriging analysis presented in the Data Evaluation and Interpretation Report (USEPA, 1997a). For comparison, the model is implemented at the scale of sediment segments, which range in size up to approximately 138,000 m^2 in the Thompson Island Pool, and up to approximately 1,283,000 m^2 downstream of the Thompson Island Pool. Model calibration was conducted primarily at the reach scale of average conditions across the Thompson Island Pool, or greater than 2,300,000 m^2. In contrast, sediment mass and concentrations exhibit large variability at areal scales of 10,000 m^2 (USEPA, 1997a). Foraging areas for resident fish may also be well less than 10,000 m^2 (USEPA, 2000a).

Lacking any true constraint in observable data, the vertical mixing depth and the vertical mixing velocity were constrained by limited evidence from site-specific coring data, values from the literature, and, finally, by the model calibration as was described in Section 6.11 and Chapter 7 of the RBMR (USEPA, 2000a). Principally, this meant achieving the measured trend in surface sediments as recorded by a limited number of sampling events, *i.e.*, satisfying the sediment concentration data obtained from GE composite samples collected in 1991 and 1998. In many regions of the river this amounted to only two data points over the calibration period. A further limitation arose from the lack of data to describe differences in cohesive and non-cohesive sediment conditions. Thus both sediment types were assigned the same rates of vertical mixing in the Thompson Island Pool (see Table 7-1 in the RBMR). Mixing depth was set shallower for non-cohesive sediments based on best professional judgement, noting that biological mixing is driven by benthic animals and the density of these animals is lower in coarser, non-cohesive sediment areas. Mixing depth and associated rates were also varied as a function of river section with shallower mixing depths in non-cohesive sediments and slower rates of mixing assumed moving downstream.

These assumptions are justifiable given the shortage of appropriate data and the desire to satisfy the measured surface sediment trends. Although data were available from individual cores that relate to these parameters, these data do not provide a basis for integration across whole reaches. For example, what are the values of these parameters for a region of fine-grained sediments which continues to accumulate sediment at its center while being eroded away at its edges? The *effective* vertical mixing depth as a segment-average representation may be much greater than the few centimeters of homogeneous concentration that might be obtained from a core collected at its center. A core collected near its edge would also tend to show a thin mixing depth as sediment might be removed faster than it could be homogenized vertically. Thus coring results that are representative of local, small-scale mixing rates may not be representative of large-scale sediment mixing in the same region.

Evidence for just such an occurrence can be seen in the USEPA and GE cores collected from *hot spot* 28. Figure 6 represents four cores collected by GE from this *hot spot* in 1998. These cores were intended to match results obtained by the USEPA collected from this area in 1994. Plate 1 shows the locations of these samples along with all other discrete core samples collected by GE in 1998 and 1999. Evident in the two upper diagrams of the figure are peak concentrations located quite close to the sediment-water interface (15 cm or less). These results should be contrasted against the lower two diagrams in the figure, which show peak concentrations at greater depth. All diagrams show a region of relatively homogeneous PCB concentration in their uppermost layers. However, the upper diagrams show a very abrupt transition with concentrations changing more than a factor of four in less than 5 cm. The lower diagrams show a much more gradual change among layers. The fact that the peak concentrations lie so close to the surface and change so abruptly suggests that these sites were subject to a sequence of deposition and scour, perhaps followed by another period of deposition. Thus the vertical mixing rate for this area does not appear to be a balance between a slow rate of deposition with accompanying bioturbation. Rather it may be a dynamic balance of periodic deposition and scour, which potentially serves to re-release a large portion of the existing inventory. The model's spatial scales cannot reflect these local processes and therefore there may be local effects which should be considered separately.

Further support of this assertion can be obtained by comparing the GE results with the matched USEPA low-resolution cores. These are shown in Figure 7. The diagrams in Figure 7 represent four coring locations in 1994 that were replicated in 1998 by GE. The diagrams correspond exactly to those in Figure 6 (*i.e.*, USEPA core LH-28E is the same location as GE core FS-28-1). Although the low-resolution cores lack the fine vertical resolution of the GE cores, they still indicate that the peak concentrations with the sediments in 1994 were substantially deeper relative to 1998 at the sites represented by the upper two diagrams. This would suggest that sediment scour had occurred at these locations during the intervening years. This assertion is also supported by the sediment inventory as represented in mass-per-unit-area. The results are summarized in Table 6. Note that the inventories for sites LH-28E and LH-28I have both declined while the other two sites have remained the same. While these data are too few in number to accurately calculate a loss between 1994 and 1998, the data do suggest that the area is not inherently stable and that its losses are not driven by a simple vertical mixing process. Indeed, the results suggest that "horizontal" mixing, *i.e.*, losses at the perimeter of the area may be quite important. The end result is to suggest that the effective vertical mixing rate and depth for this area may be much greater than that inferred from individual core profiles and expected levels of biological activity. Presumably, similar conditions may be found elsewhere in the Hudson.

Although the example above focuses on the impact of sediment movement on the effective vertical mixing rate and depth, the distribution of the biological community should also affect the relative values of these parameters for cohesive relative to non-cohesive sediments. Specifically, both the biological community and the cohesive sediments are concentrated in the near-shore environment. In particular, the biological community is centered in the finer-grained sediments since these contain higher concentrations of organic matter that are capable of supporting a more robust food web. Along with the higher concentration of biota would be expected higher levels of bioturbation, thus faster and deeper vertical mixing. The parameters used in the model do not account for this phenomenon, because it is not easily quantified and is likely to predominate at spatial scales smaller than those represented in the model.

Reliance solely on core profiles and literature discussions may serve to underestimate these parameters as well, as dateable, undisturbed core profiles are, of necessity, obtained from areas that experience only limited vertical mixing and disturbance of the profile. Use of lower mixing rate and depth values would serve to predict the sequestering of PCBs in the cohesive areas of the river more rapidly than may actually be achieved, thus yielding a more rapid rate of recovery than may actually occur. Additionally, use of mixing depths that are shallower than the *effective* mixing depth may inappropriately predict the depletion of the PCB inventory from the zone of active exchange (by whatever process) and again yield an overly optimistic recovery trajectory for the No Action scenario. Notably, this will also affect the remedial scenario model runs since the model will underestimate the impact of the remediation of cohesive sediment areas.

4.1.2 Exchange Coefficients

HUDTOX was not able to balance PCBs across the Thompson Island Pool under non-scouring conditions using only physical processes explicitly contained in the model. To replicate observed concentrations, it was instead necessary to specify a non-scouring transfer rate of PCBs from sediment to water. This transfer is described as a concentration-gradient process with rate factor k_f, with the same factor applied to both cohesive and non-cohesive sediments, and was determined by fitting to concentration data at the upstream and downstream ends of the Thompson Island Pool. The data-based value of k_f, in combination with the representation of sediment deposition and sediment vertical mixing, determines the relative rates of attenuation of surface concentrations in cohesive and non-cohesive sediments. It should be noted that a single value of k_f does not produce the same Tri+ sediment-water fluxes in cohesive and non-cohesive areas since these areas have different surface concentrations. Nonetheless, it seems possible that different mass transfer coefficients might apply to cohesive and non-cohesive sediments, particularly if the transfer is biologically mediated. If so, an alternative model calibration might be obtained by varying the mass transfer and vertical mixing rates simultaneously.

For model application, values of k_f were estimated from the water column data collected by GE at the upstream and downstream ends of the TI Pool. Observed gains in concentration across the TI Pool at non-scouring flows define k_f. While this approach matches the net gain in Tri+ integrated across the entire TI Pool, it does not take into account any differences in the exchange coefficient between cohesive and non-cohesive sediment. This parameter, just like the rate and depth of vertical mixing, is expected to be biologically influenced. Indeed, the temporal pattern of PCB release from the sediments of the TI Pool strongly suggests such an influence. Again, however, no data are available to definitively determine the degree of difference. Thus the model was calibrated with identical rates for cohesive and non-cohesive sediments.

In addition to the temporal variation of the PCB load from the sediments, there is further evidence that cohesive sediments may have a higher exchange coefficient. Specifically, the float surveys conducted by GE in 1996 and 1997 both documented enhanced surface water concentrations in the near-shore environment. Thus both the concentration of biological activity in the near-shore, cohesive sediment environment as well as the water column float survey data suggest that the sediment-water exchange coefficient for cohesive sediment should be greater than that for non-cohesive sediment. This was examined to a limited extent in Chapter 7 of the RBMR (USEPA, 2000a) and showed that the model calibration was sensitive to this parameter.

The net result of using the same exchange coefficient for both cohesive and non-cohesive sediment could be to over-emphasize the non-cohesive sediment PCB release relative to that from the cohesive sediment. This has potential significance to the remedial decision-making process, as the cohesive sediment *hot spot* areas contain substantial reservoirs of PCBs near the sediment surface.

It is also unclear whether a diffusion-like representation of the sediment-water flux, driven by concentration gradient and interfacial area, is appropriate for summer conditions in TI Pool. Measurements at TID-West over the last four years show summer water column concentrations that are nearly constant for a given month despite a two-fold variation in summer flows. An alternative hypothesis would be that biologically driven sediment-water exchange processes establish near steady-state conditions in the nearshore area, and that water column exposure concentrations are thus a direct function of sediment concentration rather than the sediment-water gradient. If the biological processes operate to a greater depth in the near-shore sediments, this would result in a condition in which the rate of attenuation in exposure concentrations would be expected to be less than is predicted by the HUDTOX model.

Given that the exchange coefficients and the vertical mixing rate and depth are uncertain, then model forecasts of the rate of decline of the PCB concentration in cohesive sediments are also uncertain. Additionally, given the uncertainties in the various parameters, it is conceivable that an alternative calibration could be attained with modified values for these coefficients, *i.e.*, with higher rates for cohesive relative to non-cohesive sediments. The net result could be to yield a larger reservoir of PCB-contaminated sediments available for exchange, resulting in a greater redistribution of PCBs between cohesive and non-cohesive sediments. Low estimates for the cohesive exchange coefficients also affect the remedial action scenarios since, just as for the vertical mixing, the model estimate for remedial alternatives focused on cohesive sediments will not yield as dramatic an effect as may actually be observed.

4.2 Summer Water Column Conditions

Summer water column concentrations represent an important route of exposure for fish in the Upper Hudson. Summer water column PCB concentrations for the period 1996 to 1999 do not show clear trends, indicating that the concentration is possibly controlled by sediment-water exchange and, more importantly, that this process and the sediments that drive it have not declined significantly over this period.

Figure 8 illustrates the consistency of summer surface water concentrations at four stations in the Upper Hudson for the period 1991 to 1999. The most obvious feature for both total PCB and Tri+ is the large change between 1992 and 1993 conditions. Also notable are the near constant mean summer values for the period 1996 to 1999. When load is examined (see Figure 9) the conditions do not seem so constant. There is the expected summer load decline between 1992 and 1993 but also a continued decline in load despite the absence of change in water column concentration. However, when load is viewed as a function of flow, the reason for the decline between 1996 and 1999 becomes evident. The loads decline largely due to a decline in summer flows (see Figure 10). In fact, for the period 1992 to 1999 the relationship between flow and total PCB concentration is linear with a slope of unity. In these years, increases in PCB load are directly proportional to increases in flow. For example, the change in flow at Ft. Edward from 1998 to 1999 is 3500/1900 or 1.84. The change in total PCB load at TID PRW2 is essentially identical at 72/40 or 1.8. The Tri+ load is similar with a ratio of 45/18 or 2.5. The TID west station yields a ratio closer to 2 for Tri+.

The reason behind this correlation with load is the narrow range of PCB concentrations seen in the TI Pool under summer conditions. This is illustrated in Figure 11, which shows the mean monthly concentrations as a function of flow. The results show that within any given month, the water column concentrations remain approximately constant over time. This is clearly seen for July, August and September. June exhibits slightly more variability largely due to conditions in 1998. Typically, concentrations vary by about ±20 percent while flow varies by more than a factor of three (±58 percent).

These results suggest that the TI Pool PCB concentrations are tightly governed by a system at an effective steady state, given that flows remain relatively low. This system is able to maintain similar conditions over a relatively wide range in flow (1500 to 5500 cfs). This suggests in turn that this system is not undergoing a rapid rate of decline and has a sufficiently large reservoir of available sediment-bound PCBs such that no decline in surface water conditions is in evidence over the last four years. This is noteworthy given that the upstream loads have declined more than an order of magnitude during the period 1992 to 1999.

The goal of this discussion is to provide additional emphasis on the importance and potential scale of the sediment reservoir of PCBs in governing TI Pool conditions. Ultimately, it is this reservoir of sediments that must either be depleted or sequestered before PCB levels in fish will decline to levels governed by upstream PCB loads.

4.3 Sediment Redistribution Rates: Evidence from Core Data

Some evidence as to the model's ability to represent sediment redistribution is available from the core data. To the extent that upstream sediment loads control surface sediment concentrations, it would be expected that surface sediment concentrations would decline in response to the decline in upstream surface water loads post-1992. If declines in surface sediment did not occur this would suggest the presence of other mechanisms that exert important controls.

For the GE cores collected in 1998, surface sediments would be responding to the more than order-of-magnitude decline in the upstream load between 1991 and 1997. The decline in water column loads and concentrations is summarized in Table 7. Both the linear interpolation technique (with pulse load corrections) and the ratio estimator yield more than an order-of-magnitude decline in annual load at Ft. Edward.

The 1998 GE coring results were summarized in the RBMR (USEPA, 2000a) in Figures 6-52a, b and c. These figures are reproduced here as Figure 12a through 12c. These core profiles represent a series of cores collected from *Hot Spots* 8, 9, 14, 16, 28, and 37 along with three additional "high resolution"-style cores collected from the TI Pool. The locations of these cores are shown in Plate 1. Most of these coring locations were selected to be coincident with low resolution coring sites (labeled "FS" by GE). The thin upper layers of these cores provide information on the most recent deposition. Evident in Figures 12 a-c is a wide range in trends in the surface sediments with some concentration profiles rising to the surface, some declining and some exhibiting little change in the top ten centimeters. These trends occurred in spite of the dramatic decline in upstream water column PCB loads; that is, they are subject to many other processes besides the upstream load at Ft. Edward.

Given the known trend in external loads, the trend in surface sediment concentration can be used as an indirect measure of the speed and direction of deposition. In instances of rapid sediment accumulation with little vertical mixing, the sediment concentrations would be expected to decline to the same degree as the water column. This is based on an assumption that the surface sediment concentrations are directly correlated with the upstream loading. To the extent that this is not the case, then processes such as vertical mixing and contaminant redistribution within the Pool would be the likely causes of the variable trends.

In Figures 12a, b and c, the range of sediment trends in the top ten centimeters indicates that a range of deposition conditions is present. The fact that water column loads peaked and then declined an order of magnitude in six to seven years would suggest that sites with rising surficial profiles have accumulated little sediment since the 1991 event, thus leaving the high concentrations associated with the Allen Mills releases at the sediment surface. This is suggested by profiles such as FS-08-5, FS-08-6, FS-09-3 and FS-09-4. Alternatively, in the case of FS-08-5 and FS-08-6, long term scour may be at work since the core maximum, and not just a local maximum, occurs at or just below the sediment-water interface. This can be seen in the profiles presented in Figure 12a.

GE obtained additional coring data in 1999 in portions of *Hot Spots* 14 and 16. These data are summarized in Figures 13a to 13d. Nearly all cores were advanced to 15 cm and sliced into 5 cm intervals. These results indicate that *Hot Spot* 14 can be characterized as exhibiting gradual burial in some areas, with core concentrations generally increasing with depth. However, this *hot spot* also contains surface sediments (0-5 cm) as high as 600 mg/kg, suggesting the continued presence of highly contaminated sediments that are not being buried. These hot surface areas might have been re-exposed by scour, or perhaps were simply emplaced in a non-depositional area in the mass movement of sediment that occurred following the removal of the Fort Edward Dam in 1973 and the high flows of the next several years. The core samples for *Hot Spot* 16 are more consistent, with higher concentrations at depth and generally a small range of surface sediment concentrations. This area is indicative of a more consistently depositional environment.

Overall, the core profiles exhibit a wide range of conditions. Only a few exhibit an order-of-magnitude decline in concentration over what might be expected to be the last 6 years of deposition, that is, in the top 5 to 15 cm (see FS-08-3, FS-09-1 and FS-09-2 as examples). The reason for the general lack of decline in the surface sediments is unknown but is undoubtedly related to the cycling of PCBs within and among the Hudson sediments. Both vertical mixing as well as horizontal mixing would serve to maintain contaminated levels near or at the surface.

To represent the fine-scale, heterogeneous nature of the mixing process shown in the core profiles at the broader spatial scale of the model, HUDTOX must make several simplifying assumptions concerning the nature of sediment mixing. Specifically, nearly all sediment mixing is tied to the vertical mixing coefficients. However, this represents an approximation since the importance and magnitude of horizontal mixing is not well constrained, as noted previously. Additionally, the heterogeneity of the core data emphasize that the vertical mixing depth and vertical mixing velocity cannot be determined from the sediment profiles themselves since the cores do not exhibit a single depositional behavior, even within a relatively small area such as a *hot* *spot.* Rather, these parameters depend strongly on the model conceptual approach and on its levels of spatial, temporal, and process resolution of the underlying fine-scale processes of sediment movement. As such, they cannot be determined independently of the model and thus their magnitude is strongly dependent on the model assumptions.

4.4 Evidence from the Low Resolution Sediment Coring Report and Supporting GE Data

The Low Resolution Sediment Coring Report (USEPA, 1998b) suggests rates of PCB loss from areas with PCB inventories greater than 10 g/m^2 that are higher than those suggested by the HUDTOX model (although the difference is not statistically significant). GE has commented that this supposed discrepancy casts doubt on the LRC results. While USEPA believes that this can be explained primarily by the differences in the scale of the analyses, another explanation could be that the differences could reflect inaccuracies in the modeling. Some additional evidence on this subject is available from examination of GE coring data.

As part of the examination of the GE sediment data, results were compiled on a Tri+ mass-per-unit-area basis to enable direct comparison among the 1984, 1994 and 1998 sampling programs. These results are summarized in Table 6 for the region below Thompson Island Dam. The GE data generally agree with the matched USEPA low resolution coring data in this region, with a potentially important difference noted in Section 3.1 above. Both surveys confirm the presence of highly contaminated sediments in *Hot Spot* 28 and yield similar levels of PCB inventory in *Hot Spot* 37.

A more useful comparison can be made between the 1984, 1994 and 1998 data for the Thompson Island Pool. The mass-per-unit-area results obtained for both the 1994 and 1998 sampling programs are clearly less than those obtained in 1984, confirming the occurrence of significant PCB losses from fine-grained areas of the TI Pool. These results are summarized in Figure 14, which presents the percent mass loss relative to 1984 plotted as a function of the reported 1984 inventory. With the noted exception of the *Hot Spot* 9 cores, the losses estimated from the GE cores were comparable to or greater than that obtained from the 1994 cores in the same area.

The net result of this analysis is a confirmation of the Low Resolution Sediment Coring Report conclusions, the most important of which is repeated here. Specifically, since 1984 there has been a significant loss of the total PCB inventory from some of the more contaminated sediment areas of the Upper Hudson. As surface sediment concentrations have remained elevated in many of these areas, this loss must occur in conjunction with either vertical mixing of buried PCBs or by scour. Presumably a significant fraction of the PCB mass loss from these areas was redistributed to other nearby sediments while the remainder was transported downstream. The corollary to this conclusion is also worth restating here: The long-term burial of PCBs within the sediments of the Upper Hudson is not assured, since natural sedimentological processes such as resuspension, deposition and bioturbation serve to renew the PCB concentration in the surface sediments of the riverbed. Apparent discrepancies between the LRC and HUDTOX modeling results are likely due to differing spatial scales of observations and modeling, as the model is not designed to simulate the lateral redistribution of sediment within a model segment.

4.5 Conclusions Regarding Potential Model Bias

The conclusions of the analysis of potential model bias are briefly described below:

1. The HUDTOX model is based, wherever possible, on constraints derived from data and avoids using circumstantial evidence to determine model parameters. However, the data are not sufficient to fully constrain a unique set of parameters. The model does not incorporate built-in conservative assumptions, and potentially may over-estimate rates of natural attenuation. Application of a margin of safety to model results is appropriate to select a remedial option that provides reasonable assurances of meeting risk targets.

2. Sediment core tops show a wide range of conditions, even within the upper ten centimeters, indicating the complexity and heterogeneity of the sediment-PCB transport process. As a result, there is little direct sediment core evidence to constrain the vertical mixing parameters.

3. The model parameters for vertical mixing velocity, vertical-mixing depth, sediment-water exchange from specific sediment areas, and sediment deposition are poorly constrained by data and largely dependent upon the model calibration. These parameters were not specifically developed to address cohesive and non-cohesive sediment conditions and may underestimate the role of cohesive sediments in the Upper Hudson PCB balance. Data to define the spatial resolution of these parameters are limited and the assigned values may not accurately characterize the relative contributions of cohesive and non-cohesive sediments. This raises the possibility that the model may represent a somewhat optimistic estimate of the rate of river recovery at the model segment scale. Even slower rates of recovery are likely in localized areas at scales smaller than the model segments.

4. Summer water column conditions show little sign of decrease over the past 4 years. These results suggest a robust system of sediment-water exchange that may not be sensitive to rapid depletion of PCB concentration at the sediment-water interface. Thus, the model is also potentially optimistic as to the rate of decline in water column exposure concentrations.

5. The 1998 GE coring results confirm the major conclusions of the Low Resolution Sediment Coring Report. Specifically, since 1984 there has been a significant redistribution of PCB mass from some areas of high concentration in the Upper Hudson.

6. The long-term burial and sequestration of PCBs within the sediments of the Upper Hudson is not assured. Even if burial and depletion of near-surface concentrations occurs at the reach-averaged scale, this does not assure reduction of sediment exposure concentrations at the more localized scale at which fish feed.

5. Spatial Scale

The choice of model spatial scale influences both the model behavior over the forecast period and the ability of the model to represent potentially important processes occurring on a small spatial scale. For example, a model representing the entire TI Pool as a single cell would not be able to distinguish between actively eroding portions of TI Pool and depositional areas. Such a model could only capture the average changes in concentrations in the TI Pool. A finer scale model may well describe the same average behavior as a single-cell model. However, it could also potentially describe fine-scale differences in erosion and scour behavior. The HUDTOX model represents long-term dynamics on the scale of the model segments, but not specific events on smaller spatial scales (it predicts net erosion or net deposition within a given model segment). Erosion may also be occurring on smaller spatial scales, maintaining elevated surficial concentrations in localized areas, which may not show up in the forecast predictions. As noted previously, the spatial scale of sediment segments within the Thompson Island Pool ranges up to 138,000 m^2 in the Thompson Island Pool and up to approximately 1,283,000 m^2 downstream of the Thompson Island Pool, whereas sediment mass and concentrations exhibit large-scale variability at areal scales of less than 10,000 m^2 (USEPA 1997a).

During the RBMR Peer Review, it was emphasized that the Hudson River is not a lake. In a lake, deposition is likely to be relatively constant and homogeneous, resulting in burial of inplace sediments. In the more dynamic riverine environment of the Hudson, deposition is expected to vary in both space and time.

The spatial variability of deposition means that net deposition at the reach-average scale does not guarantee that any specific location within the river is being buried at the reach-averaged rate, and some locations may be subject to intermittent scour, while others simply may not receive any significant deposition. This type of situation is evident in the area of *Hot Spot* 14 in the Thompson Island Pool. *Hot Spot* 14 appears to have been emplaced by mass movement of sediment following the removal of the Fort Edward Dam, and not by regular depositional processes. As discussed in the previous section and shown in Figures 13a and 13b, recent vertical profiles in this area appear to show a mix of some areas receiving gradual deposition and other areas that are either being eroded or at least are not being buried. The key to understanding these observations is that they represent processes which are occurring at a spatial scale smaller than can be represented in the HUDTOX model.

Net deposition occurring within a river segment should also not be confused with the *steady* deposition typical of lake environments. In many areas in which net deposition does occur, it is likely to occur through a seasonal cycle of disturbance and resettling, which may include bedload movement and sediment wave propagation. This can result in a situation in which new sediment mixes with, rather than overlays existing sediment. In such a situation, deposition does not result in "capping" of existing sediment inventory; rather it leads to gradual dilution of the surface sediment concentration (Figure 15).

Nonetheless, as noted in previous sections, HUDTOX provides the best basis to forecast future conditions on a *reach-averaged* basis. But, fish do not feed on the reach-averaged scale. Indeed, their foraging range is likely to be significantly smaller. For instance, the reported foraging range of largemouth bass is on the order of 7,000 square meters (RBMR [USEPA, 2000a], Appendix A). Thus, representation of average geochemical processes at the model reach scale does not guarantee accurate representation of exposure concentrations experienced by individual fish.

These concepts are useful for understanding limitations of the model and for comparing the HUDTOX predictions and observations from the LRC (USEPA, 1998b). Because the HUDTOX model segmentation can only describe average behavior on the scale of the segmentation grid, the model may not show erosion of sediments in a model segment, even though such processes may in fact be occurring at specific locations within the segment. The importance of these erosion processes could increase in the future. The LRC findings may provide insight into the variability of these processes and do in fact seem to support the notion that there may be reworking of the sediments on scales finer than the model segmentation.

The relative importance of exposure from fine-scale areas of elevated sediment concentration may increase over time as surface sediment concentrations continue to decline, given the assumption that bioaccumulation by benthos is driven by the concentration gradient between sediment and the organisms. The model may predict that segment-averaged concentrations show a steady decline due to net deposition of cleaner sediments. But, if localized areas of higher concentration continue to be exposed, significant bioaccumulation by benthos may occur despite the segment-average decline in concentration. For example, the influence of a localized sediment area exposed at an average PCB concentration of 10 mg/kg within a specific river subsection is larger if the other sediments are at 0.2 mg/kg as opposed to 2 mg/kg. This may cause a change in the rate of response of average surface sediment concentrations from that observed in the calibration, and the model may not necessarily describe this because the localized areas of scour are smaller than the model segmentation.

The significance of the points discussed above is that even though the model may predict net deposition on a river subsection basis over the forecast period, there may be localized areas that continue to experience erosion. These localized areas are at spatial scales smaller than can be accurately represented in the model given available data; however, they may have an important impact on PCB body burden of fish that forage in the area. Remediation that addresses such areas will provide risk reduction benefits that cannot be captured at the segment-averaged scale of the models.

6. Construction of a Bounding Forecast

In general, HUDTOX and FISHRAND represent credible, defensible tools for forecasting time trends in PCB concentrations in the Hudson River. But, these forecasts are subject to considerable uncertainty, and deficiencies in the data available for calibration raises the possibility that the model "best estimate" of trends could be overly optimistic for the No Action and Monitored Natural Attenuation scenarios. This is particularly likely at localized spatial scales at which fish feed, and may be reflected in the lack of a declining trend in recent fish data collected by NYSDEC in TI Pool and in the Stillwater-Coveville area.

The discussions in previous sections highlight the rate of decline of bioavailable cohesive sediment PCB concentrations (at the local exposure scale) as a key uncertainty for the model forecasts. To address this issue, an upper bound forecast may be constructed based on the assumption that sediment exposure concentrations experienced by fish decline at a slower rate than predictions at the reach scale provided by HUDTOX.

Construction of this alternative, bounding forecast starts from 1998, because FISHRAND is calibrated to data through 1997, and provides a good estimate of fish concentrations (on a lipid basis) in the 1998 validation period. A slower rate of decline in the cohesive sediment exposure concentration is assumed from this point, and compared to the No Action and Monitored Natural Attenuation forecasts obtained directly from HUDTOX and FISHRAND. The following procedure was used to develop the bounding forecast:

1. Assume HUDTOX provides a best-estimate forecast of water column concentrations and non-cohesive sediment concentrations. These concentration fields are likely to be less heterogeneous than cohesive sediment concentrations, and the ability of the model to predict water column loads is validated at the reach scale. The potential for model bias in the prediction of water column concentrations, both temporally and spatially, as discussed above, is not accounted for in the bounding forecast, but should be considered in the risk management process.

2. Assume that localized bioavailable surface sediment concentrations (that is, the PCB concentration in the depth range subject to feeding by burrowing benthic organisms) in cohesive sediments declines at a rate much slower than the reach averaged rate predicted by HUDTOX. Assume that the 1997 sediment exposure concentrations are approximately correct (that is, they result in approximately correct predictions of lipid-based fish body burden with the calibrated FISHRAND model), but that the half-life for future declines in cohesive sediment exposure concentration is on the order of 50 years, consistent with recent observations of concentration trends in brown bullhead in the Thompson Island Pool.

3. Calculate sediment exposure concentration by year assuming 75 percent of exposure is derived from cohesive sediments (based on 1997 concentrations with a 50-year half-life) and 25 percent from non-cohesive sediment concentrations predicted by HUDTOX. This is consistent with assumptions used for the sediment exposure pathway in previous FISHRAND modeling.

4. Substitute the new forecast sediment exposure field into FISHRAND and re-run the No Action and

Monitored Natural Attenuation (MNA) scenarios to provide a bounding calculation. These scenarios are run with a model "spin up" that includes the 1991 sediment reinitialization and 1998-1999 HUDTOX validation results, using observed flows and upstream loads, except that the 50-year half life trend is imposed on cohesive sediment exposure concentrations starting in 1997.

Results of the alternative bounding forecast for the No Action (constant upstream load) and Monitored Natural Attenuation (step-down upstream load in 2005) are shown in Figures 16–21 for largemouth bass, brown bullhead, and yellow perch at RM 189 (Thompson Island Pool) and RM 184 (Schuylerville). In these figures, the bounding forecasts are denoted as "No Action (alt.)" and "MNA (alt.)"

As is evident from the figures, assumption of a slower rate of decline in cohesive sediment exposure concentrations has a large impact on forecasts. The difference between the alternative bounding calculation and the baseline HUDTOX/FISHRAND forecast is greatest for brown bullhead, as these are the fish whose PCB body burdens are most closely tied to sediment concentrations. Interestingly, the magnitude of the responses to the alternative formulation are different at RM 189 and 184, particularly for largemouth bass. This reflects the fact that the FISHRAND calibration differs above and below Thompson Island Dam, reflecting differing observations on total organic carbon concentrations and benthic lipid content. As a result, largemouth bass body burdens are simulated as being more strongly dependent on sediment exposure concentrations at Schuylerville than in the Thompson Island Pool. It is also of interest to note that when the cohesive sediment concentrations are held high, the MNA and No Action results converge for the species more sensitive to sediment exposures. This implies that the major impact of upstream load reduction in the HUDTOX forecasts for MNA is through its effect on depletion of near-surface cohesive sediment concentrations in the model. Given the presence of areas such as *Hot Spot* 14 in which near-surface PCB concentrations do not appear to depend strongly on upstream PCB concentrations, construction of a bounding forecast which essentially decouples the localized sediment exposure field from upstream appears reasonable.

Table 1. Half-Life Comparison of Model and Data Lipid-Based Annual Average PCB Concentrations in Fish

		Thompson Island Pool (RM 189)					Stillwater Reach (RM 168–176)				
		1985–99	1985-91	1995-99	1999-2004	1999-2020	1985–99	1985-91	1995-99	1999-2004	1999-2020
Brown Bull-head	Data - Consistent Tri+	5.57 (1986-99)	3.06 (1986-91)	50.00			6.97	3.61	Increasing		
	Data - NYSDEC Sum	8.15 (1986-98)	4.65 (1986-91)	Increasing (1995-98)			8.51 (1985-98)	4.28	Increasing (1995-98)		
	Data - NYSDEC 1254	5.41 (1986-98)	3.30 (1986-91)	14.48 (1995-98)			7.47 (1985-98)	3.57	Increasing (1995-98)		
	Model	5.22	4.42	7.27	8.75	12.65	9.83	10.69	6.06	5.89	12.30
Large-mouth Bass	Data - Consistent Tri+	12.78	Increasing	Increasing			9.19	6.10	41.95		
	Data - NYSDEC Sum	46.97 (1985-98)	Increasing	Increasing (1995-98)			15.90 (1985-98)	17.53	20.44 (1995-98)		
	Data - NYSDEC 1254	21.26 (1985-98)	294.01	Increasing (1995-98)			9.81 (1985-98)	11.99	10.56 (1995-98)		
	Model	7.35	5.05	4.10	12.66	25.16	9.65	9.10	7.18	6.52	13.18
Pump-kinseed	Data - Consistent Tri+	5.91 (1987-98)	Increasing (1987-91)	Increasing (1995-98)			7.96 (1985-98)	7.43	2.66 (1995-98)		
	Data - NYSDEC Sum	15.04 (1987-98)	Increasing (1987-91)	Increasing (1995-98)			25.61 (1985-98)	18.46	3.37 (1995-98)		
	Data - NYSDEC 1254	9.87 (1987-98)	Increasing (1987-91)	Increasing (1995-98)			12.63 (1985-98)	15.77	2.83 (1995-98)		
	Model	8.10	7.44	4.33	38.62	35.38	9.62	11.40	7.21	6.06	13.09

		Thompson Island Pool (RM 189)					Stillwater Reach (RM 168–176)				
		1985–99	**1985-91**	**1995-99**	**1999-2004**	**1999-2020**	**1985–99**	**1985-91**	**1995-99**	**1999-2004**	**1999-2020**
Yellow Perch	Data - Consistent Tri+								Increasing		
	Data - NYSDEC Sum						5.78 (1984-98)		Increasing (1995-98)		
	Data - NYSDEC 1254						5.10 (1984-98)				
	Model	7.16	5.74	4.36	14.87	25.44	9.82	9.80	7.00	6.36	12.37

Notes:

Consistent Tri+: NYSDEC data converted to consistent Tri+ basis (see RBMR) plus NEA congener data.
NYSDEC Sum: Uncorrected sum of lipid-based PCBs reported by NYSDEC, including provisional 1999 results
NYSDEC 1254: Uncorrected Aroclor 1254 quantitations reported by NYSDEC.
Model: Output of HUDTOX/FISHRAND models on lipid basis; forecasts represent No Action simulation with constant load upstream boundary. Annualized arithmetic means computed from 25th, 50th, and 95th percentile estimates.

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Table 2. Model Half Lives (years) for Annual PCB Tri+ Water Column Load

	Thompson Island Dam	Northumberland Dam (Schuylerville)	Federal Dam (Waterford)
1985-1999	9.81	9.72	10.56
1985-1990	18.99	24.49	27.26
1985-1989	5.23	5.65	6.02
1995-1999	9.12	7.65	7.85
1999-2004	14.37	10.79	5.51
1999-2020	23.85	18.54	12.19

Table 3. Model Half Lives (years) for Average PCB Tri+ Water Column Concentration

Annual Average	Thompson Island Dam - West	Northumberland Dam (Schuylerville)	Federal Dam (Waterford)
1985-1999	9.45	9.57	9.816
1985-1990	6.15	6.36	6.24
1995-1999	7.75	7.18	6.92
1999-2004	67.82	25.71	8.56
1999-2020	29.49	23.64	13.25
Summer Average (May-September)			
1985-1999	9.14	9.13	9.42
1985-1990	4.50	4.84	5.21
1995-1999	7.18	6.73	6.79
1999-2004	63.67	24.56	8.83
1999-2020	24.83	20.73	12.75

Table 4. Half Life (years) for Tri+ PCB Concentrations in Surface Sediment Layer from HUDTOX Model

Time Span	TIP Average - Cohesive	TIP Average - Noncohesive	Lower TIP - Cohesive	Stillwater Pool - Cohesive	Federal Dam - Noncohesive
1977-1985	6.04	7.92	5.95	4.47	5.91
1985-1990	5.84	8.27	5.60	4.63	6.16
1985-1999	8.40	9.54	4.50	10.23	7.78
1991-1998	8.16	8.87	8.42	5.17	10.37
1995-1999	7.89	9.10	8.38	5.28	9.50
1999-2004	7.36	9.86	7.22	4.72	6.64
1999-2020	9.42	10.22	11.45	9.90	8.97

Notes: Estimates correspond to the model series used in FISHRAND, which combine the longterm hindcast for 1977-1990, 1991 restart short-term hindcast for 1991-1997, validation runs for 1998-1999 using actual boundary conditions, and No Action constant upstream load forecasts (p3nacw) for 2000 on.

The TIP average results represent averages across all model segments within the Thompson Island Pool. The last three columns are results from the segments of the HUDTOX model used in the FISHRAND calibration.

Table 5. Surface (0-5 cm average) PCB Concentrations in Co-located 1991 and 1998 GE Samples

Location	Sedt. Type	1991 Samples		1998 Samples		
		Identifier	Average Tri+	Identifier	Average Tri+	Change
TIP RM 193, East Shore	fine	8B-F3	5.36	BS-06T-200	3.88	-27.6%
TIP RM 193, West Shore	fine	8B-F6	6.44	BS-06F-100	2.47	-61.6%
TIP: above Snook Kill	fine	8C-F4, 8C-F5	10.72	BS-08F-100	5.64	-47.4%
TIP: opposite Snook Kill	fine	8C-F7	11.64	BS-08F-200	21.18	82.0%
TIP: Hot Spot 10	fine	8C-F6	31.10	BS-10T-100	18.69	-39.6%
TIP: Griffin Is., Hot Spot 14	mixed	8E-F4, 8E-F5, 8E-C2	40.72	BS-14T-100, BS-14F-200	36.85	-9.5%
TIP: below Griffin Is.	coarse	8F-C1	12.95	BS-15C-200	6.67	-48.5%
TIP: below Griffin Is.	coarse	8F-C2	1.07	BS-15C-300	1.11	3.7%
TIP: above TI Dam	mixed	8F-F3, 8F-C4	9.28	BS-18T-100, BS-18C-200, BS-18C-300, BS-18C-400	8.67	-6.6%
below Lock 6	fine	6B-F2	26.3	FS-28, 1-3	26.6	1.1%
Lock 3	fine	4AB-F1	5.83	FS-37, 1-3	5.47	-6.2%

Table 6. Comparison of Mass-per-Unit-Area Results from NYSDEC (1984), USEPA Phase 2 (1994) and GE (1998&99) Sampling Events

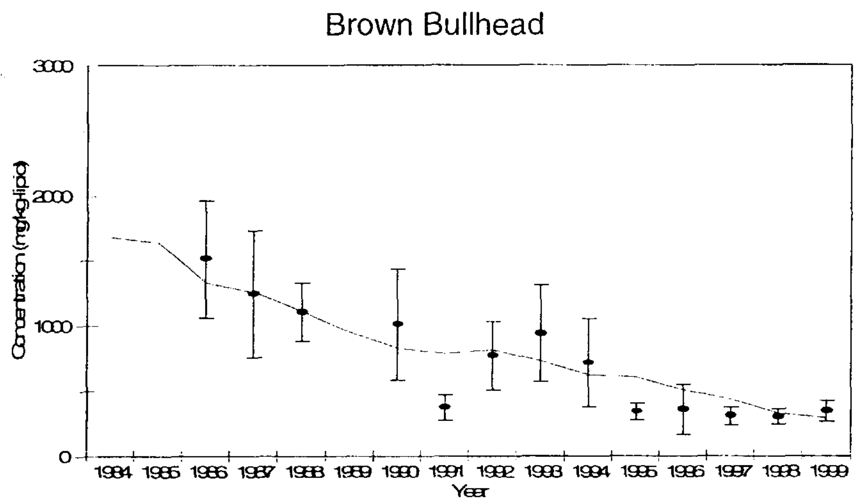
1994 Phase 2 Location	1984 Tri+ MPA g/m^21994 Tri+ MPA g/m^2		1998&99 GE Location 1998&99 Tri+ MPA g/m^2		Percent decline from 84 to 94 %	Percent decline from 84 to 98&99 %	Tri+ MPA Difference (94-84) g/m^2	Tri+ MPA Difference (94-98&99) g/m^2
Below [illegible] Dam								
LH-28E		75.73	FS-28-1	3.00				72.7
LH-28I		47.69	FS-28-2	41.21				6.5
LH-28M		54.59	FS-28-3	50.82				3.8
LH-28N		31.53	FS-28-4	32.68				-1.1
LH-37C		3.04	FS-37-1	6.68				-3.6
LH-37J		7.16	FS-37-2	5.42				1.7
LH-37K		1.76	FS-37-3	4.59				-2.8
LH-37O		25.95	FS-37-4	33.15				-7.2
TI Pool								
LR-12C	3.9	2.09	FS-08-5	3.14	-47	-20	-1.8	-1.1
LR-11C	48.0	10.50	FS-08-6	2.82	-78	-94	-37.5	7.7
LR-11B	62.1	13.09	FS-08-7	2.18	-79	-96	-49.0	10.9
LR-09F	11.7	3.54	FS-09-1	3.31	-70	-72	-8.2	0.2
LR-09E	43.0	4.01	FS-09-21	0.68	-91	-98	-39.0	3.3
LR-09C	23.4	6.00	FS-09-3	16.97	-74	-27	-17.4	-11.0
LR-09A	11.1	5.46	FS-09-4	9.09	-51	-18	-5.7	-3.6
LR-09D	75.4	2.00	FS-09-5	6.11	-97	-92	-73.4	-4.1
LR-04A	68.3	7.30	FS-14-1	14.13	-89	-79	-61.0	-6.8
LR-04A	68.3	7.30	FS-14-11	20.17	-89	-70	-61.0	-12.9
LR-04A	68.3	7.30	FS-14-12	22.84	-89	-67	-61.0	-15.5
LR-04A	68.3	7.30	FS-14-13	17.02	-89	-75	-61.0	-9.7
LR-04A	68.3	7.30	FS-14-14	15.43	-89	-77	-61.0	-8.1
LR-03A	17.6	0.07	FS-16-1	0.20	-100	-99	-17.5	-0.1
LR-03A	17.6	0.07	FS-16-14	0.12	-100	-99	-17.5	0.0
LR-02B	52.7	10.26	FS-16-2	1.50	-81	-97	-42.5	8.8
LR-02B	52.7	10.26	FS-16-11	0.13	-81	-100	-42.5	10.1
				Average decline	-80	-76		

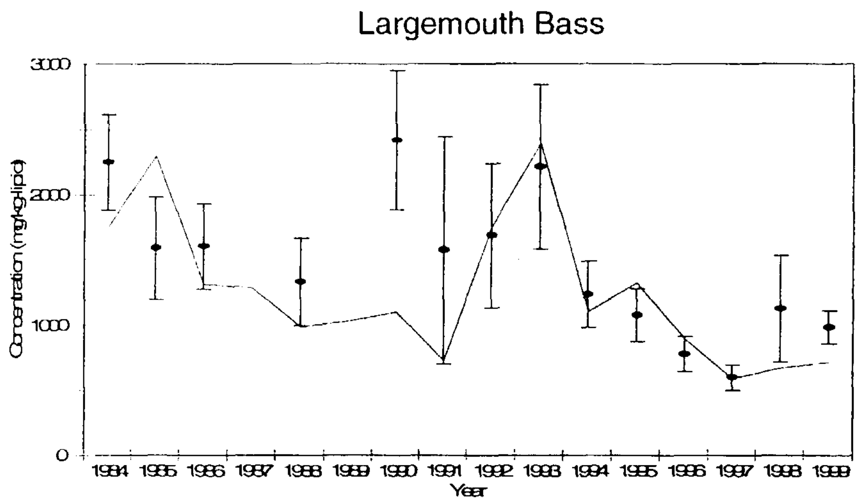
Table 7. Upper Hudson Tri+ PCB Water Column Load Estimates

Year	Average Tri+ Conc. (ng/L) (Linear Interp.)[1]	Ft. Edward Tri+ Conc. (ng/L) (Ratio Est.)	Annual Tri + Load (kg.) (Linear Interp.)[1]	Annual Tri+ Load (kg.) (Ratio Est.)	Flow weighted yearly avg. Tri+ Conc. (ng/L) (Linear Interp.)[1]
1991	100.8		268		67.3
1992	149.2	150.8	608	660	139.1
1993	43.1	92.6	246	409	55.7
1994	39.8		166		35.3
1995	34.0	60.8	117	224	31.7
1996	13.1	10.9	72	66	11.8
1997	10.3[2]	7.3	31[2]	35	8.8
1998	30.0	14.7	137	67	
1999		15.3		32	

Notes:

1. As reported in the RBMR (USEPA, 2000).
2. Results are based upon the partial year's data (1/1/97 to 7/25/97).





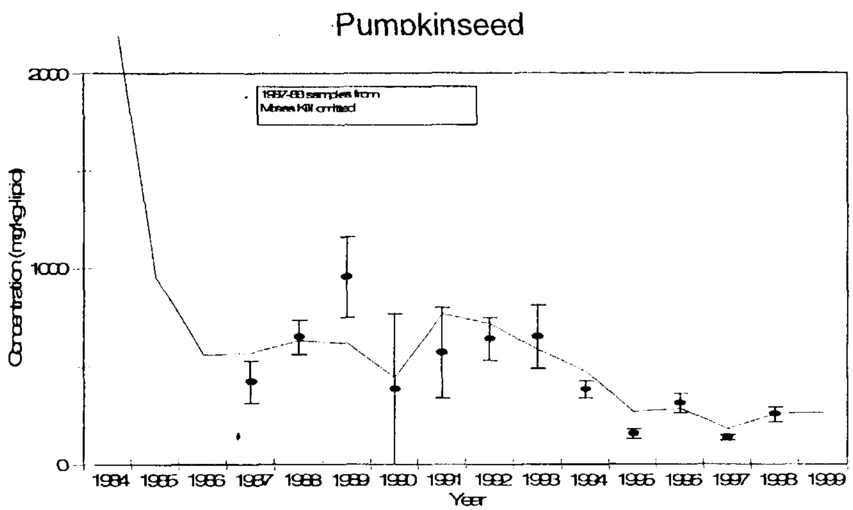


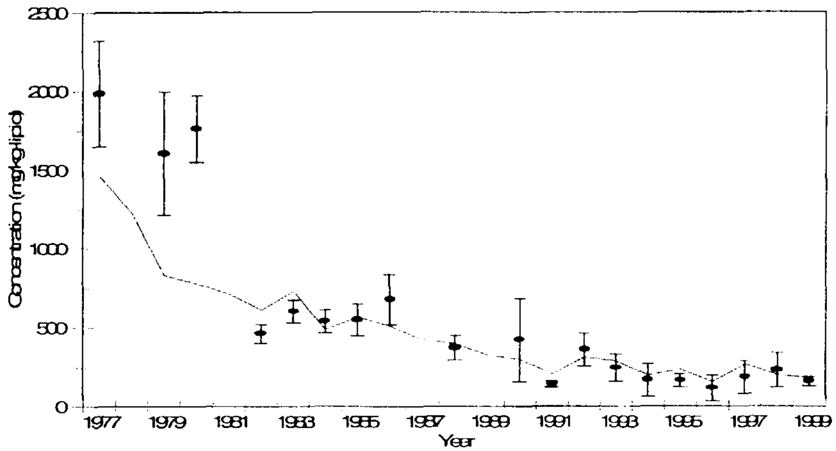
Figure 1. Lipid-based Tri+ PCB Concentrations in Fish, Thompson Island Pool (RM 189)

Vertical bars show arithmetic means and 95% confidence limits for NYSDEC observations, converted to a consistent Tri+ basis.

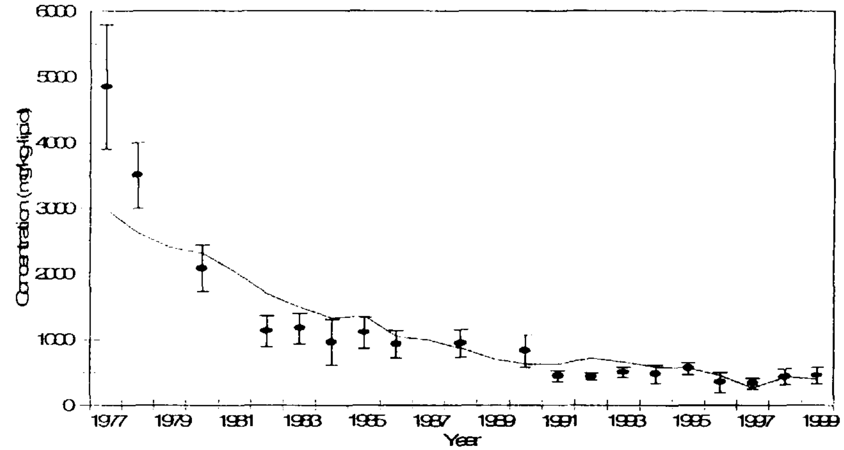
Solid line shows FISHRAND median predictions.

Note 1998-1999 FISHRAND predictions are based on HUDTOX forecast runs rather than actual hydrology and upstream boundary loads.

Brown Bullhead



Largemouth Bass



Pumpkinseed

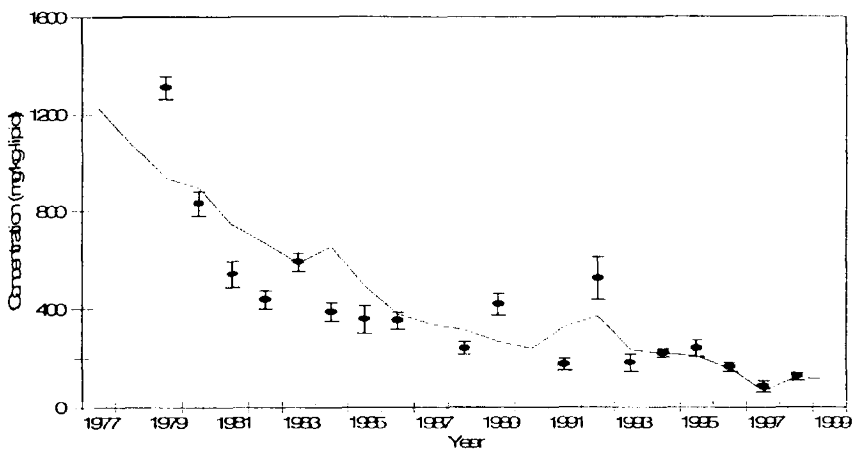


Figure 2. Lipid-based Tri+ PCB Concentrations in Fish, Stillwater Reach

Vertical bars show arithmetic means and 95% confidence limits for NYSDEC observations, converted to a consistent Tri+ basis.

Solid line shows FISHRAND median predictions.

Note 1998-1999 FISHRAND predictions are based on HUDTOX forecast runs rather than actual hydrology and upstream boundary loads.

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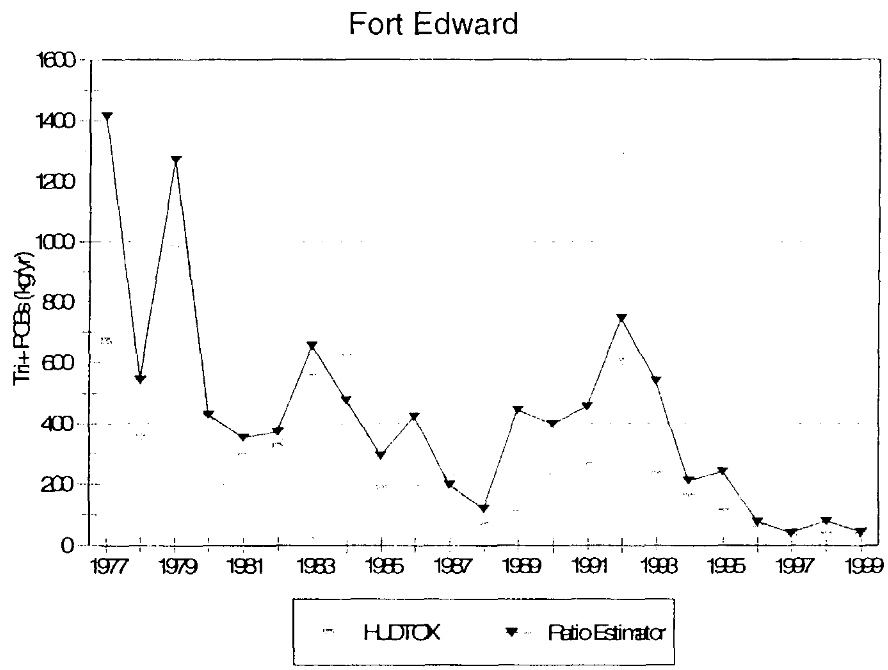

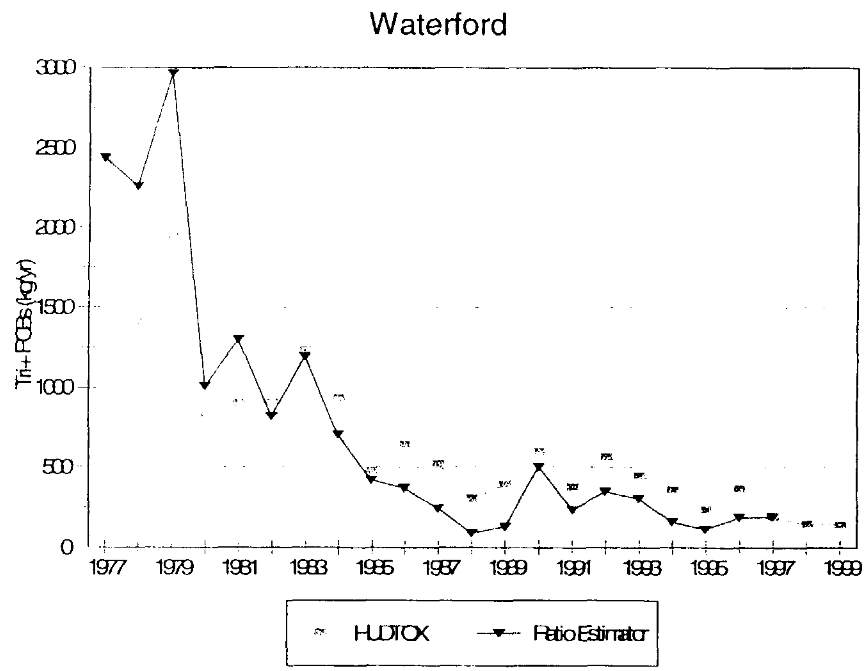

Figure 3. Model/Data Comparisons of Tri+ Load at Fort Edward and Waterford

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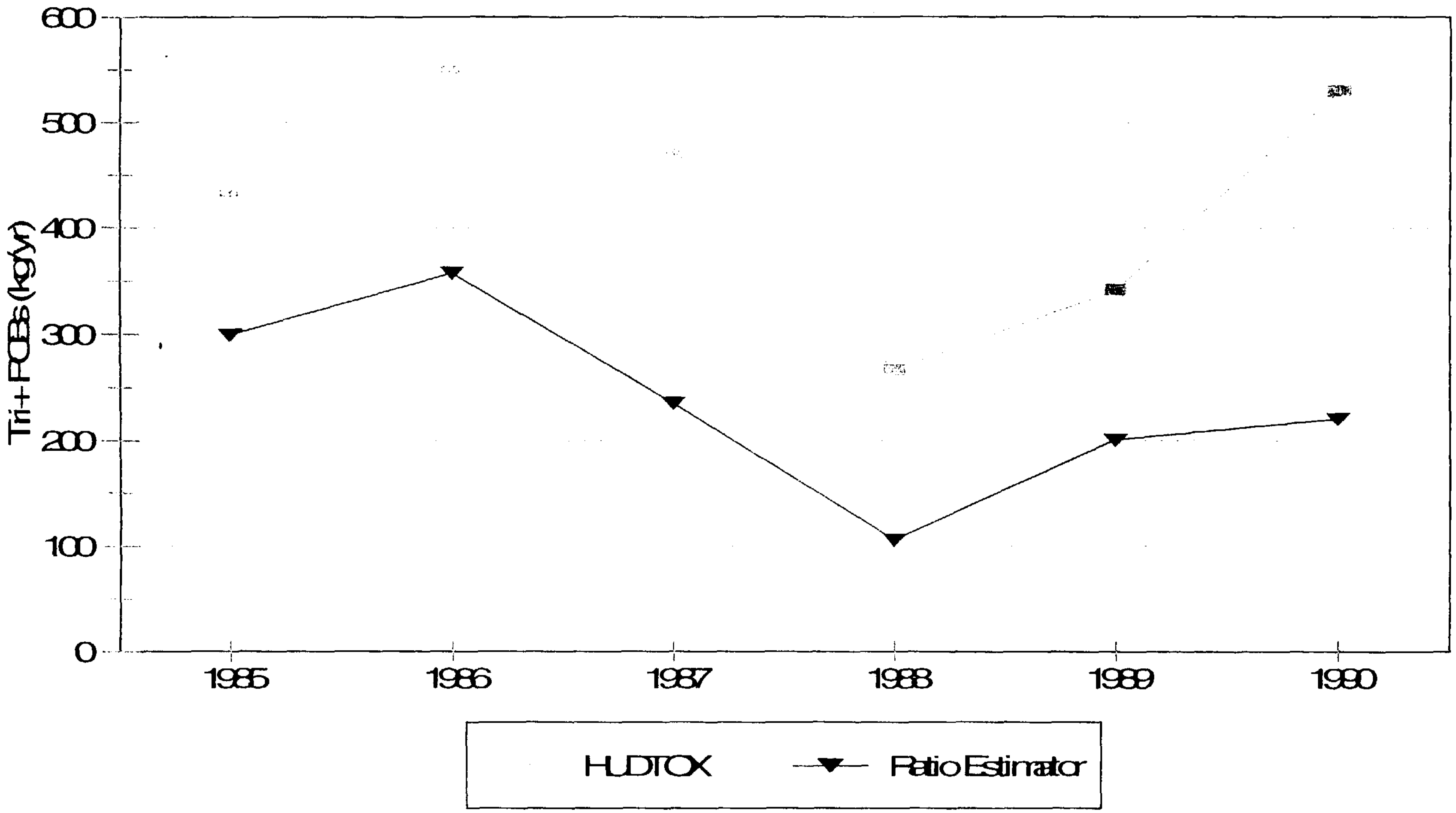

Figure 4. Annual Tri+ PCB Loads at Stillwater, 1985-1990

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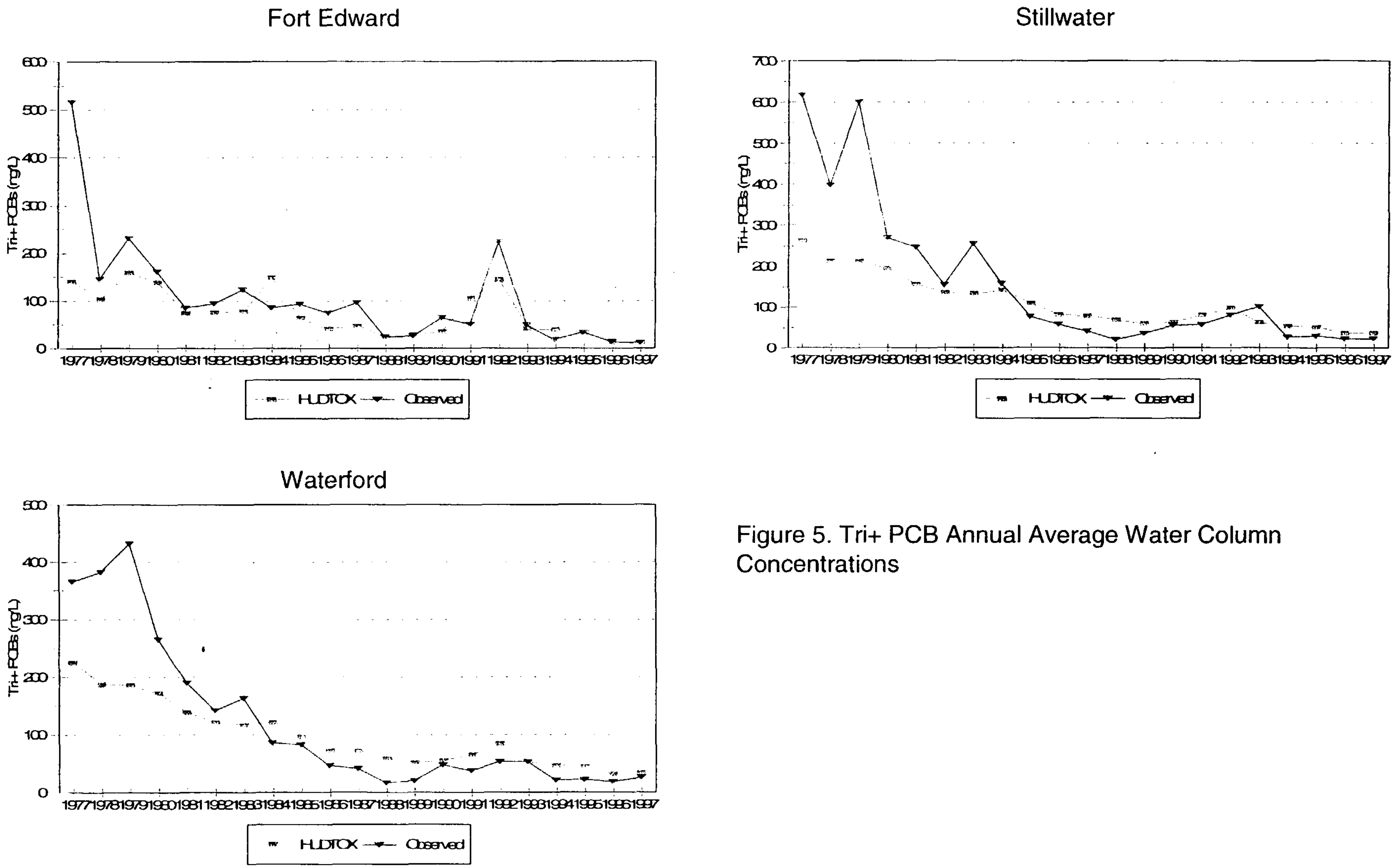

Figure 5. Tri+ PCB Annual Average Water Column Concentrations

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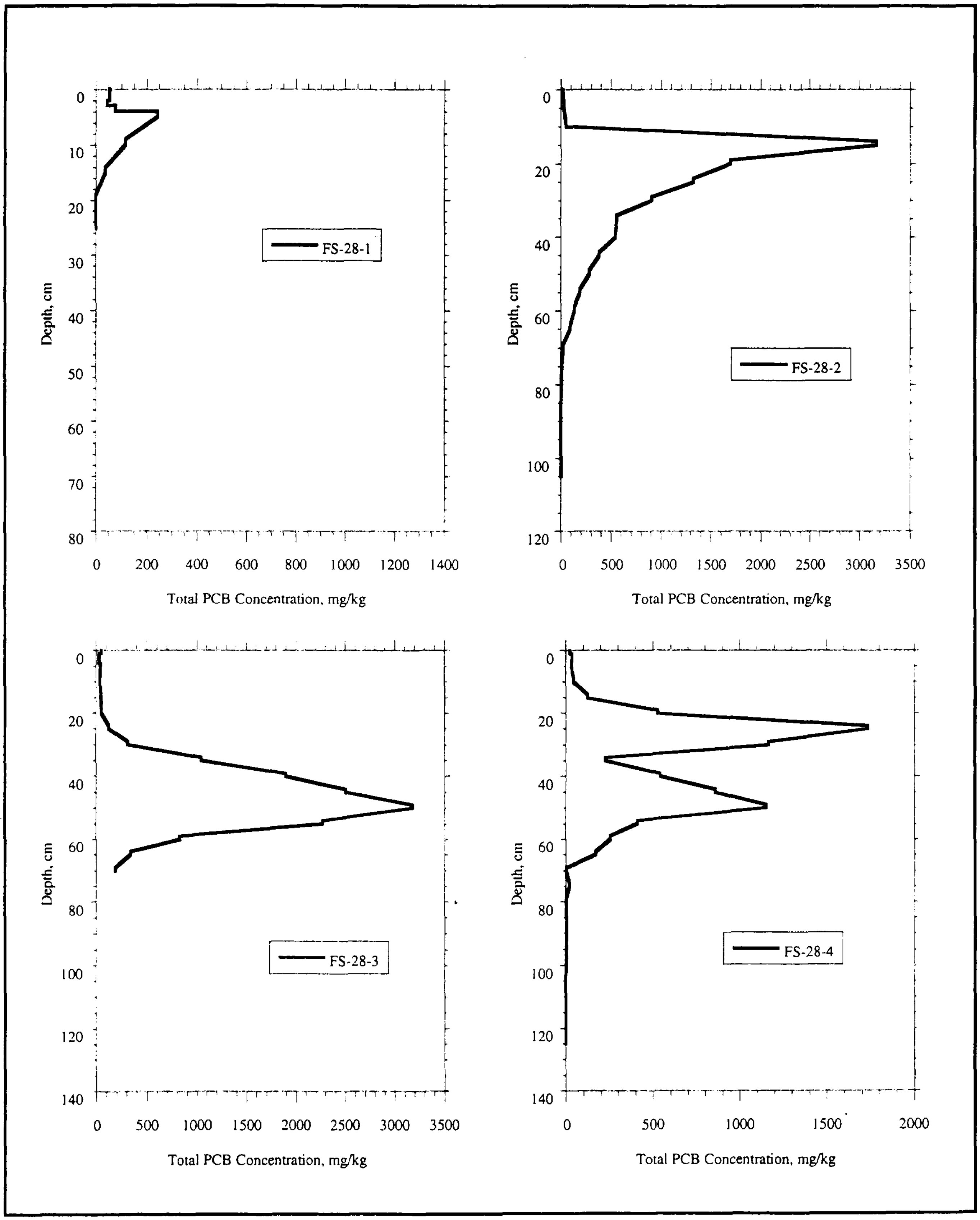

Figure 6.
1998 Total PCB Profiles at Hot Spot 28 (GE Samples)

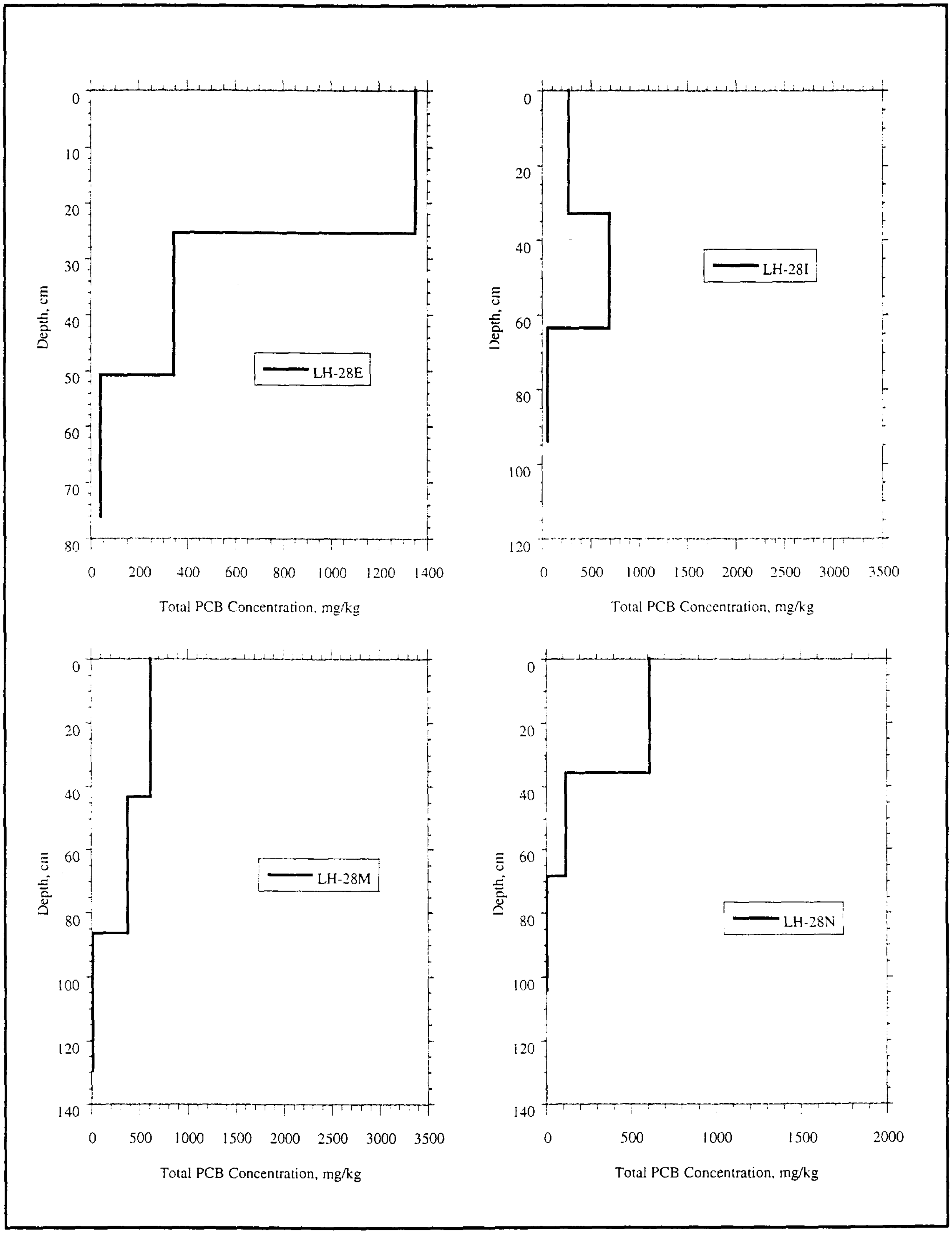

Figure 7.
1994 Total PCB Profiles at Hot Spot 28 (Phase 2 LRC Samples)

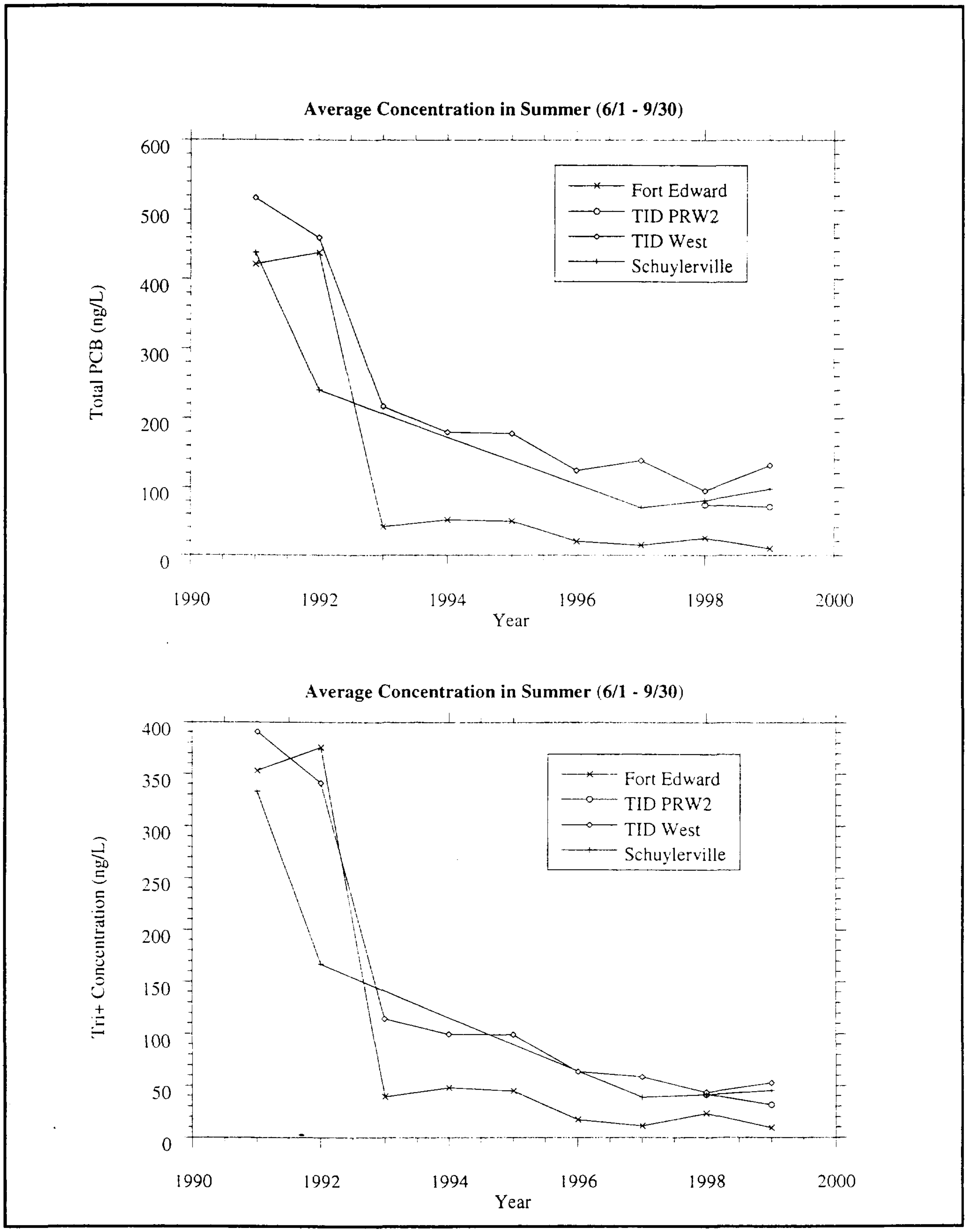

Figure 8.
Average Summer Water Column Concentration in the Upper Hudson 1991-1999 (Ratio Estimator)

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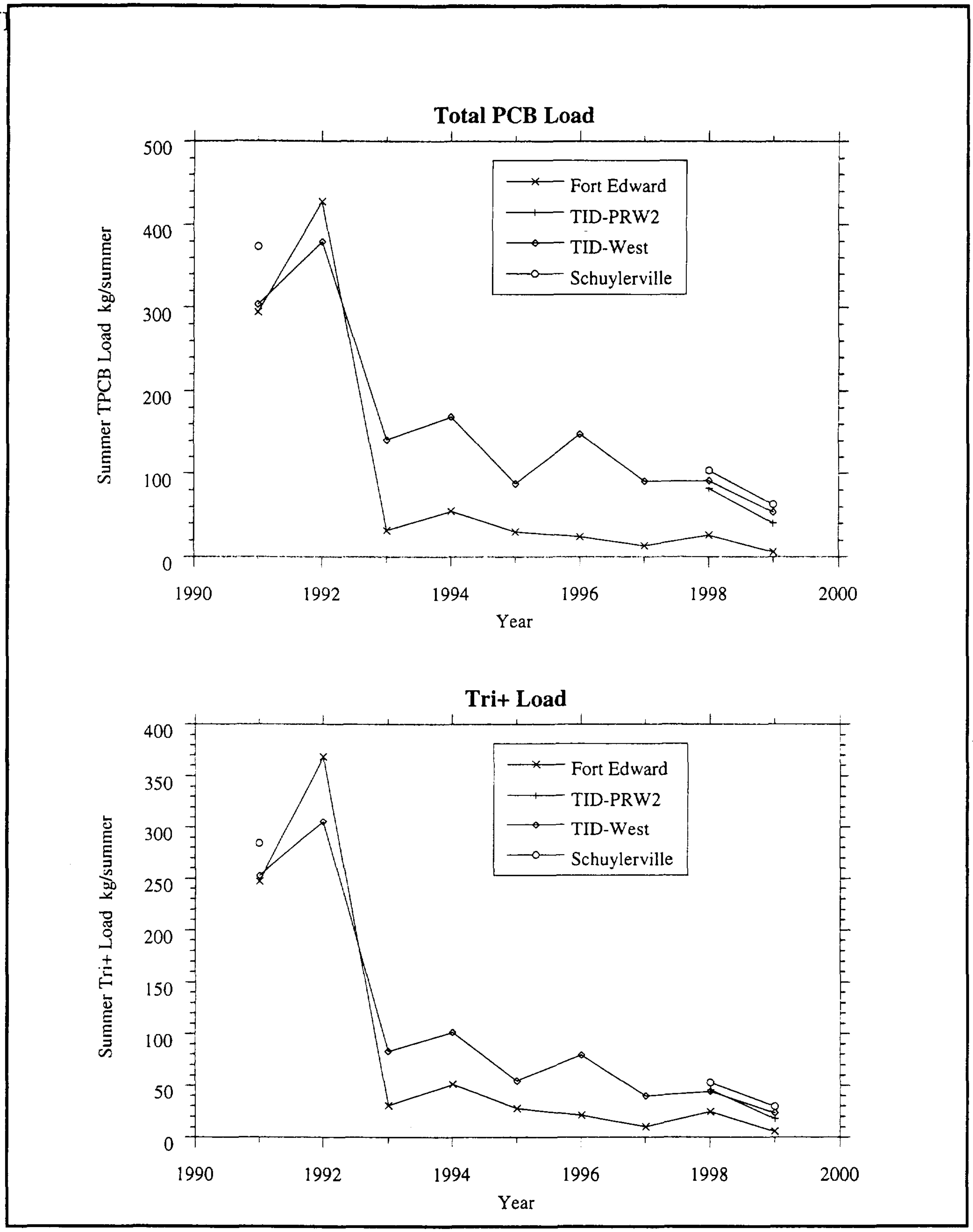


Figure 9.
Summer Water Column Load in the Upper Hudson 1991-1999
(Ratio Estimator)

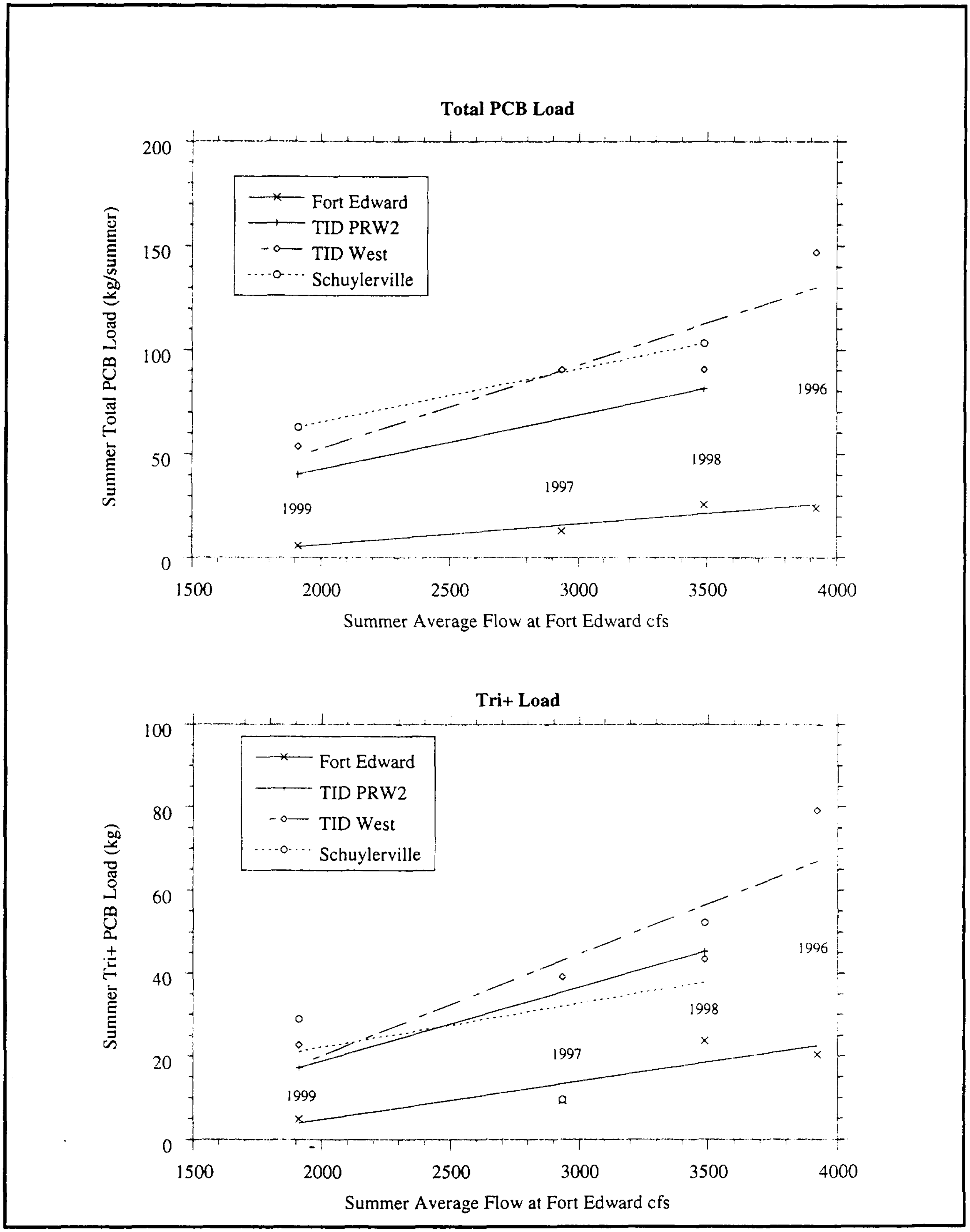


Figure 10.
Summer Water Column Load versus Flow in the Upper Hudson 1996-1999 (Ratio Estimator)

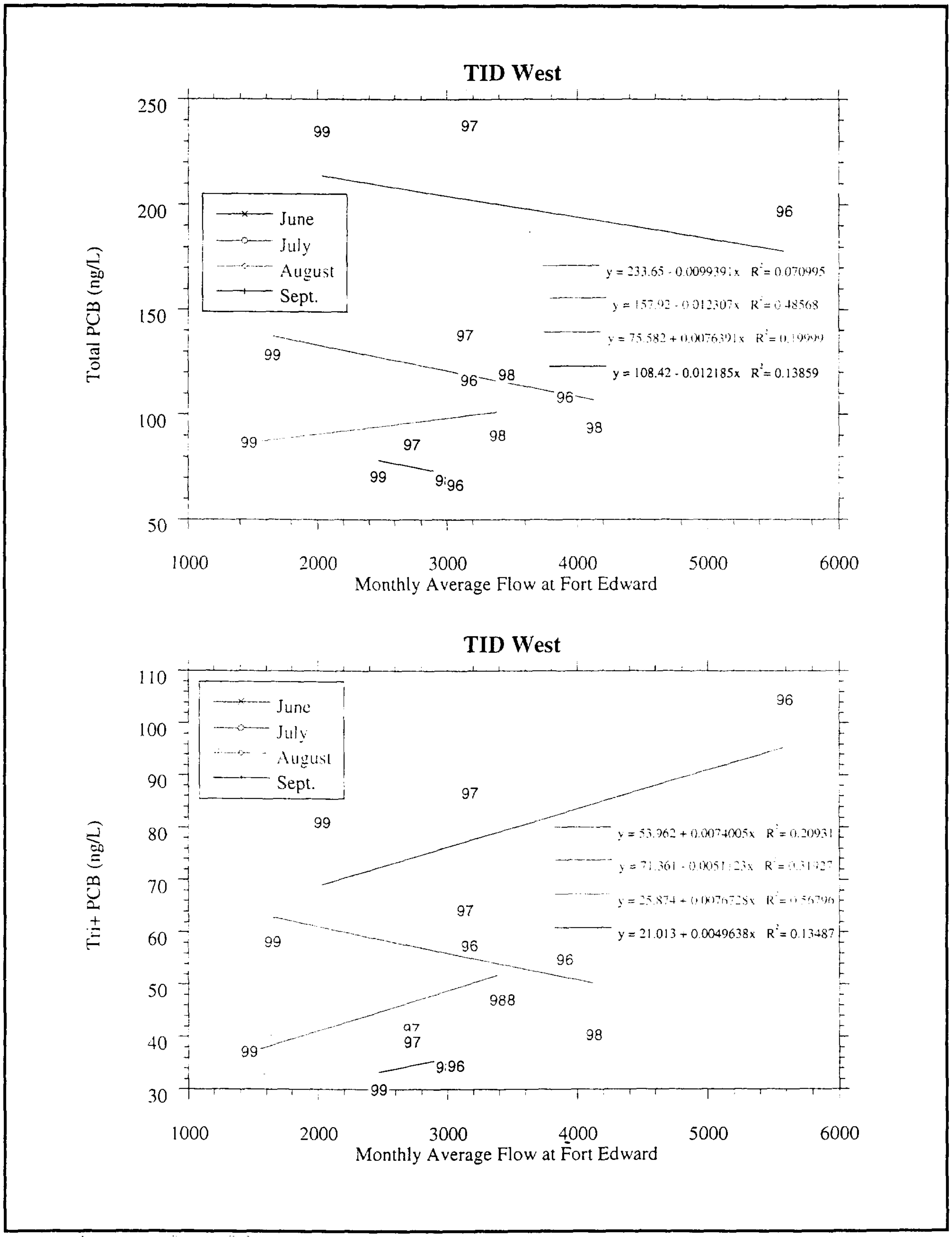
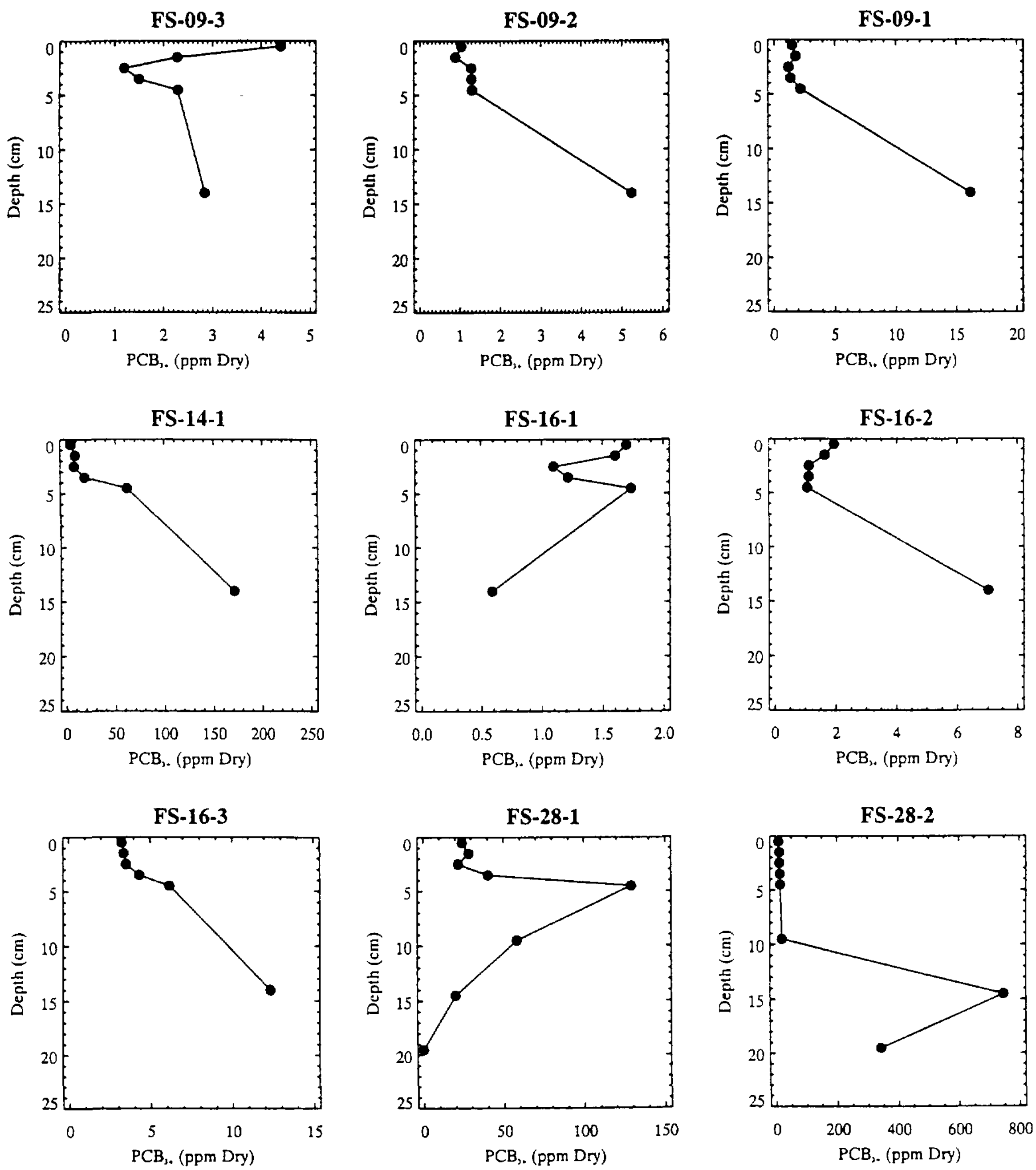


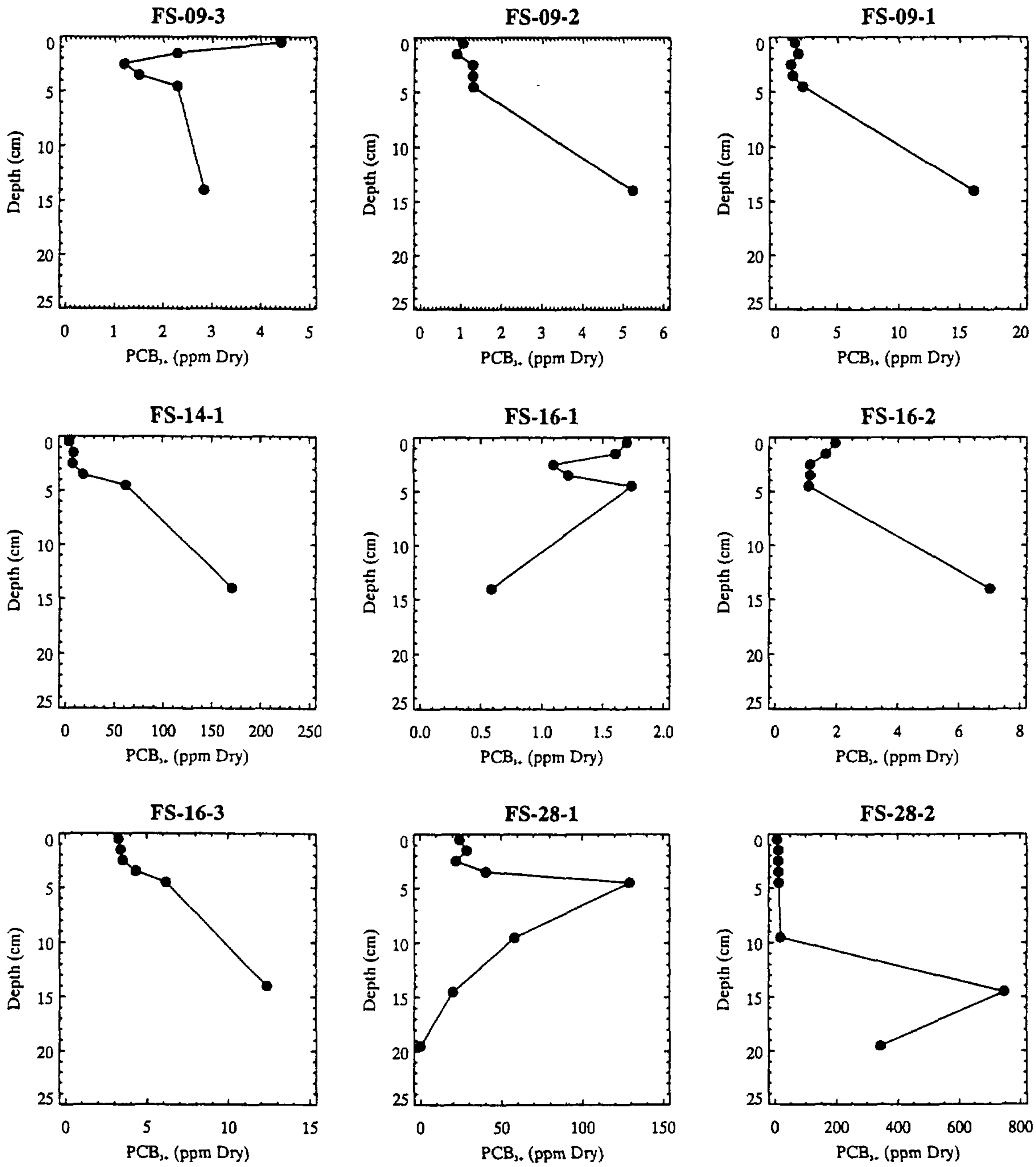
Figure 11.
Summer Water Column Concentration at TID West versus Monthly Average Flow at Fort Edward 1996 - 1999 (Ratio Estimator)



Note: Core sections shown are the top 23 cm of each core, plotted at segment midpoint.

Figure 12a.

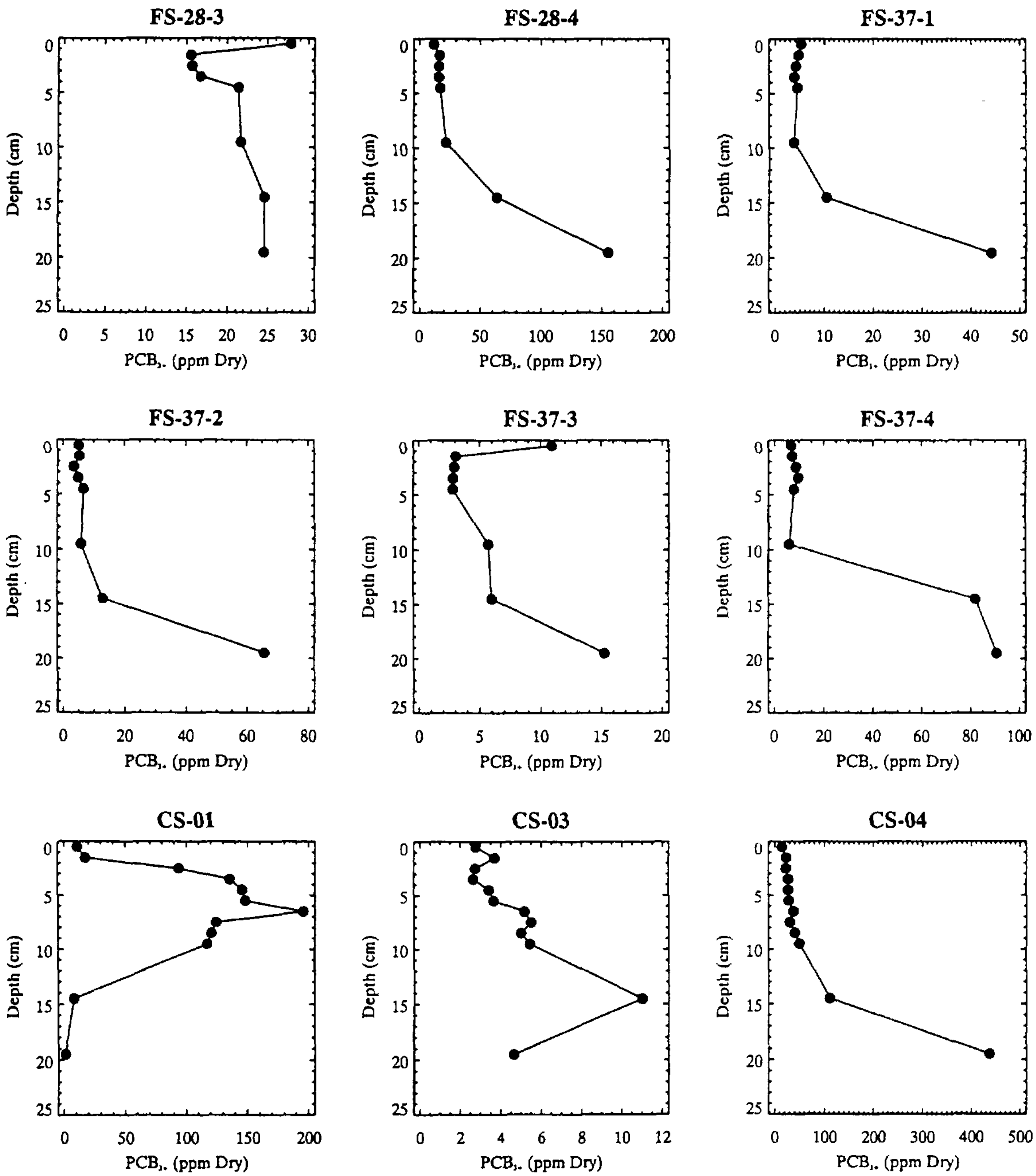
Vertical Profiles of PCB_{3+} within Finely Segmented Sediment Cores Collected from the Upper Hudson River (from QEA, 1999).



Note: Core sections shown are the top 23 cm of each core, plotted at segment midpoint.

Figure 12b.

Vertical Profiles of PCB_{3+} within Finely Segmented Sediment Cores Collected from the Upper Hudson River (from QEA, 1999).



Note: Core sections shown are the top 23 cm of each core, plotted at segment midpoint.

Figure 12c.
Vertical Profiles of PCB_{3+} within Finely Segmented Sediment Cores Collected from the Upper Hudson River (from QEA, 1999).

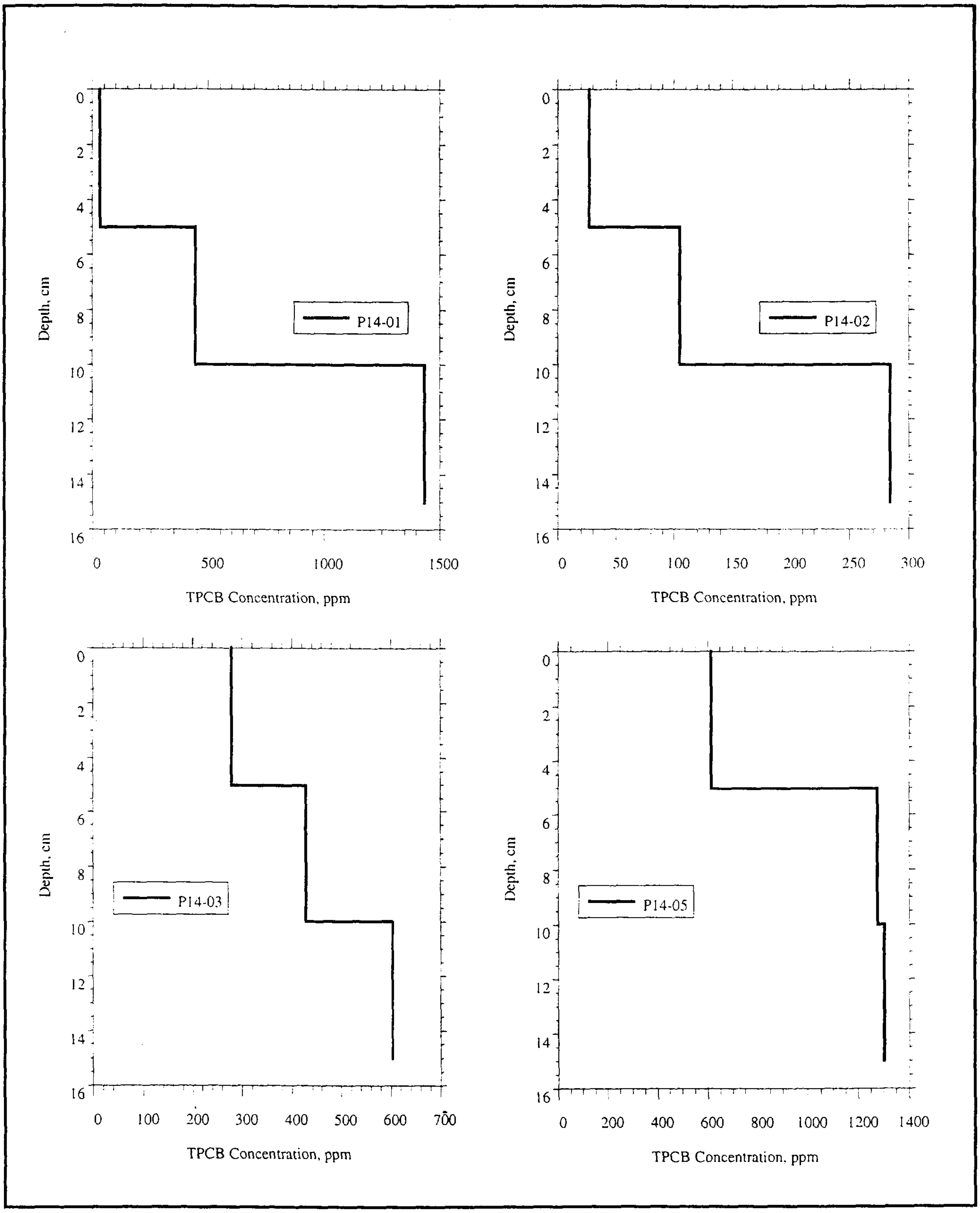


Figure 13a.
Total PCB Profiles from GE 1999 "P" Sediment Samples
(1 of 4)

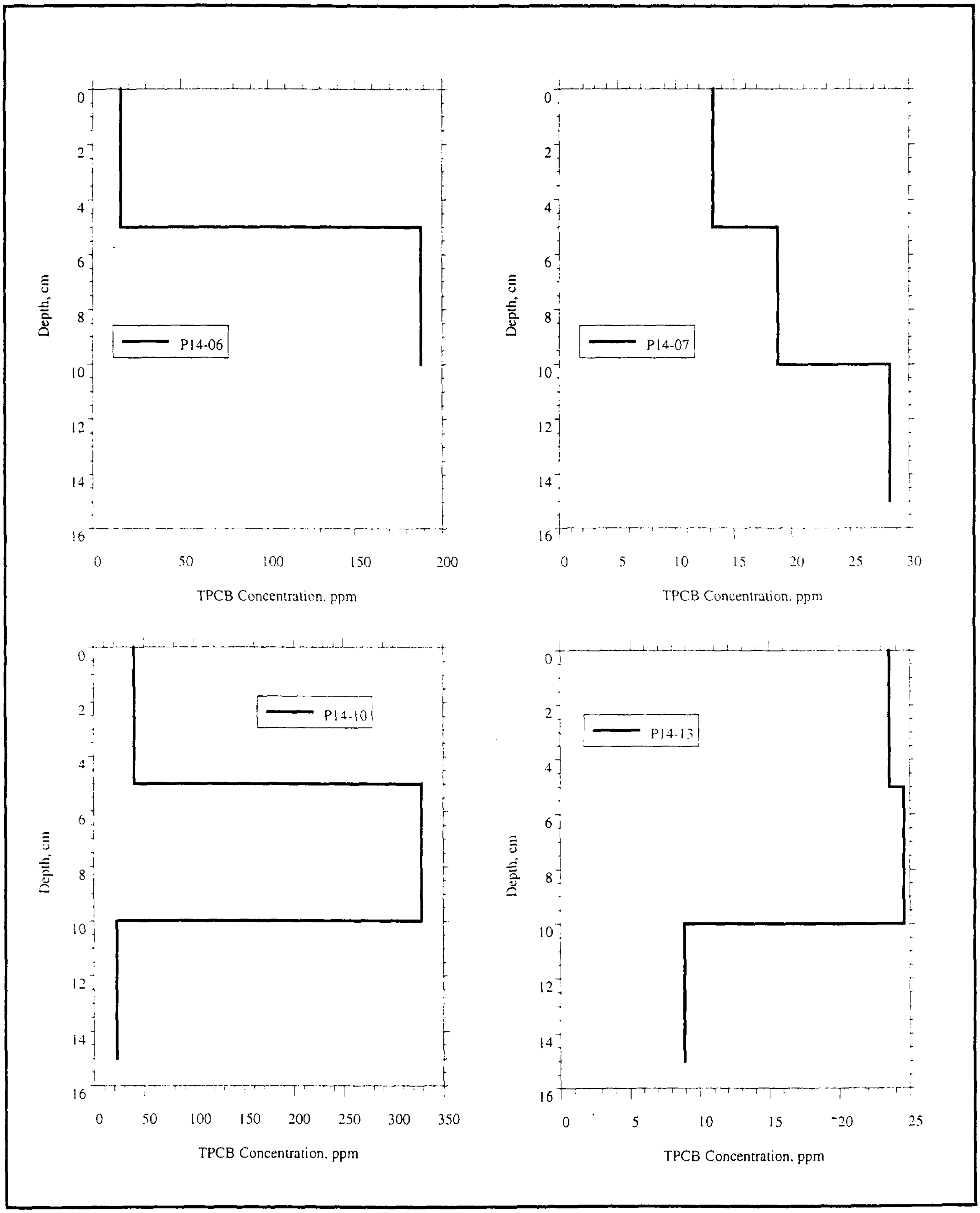


Figure 13b.
Total PCB Profiles from GE 1999 "P" Sediment Samples
(2 of 4)

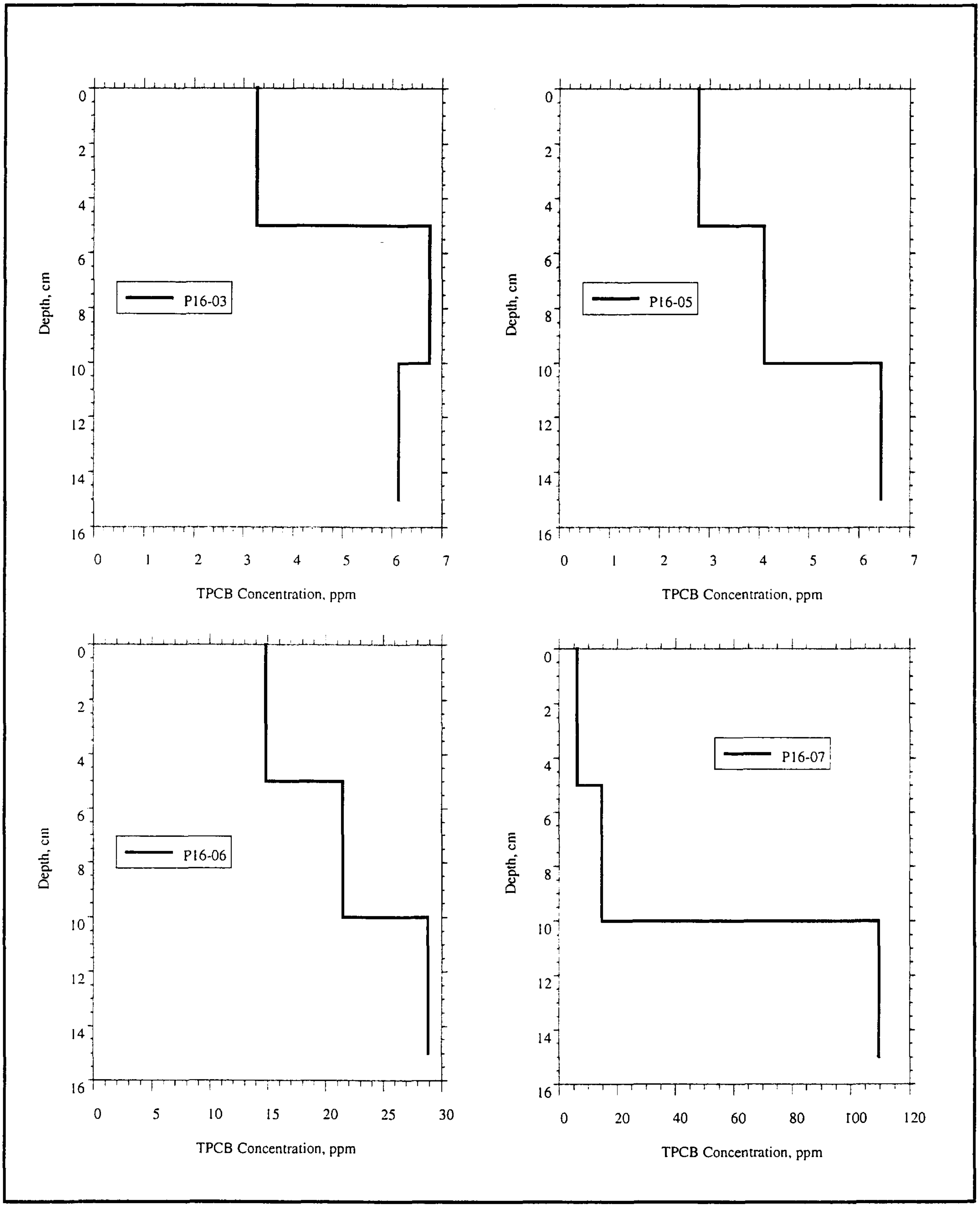


Figure 13c.
Total PCB Profiles from GE 1999 "P" Sediment Samples
(3 of 4)

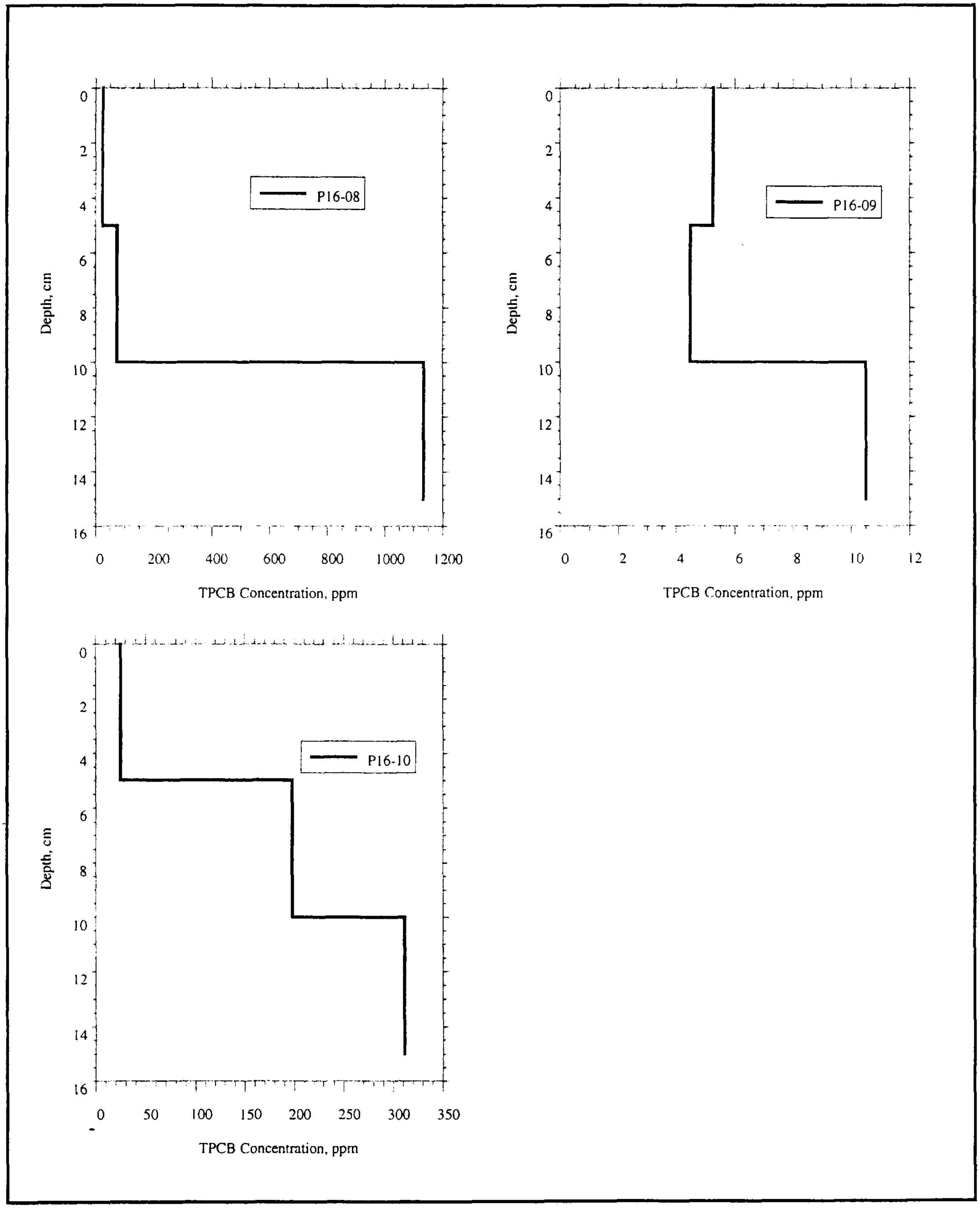
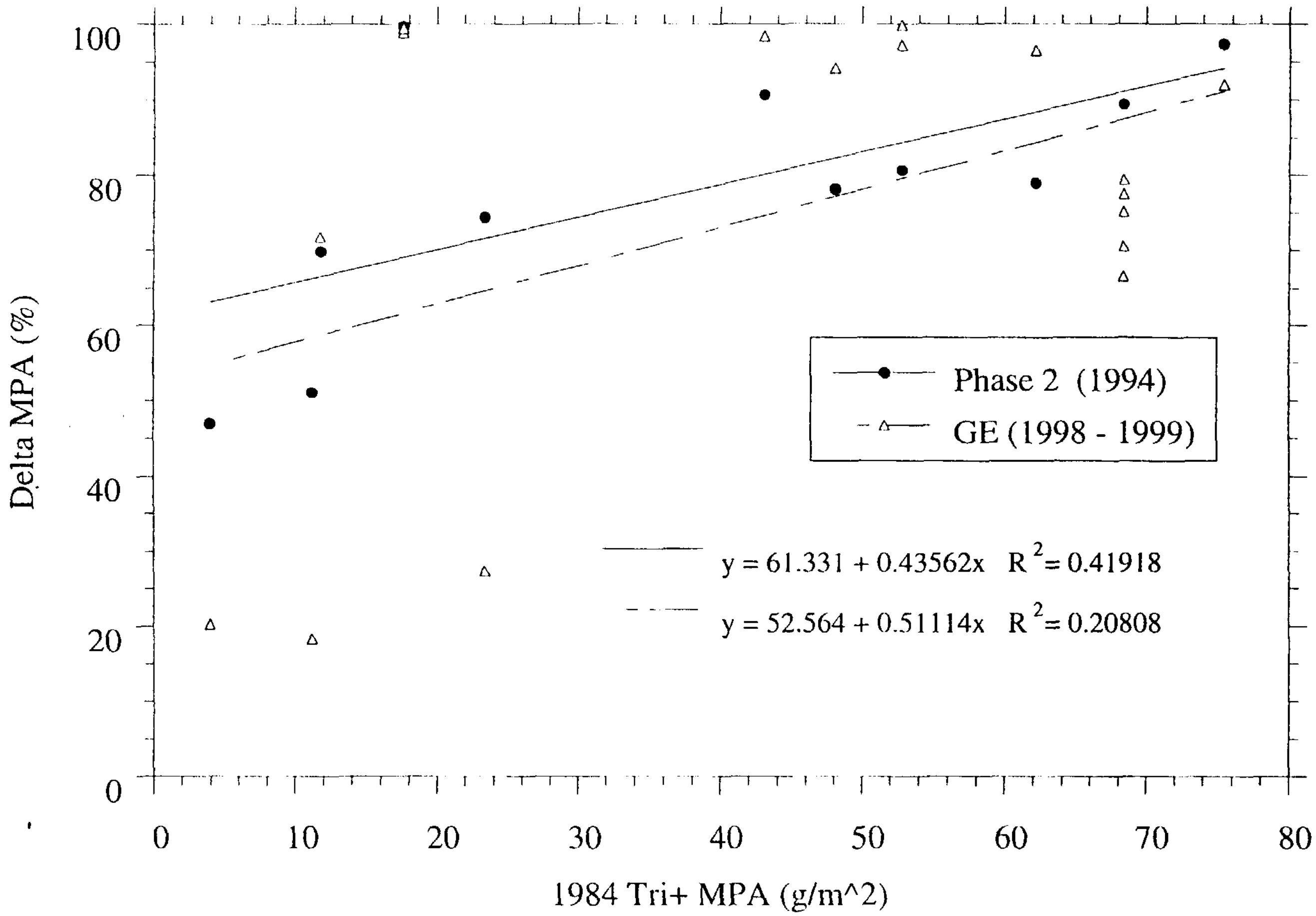


Figure 13d.
Total PCB Profiles from GE 1999 "P" Sediment Samples
(4 of 4)



Note:
Delta MPA is equal to:
(1984 Tri+ MPA - Phase 2 or GE Tri+ MPA) / 1984 Tri+ MPA
Positive values represents PCB loss from sediment.

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Figure 14.
Mass Per Unit Area Changes in 1984 Sediment PCB Tri+ Inventory Based on Phase 2 and GE Samples

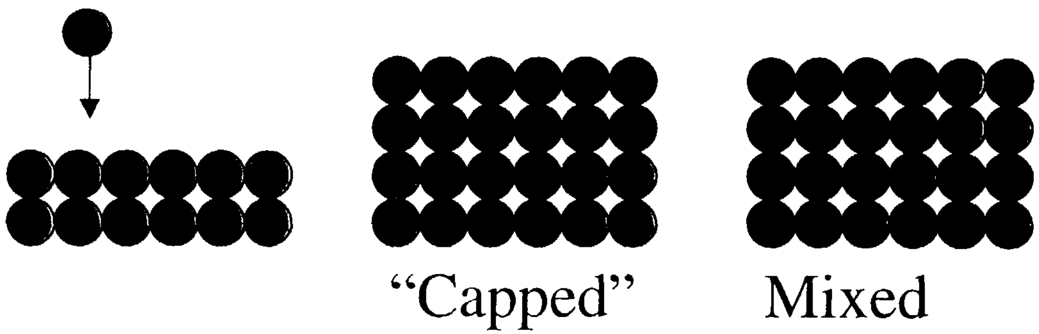

Figure 15. Sediment Deposition: Schematic of Capping versus Mixing

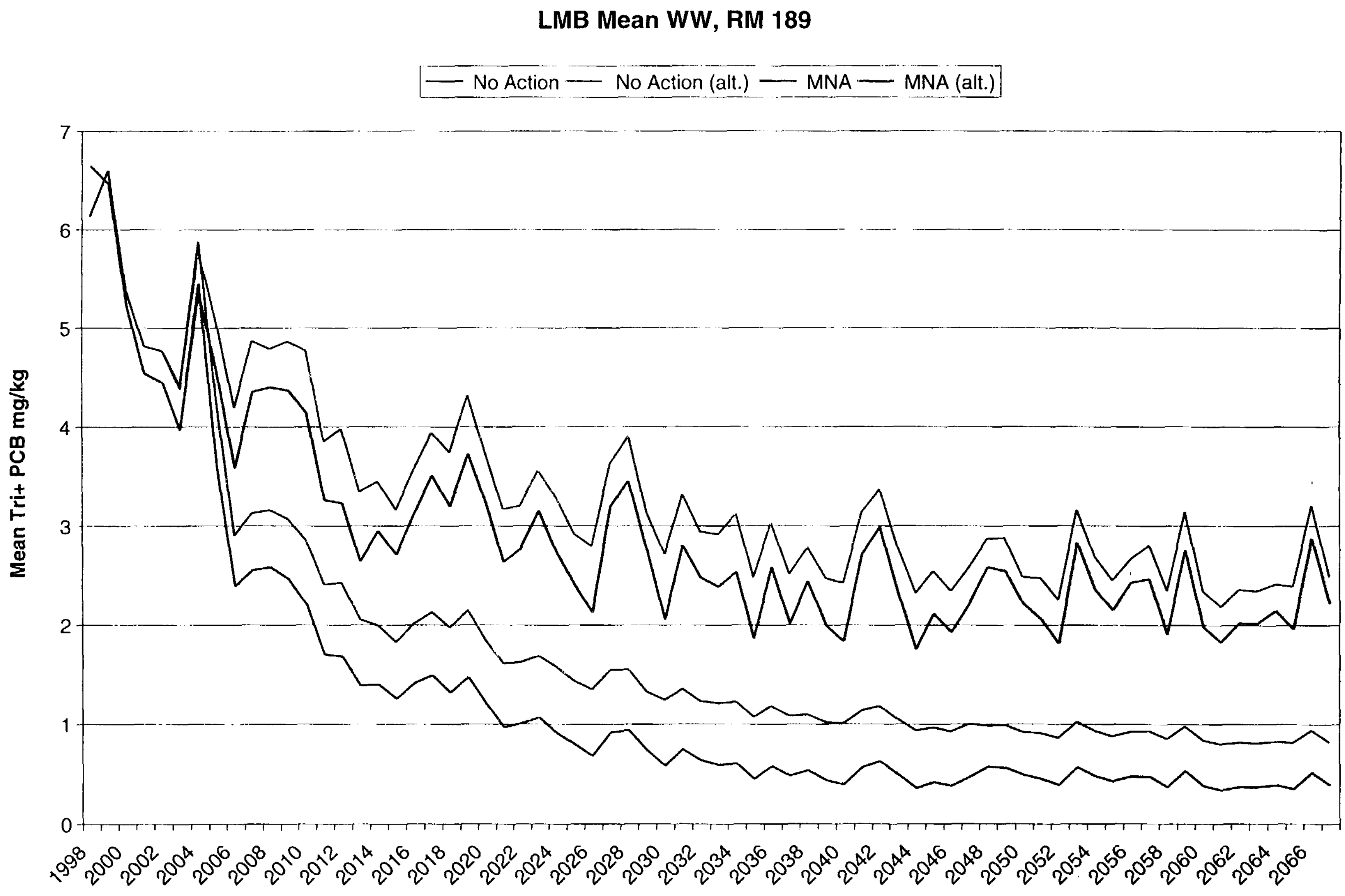

Figure 16. Bounding Forecast for Wet Weight PCB Concentrations in Largemouth Bass at RM 189

401560

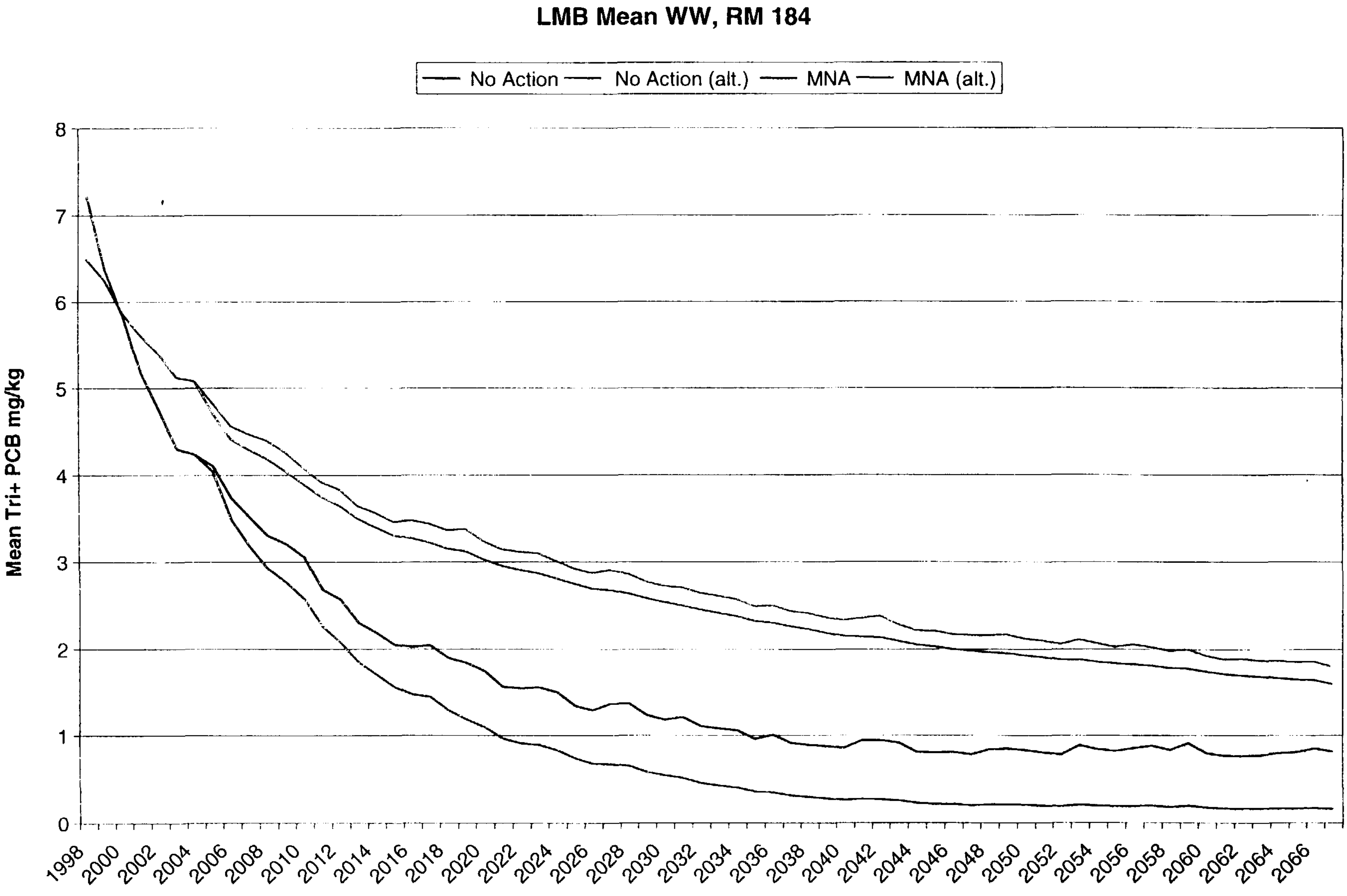

Figure 17. Bounding Forecast for Wet Weight PCB Concentrations in Largemouth Bass at RM 184

401561

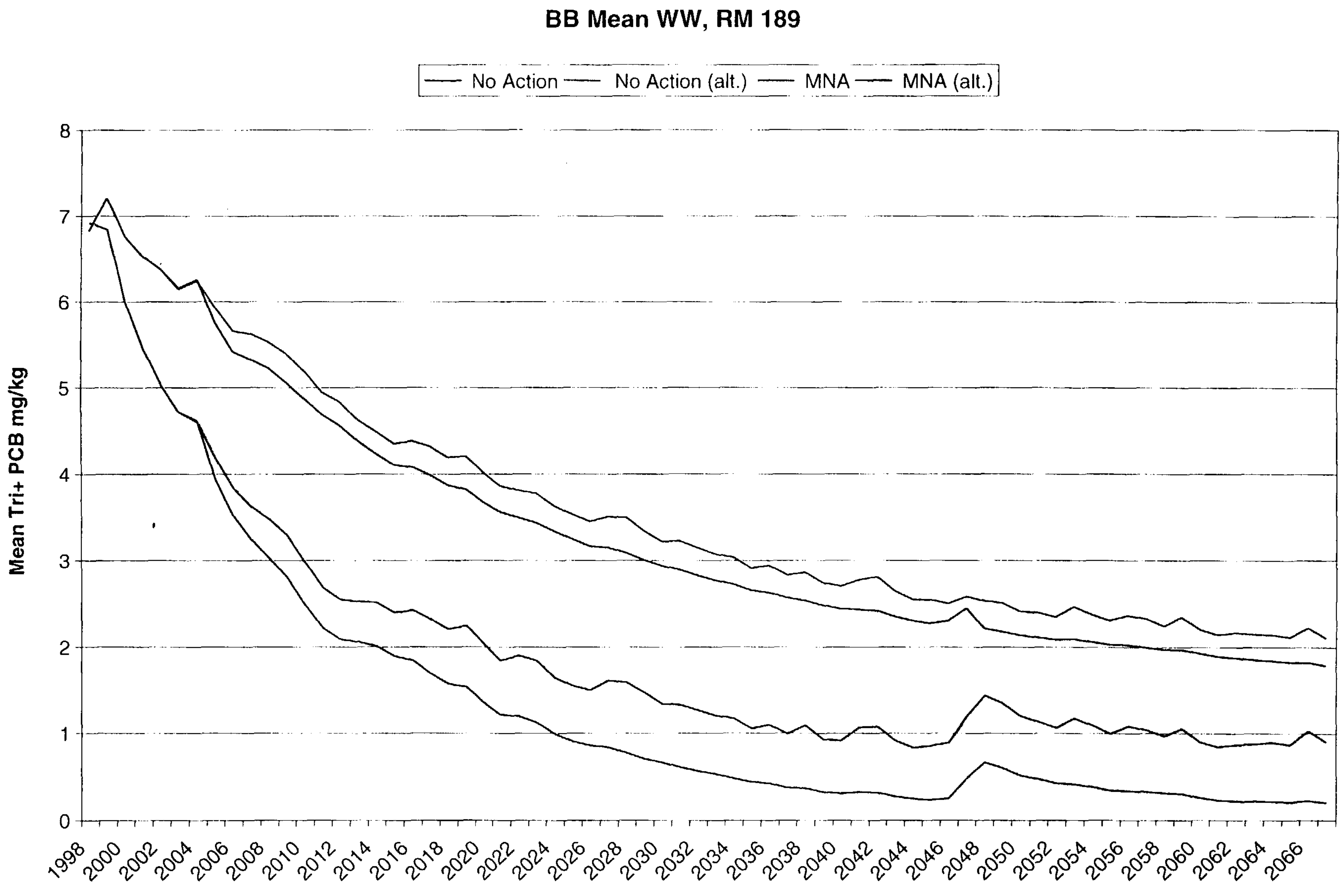

Figure 18. Bounding Forecast for Wet Weight PCB Concentrations in Brown Bullhead at RM 189

401562

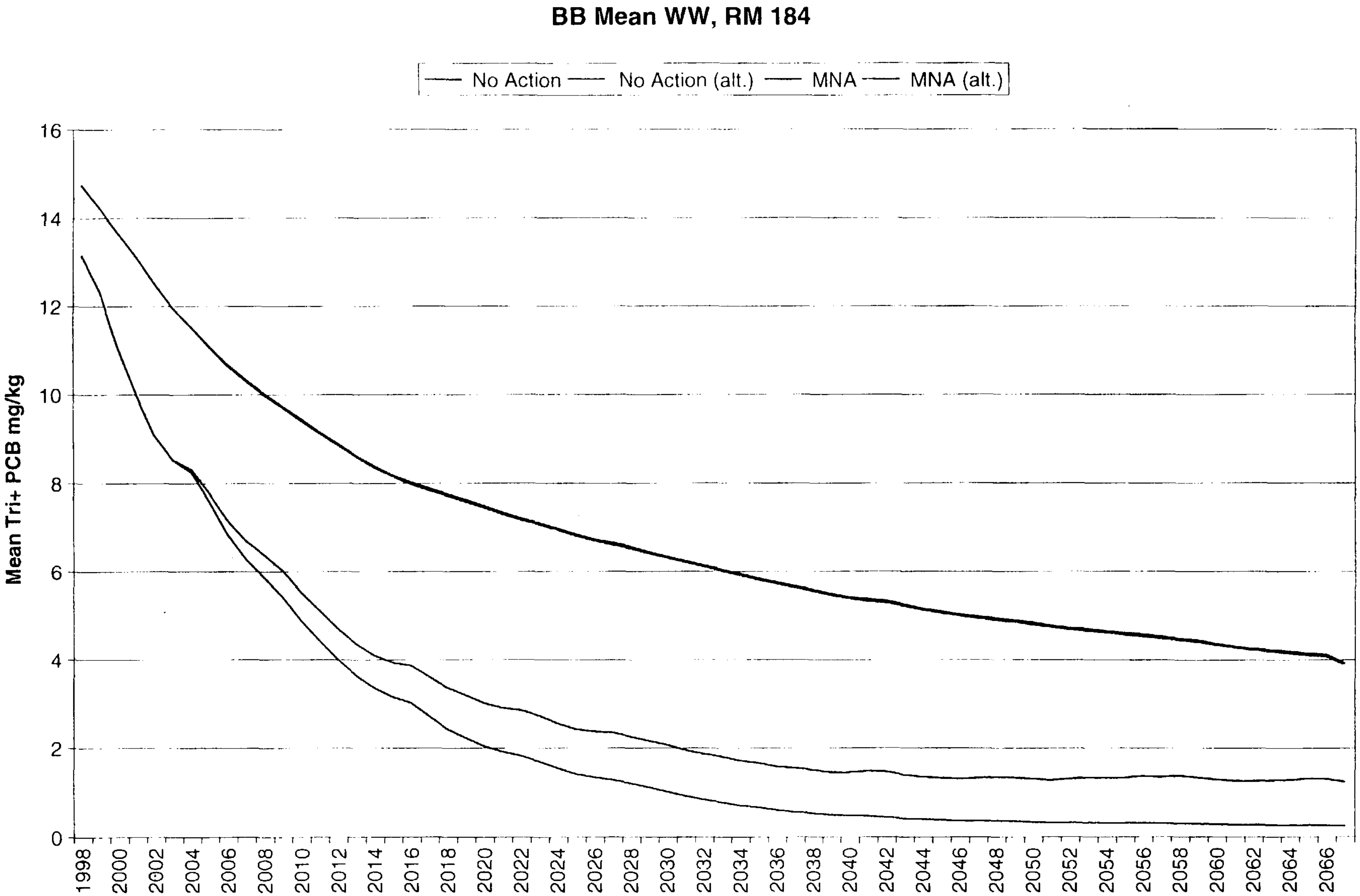

Figure 19. Bounding Forecast for Wet Weight PCB Concentrations in Brown Bullhead at RM 184

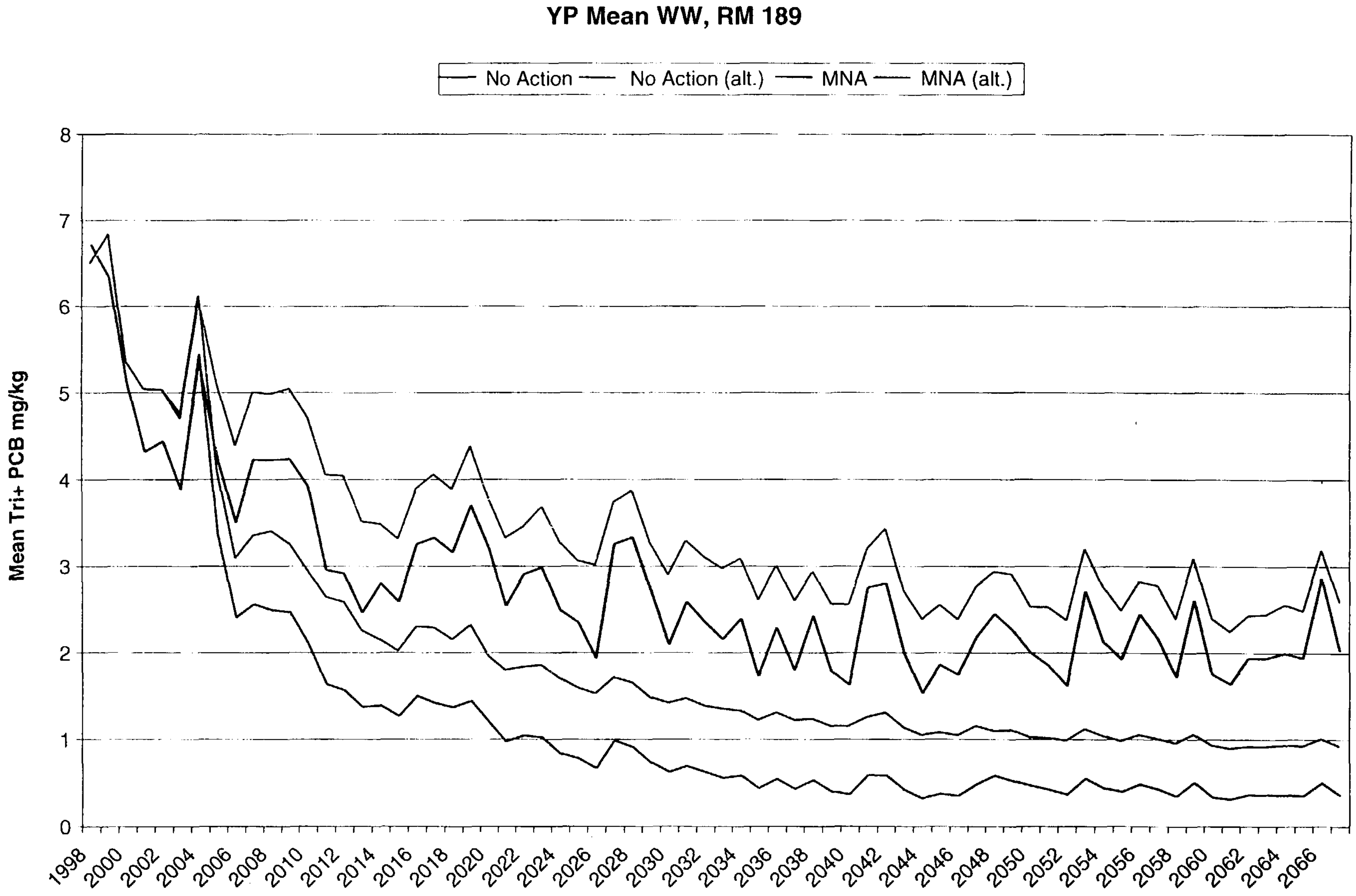

Figure 20. Bounding Forecast for Wet Weight PCB Concentrations in Yellow Perch at RM 189

401564

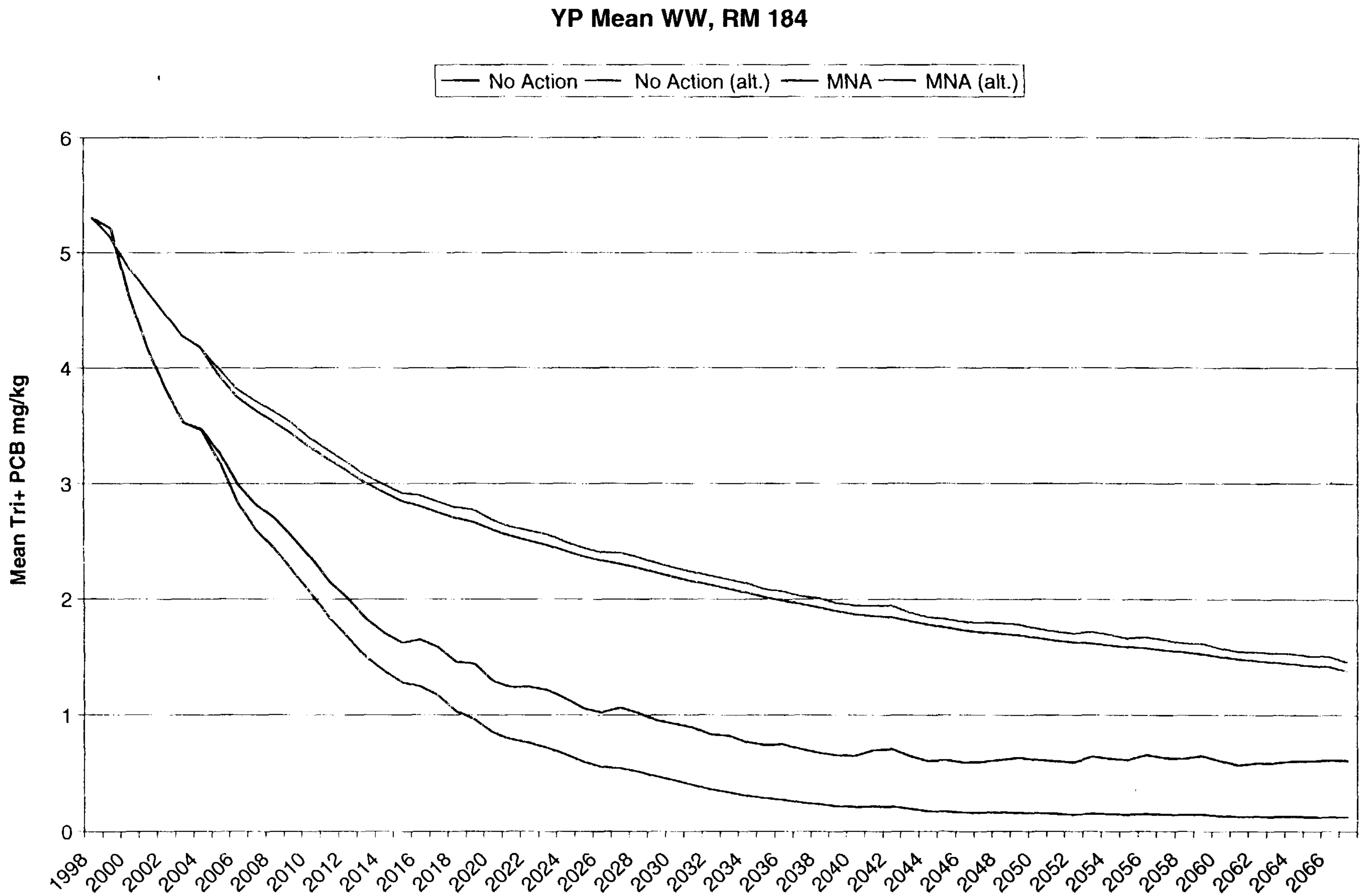

Figure 21. Bounding Forecast for Wet Weight PCB Concentrations in Yellow Perch at RM 184

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HUDSON RIVER PCBS REASSESSMENT FS

APPENDIX D

MODEL INTERPRETATION, SPECIFICATIONS AND RESULTS

D.2 Model Input Specifications

HUDSON RIVER PCBs REASSESSMENT FS
Preliminary Modeling Scenarios Input Specifications

General

All scenario input is based on the 1977 NYSDEC sample data set. Although the HUDTOX model is initialized using the 1991 data set, the 1977 data set provides better coverage (more sampling locations) and, as such, was considered to be a better data set for evaluating remedial scenarios.

LTI used averaging groups (which encompass more than one sediment segment) to calculate initial conditions for the sediment segments. An averaging group was used to compensate for a limited number of samples and to smooth out the effects of spatial heterogeneity. Data points within an averaging group were averaged to establish average conditions for each of the segments within the averaging group. Therefore, all sediment segments within an averaging group have identical initial concentrations.

LTI provided the 1977 NYSDEC sample data set used to calculate initial conditions for the HUDTOX model. The data for a given sampling location was provided at 2 cm depth intervals to a total depth of 26 cm (13 intervals or slices). Note that grab samples were assumed to represent the 0 to 13 cm interval. Therefore, no data was provided for the grab samples below a depth of 13 cm. Corresponding intervals or slices were averaged for all points within a given averaging group to develop an average core profile considered representative of all sediment segments within the averaging group. Grab samples were not included in the calculation of the average profile below 13 cm since no data was available for these samples below 13 cm.

Data manipulation was altered for Scenarios 11 and 12 as compared to that performed for Scenarios 1 through 10. Specifically, for Scenarios 11 and 12, points removed due to dredging or capping are considered to have a concentration of 0 mg/kg. These 0 values are then used in calculating the average post-remediation conditions for a segment or averaging group. In contrast, for Scenarios 1 through 10, points removed due to dredging were eliminated from the data set; post-remediation average conditions were calculated using only the remaining data points. The type of analysis performed for Scenarios 1 through 10 did not provide meaningful results for the Scenarios 11 and 12 scenarios since for Scenarios 11 and 12, in general, involve removal of lesser contaminated points (dredging and capping activities were in deeper parts of the river and, therefore, likely impact the more coarse-grained sediments within a segment; PCBs tend to be more concentrated in the fine-grained sediments). Therefore, by removing the lesser contaminated points from the data set for a given segment or averaging group, the calculated post-remediation concentrations for the segment or averaging group tended to be greater than the initial condition concentrations. This difference in data manipulation must be considered in comparing the results from Scenarios 1 through 10 to the results from Scenarios 11 and 12.

The data provided to LTI for each of the preliminary scenarios are presented in Table 1.

Scenario 1

All sediment is dredged (bank to bank) from Rogers Island to Thompson Island Dam; cohesive sediment is dredged between Thompson Island Dam and Lock 5; and target areas (cohesive and non-cohesive) are dredged between Lock 5 and Federal Dam. The upstream loading for this scenario is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Calculation of Percent Mass Removed Associated with Dredging

Between Rogers Island and Thompson Island Dam, 100 percent of the PCB mass within each sediment segment is removed.

Between Thompson Island Dam and Lock 5, 100 percent of the PCB mass within the cohesive sediment segments is removed. 0 percent of the PCB mass is removed from the non-cohesive sediment segments.

Below Lock 5, sediment (cohesive and non-cohesive) exceeding the threshold Tri+ PCB concentration of 10 grams per square meter is removed. This concentration was selected as a threshold concentration based upon review of the distribution of the 1977 data set for the entire upper river as well as the portion of the river below Lock 5. Removal of this sediment was simulated for input to the HUDTOX model as follows:

Initial average mass per unit area conditions were calculated for a given segment by averaging the mass per unit area of each point (on a slice by slice basis) within the corresponding averaging group; this assumes that each point contributes equally to the initial conditions of the averaging group - none is more heavily weighted than the others. The average mass per unit area was then re-calculated for the averaging group (assuming removal of those points which exceed the 10 grams/square meter threshold concentration) by averaging the mass per unit area of each remaining point (on a slice by slice basis). One minus the ratio of the re-calculated mass per unit area to the initial condition mass per unit area represents the percent mass removed for the averaging group due to dredging. This calculated percent mass removed is assumed to be representative of each of the sediment segments within the averaging group.

Data Provided to LTI

For each sediment segment, a percent mass removed associated with the dredging was provided. It was assumed that the residual sediment concentration within the dredged areas is 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Scenario 2

Same as Scenario 1 except the upstream loading is assumed to be 0 ng/L.

Scenario 3

All sediment is dredged (bank to bank) from Rogers Island to Thompson Island Dam. The upstream loading for this scenario is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Calculation of Percent Mass per Unit Area Removed Associated with Dredging

Between Rogers Island and Thompson Island Dam, 100 percent of the PCB mass within each sediment segment is assumed to be removed.

Data Provided to LTI

For each sediment segment between Rogers Island and Thompson Island Dam, 100 percent of the contaminant mass was assumed to be removed.. It was assumed that the residual sediment concentration within the dredged areas is 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Scenario 4

Same as Scenario 3 except the upstream loading is assumed to be 0 ng/L.

Scenario 5

All cohesive sediment is dredged between Rogers Island and Lock 5; all non-cohesive target areas are dredged between Rogers Island and Lock 5; and all target areas (cohesive and non-cohesive) are dredged between Lock 5 and Federal Dam. The upstream loading for this scenario is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Calculation of Percent Mass Removed Associated with Dredging

Between Rogers Island and Thompson Island Dam, 100 percent of the PCB mass within the cohesive sediment segments is removed. Non-cohesive sediment exceeding the threshold concentration of 10 grams per square meter is removed. Removal of this non-cohesive sediment was simulated for input to the HUDTOX model as described above for the river reach below Lock 5 for Scenario 1.

Between Thompson Island Dam and Lock 5, 100 percent of the PCB mass within the cohesive sediment segments is removed. Non-cohesive sediment exceeding the threshold concentration of 10 grams per square meter is removed. Removal of this non-cohesive sediment was simulated for input to the HUDTOX model as described above for the river reach below Lock 5 for Scenario 1.

Below Lock 5, cohesive and non-cohesive sediment exceeding the threshold concentration of 10 grams per square meter is removed. Removal of sediment from these target areas was simulated for input to the HUDTOX model as described above for the river reach below Lock 5 for Scenario 1.

Data Provided to LTI

For each sediment segment, a percent mass removed associated with the dredging was provided. It was assumed that the residual sediment concentration within the dredged areas is 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Scenario 6

Same as Scenario 7 except an upstream loading of 0 ng/L is assumed.

Scenario 7

All sediment is dredged (bank to bank) from Rogers Island to Lock 5; and target areas (cohesive and non-cohesive) are dredged between Lock 5 and Federal Dam. The upstream loading for this scenario is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Calculation of Percent Mass Removed Associated with Dredging

Between Rogers Island and Lock 5, 100 percent of the Tri+ PCB mass within each sediment segment is removed.

Below Lock 5, sediment (cohesive and non-cohesive) exceeding the threshold Tri+ PCB concentration of 10 grams per square meter is removed. Removal of this target area sediment was simulated for input to the HUDTOX model as described above for the river reach below Lock 5 for Scenario 1.

Data Provided to LTI

For each sediment segment, a percent mass removed associated with the dredging was provided. It was assumed that the residual sediment concentration within the dredged areas is 1 mg/kg in the top 10 cm of sediment and 0 mg/kg at greater depth.

Scenario 8

Same as Scenario 7 except an upstream loading of 0 ng/L is assumed.

Scenario 9

Same as Scenario 7 except a residual sediment concentration of 0.1 mg/kg is assumed for the top 10 cm of sediment within the dredged areas and 0 mg/kg at greater depth.

Scenario 10

Same as Scenario 9 except assume upstream loading of 0 ng/L.

Scenario 11

Scenario 11 consists of three parts. For each part, an upstream loading of 10 ng/L is assumed.

1. Capping and Dredging between Rogers Island and Thompson Island Dam

All sediment associated with water depths greater than 6 feet and less than 12 feet will be capped.

The 12-foot water depth contour is assumed to represent the edge of the navigation channel. Sediment within the navigation channel will be dredged.

All sediment associated with water depths greater than 6 feet will be capped in that portion of the river in which the navigation channel is located within a land cut adjacent to the river.

To simulate this action for input into the HUDTOX model:

Calculation of Percent Mass Removed Associated with Capping

Within a given segment or averaging group, all points (cohesive and non-cohesive) within the area to be capped will be removed from the total number of sampling points within the segment or averaging group. The average conditions for the segment or averaging group will be re-calculated assuming the removed points have a mass per unit area contribution of 0 grams per square meter (this is done to keep the initial condition area associated with each sample point constant throughout the analysis). The ratio of the re-calculated mass per unit area to the initial condition mass per unit area represents the percent mass remaining. One minus this ratio represents the percent mass removed. For modeling purposes, it is assumed that the cap is ideal. Therefore, no leakage from the cap will occur and the residual concentration in the capped areas will be 0 mg/kg.

In the cases where an averaging group encompasses more than one sediment segment, the percent mass removed will be the same for each segment within the averaging group.

Calculation of Percent Mass Removed Associated with Dredging:

Within a given segment or averaging group, all points (cohesive and non-cohesive) within the area to be dredged will be removed from the total number of sampling points within the segment or averaging group. The percent mass per unit area that these removed sampling points represents will be calculated as described above for the estimation of mass removed due to capping. For modeling purposes, it is assumed that the residual sediment concentration in the dredged areas will be 1 mg/kg.

In the cases where an averaging group encompasses more than one sediment segment, the percent mass removed will be the same for each segment within the averaging group.

Data Provided to LTI

For each segment, a total percent mass removed associated with dredging and capping will be calculated. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/Kg and the residual sediment concentration in the dredged area will be 1 mg/Kg. A weighted average residual sediment concentration will be calculated for the combined capped and dredged area based on the relative contribution of each area (derived from bathymetric data) to the total treated (capped or dredged) area. The data provided to LTI will be the total percent mass removed (capped and dredged) within a given sediment segment and the corresponding weighted residual sediment concentration in the capped/dredged area.

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2. Capping and Dredging between Thompson Island Dam and Northumberland Dam

All sediment associated with water depths greater than 6 feet and less than 12 feet will be capped. The 12-foot water depth contour is assumed to represent the edge of the navigation channel. Sediment within the navigation channel will be dredged.

All sediment associated with water depths greater than 6 feet will be capped in that portion of the river in which the navigation channel is located within a land cut adjacent to the river (i.e., from the Thompson Island Dam to just below Lock 6).

To simulate these actions for input into the HUDTOX model: Same as described above.

Note: the Northumberland Dam is used as a lower boundary for this river segment instead of Lock 5 since the bathymetric data is only available to the Northumberland Dam (bathymetric data between the Northumberland Dam and Lock 5 is within the land cut navigation channel adjacent to the river.

3. Capping and Dredging between the Northumberland Dam and Federal Dam

Because no bathymetric data is available between the Northumberland Dam and Federal Dam, the dredging and capping analysis applied above the Northumberland Dam can not be conducted. Instead, it is assumed that all portions of the river below the Northumberland Dam will be capped in those areas in which the sediment concentrations equals or exceeds 10 grams/m^2. No channel dredging is assumed.

<u>Calculation of Percent Mass Removed Associated with Capping</u>

Within a given segment or averaging group, all points with a sediment mass per unit area equal to or greater than 10 grams/m^2 will be removed from the total number of sampling points within the segment or averaging group. The average conditions for the segment or averaging group will be re-calculated assuming the removed points have a mass per unit area contribution of 0 grams per square meter (this is done to keep the initial condition area associated with each sample point constant throughout the analysis). The ratio of the re-calculated mass per unit area to the initial condition mass per unit area represents the percent mass remaining. One minus this ratio represents the percent mass removed. For modeling purposes, it is assumed that the cap is ideal. Therefore, no leakage from the cap will occur and the residual concentration in the capped areas will be 0 mg/kg.

In the cases where an averaging group encompasses more than one sediment segment, the percent mass removed will be the same for each segment within the averaging group.

<u>Data Provided to LTI</u>

For each segment, a percent mass removed associated with capping will be calculated. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/Kg. The data provided to LTI will be the total percent mass removed (capped) within a given sediment segment and the corresponding residual sediment concentration in the capped area of 0 mg/Kg.

Scenario 12

Same as Scenario 11 except assume an upstream loading of 0 ng/L.

Scenario 13

The description for Scenario 13 is given in the LTI memorandum, dated September 15, 1999 as the fifth simulation, Capping - Rogers Island to Federal Dam. This memorandum is attached. The other four simulations listed in this memorandum were not used in this FS report.

Table 1
HUDTOX Input as Provided to LTI For Preliminary Screening

Segment	Type	Region	Percent of PCBs Removed					
			Scenarios 1&2	Scenarios 3&4	Scenarios 5&6	Scenarios 7 through 10	Scenarios 11&12	Scenario 13
48	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	0.0%
49	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	0.0%
50	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	0.0%
51	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	1.7%
52	C	Above TID	100.0%	100.0%	100.0%	100.0%	32.5%	11.4%
53	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	3.3%
54	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	3.1%
55	N	Above TID	100.0%	100.0%	57.9%	100.0%	30.3%	2.8%
56	C	Above TID	100.0%	100.0%	100.0%	100.0%	17.4%	4.3%
57	N	Above TID	100.0%	100.0%	58.2%	100.0%	26.1%	4.9%
58	N	Above TID	100.0%	100.0%	58.2%	100.0%	26.1%	2.5%
59	C	Above TID	100.0%	100.0%	100.0%	100.0%	17.4%	0.1%
60	N	Above TID	100.0%	100.0%	58.2%	100.0%	26.1%	0.0%
61	C	Above TID	100.0%	100.0%	100.0%	100.0%	17.4%	33.6%
62	N	Above TID	100.0%	100.0%	58.2%	100.0%	26.1%	1.0%
63	N	Above TID	100.0%	100.0%	58.2%	100.0%	26.1%	0.3%
64	C	Above TID	100.0%	100.0%	100.0%	100.0%	17.4%	0.0%
65	N	Above TID	100.0%	100.0%	58.2%	100.0%	26.1%	4.7%
66	C	Above TID	100.0%	100.0%	100.0%	100.0%	67.2%	5.4%
67	N	Above TID	100.0%	100.0%	69.5%	100.0%	20.4%	1.0%
68	C	Above TID	100.0%	100.0%	100.0%	100.0%	67.2%	4.2%
69	N	Above TID	100.0%	100.0%	69.5%	100.0%	20.4%	3.4%
70	C	Above TID	100.0%	100.0%	100.0%	100.0%	67.2%	20.2%
71	N	Above TID	100.0%	100.0%	69.5%	100.0%	20.4%	4.4%
72	C	Above TID	100.0%	100.0%	100.0%	100.0%	18.6%	25.7%
73	N	Above TID	100.0%	100.0%	50.1%	100.0%	61.7%	4.0%
74	N	Above TID	100.0%	100.0%	50.1%	100.0%	61.7%	2.4%
75	C	Above TID	100.0%	100.0%	100.0%	100.0%	18.6%	1.7%
76	N	Above TID	100.0%	100.0%	50.1%	100.0%	61.7%	0.0%
77	N	Above TID	100.0%	100.0%	52.5%	100.0%	42.6%	0.0%
78	C	Above TID	100.0%	100.0%	100.0%	100.0%	46.9%	48.0%
79	N	Above TID	100.0%	100.0%	52.5%	100.0%	42.6%	0.0%
80	C	Above TID	100.0%	100.0%	100.0%	100.0%	46.9%	31.5%
81	C	Above TID	100.0%	100.0%	100.0%	100.0%	95.5%	3.3%
82	N	Above TID	100.0%	100.0%	37.5%	100.0%	82.2%	6.3%
83	N	Above TID	100.0%	100.0%	37.5%	100.0%	82.2%	2.6%
84	C	Above TID	100.0%	100.0%	100.0%	100.0%	95.5%	23.1%
85	N	Above TID	100.0%	100.0%	37.5%	100.0%	82.2%	0.0%
86	N	Above TID	100.0%	100.0%	85.6%	100.0%	9.8%	2.3%
87	N	Above TID	100.0%	100.0%	85.6%	100.0%	9.8%	7.2%
88	C	Above TID	100.0%	100.0%	100.0%	100.0%	51.2%	7.5%
89	N	Above TID	100.0%	100.0%	85.6%	100.0%	9.8%	12.6%
90	C	TID-Lock 5	100.0%	0.0%	100.0%	100.0%	36.9%	11.2%
91	N	TID-Lock 5	0.0%	0.0%	40.6%	100.0%	45.8%	0.8%
92	C	TID-Lock 5	100.0%	0.0%	100.0%	100.0%	35.2%	6.9%

Table 1
HUDTOX Input as Provided to LTI For Preliminary Screening

Segment	Type	Region	Percent of PCBs Removed Scenarios 1&2	Scenarios 3&4	Scenarios 5&6	Scenarios 7 through 10	Scenarios 11&12	Scenario 13
93	N	TID-Lock 5	0.0%	0.0%	16.6%	100.0%	62.2%	3.5%
94	C	TID-Lock 5	100.0%	0.0%	100.0%	100.0%	23.4%	18.6%
95	N	TID-Lock 5	0.0%	0.0%	65.7%	100.0%	71.5%	0.0%
96	N	TID-Lock 5	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
97	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
98	C	Below Lock 5	41.3%	0.0%	41.3%	41.3%	49.3%	0.0%
99	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
100	C	Below Lock 5	47.3%	0.0%	47.3%	47.3%	48.2%	0.0%
101	N	Below Lock 5	30.8%	0.0%	30.8%	30.8%	33.4%	0.0%
102	C	Below Lock 5	47.3%	0.0%	47.3%	47.3%	48.2%	0.0%
103	N	Below Lock 5	30.8%	0.0%	30.8%	30.8%	33.4%	0.0%
104	C	Below Lock 5	47.3%	0.0%	47.3%	47.3%	48.2%	8.3%
105	N	Below Lock 5	30.8%	0.0%	30.8%	30.8%	33.4%	1.1%
106	C	Below Lock 5	13.8%	0.0%	13.8%	13.8%	17.0%	12.2%
107	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
108	C	Below Lock 5	13.8%	0.0%	13.8%	13.8%	17.0%	0.0%
109	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
110	C	Below Lock 5	47.0%	0.0%	47.0%	47.0%	54.2%	5.7%
111	N	Below Lock 5	28.8%	0.0%	28.8%	28.8%	32.2%	0.0%
112	C	Below Lock 5	47.0%	0.0%	47.0%	47.0%	54.2%	1.6%
113	N	Below Lock 5	28.8%	0.0%	28.8%	28.8%	32.2%	1.1%
114	C	Below Lock 5	55.7%	0.0%	55.7%	55.7%	63.0%	0.0%
115	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
116	C	Below Lock 5	55.7%	0.0%	55.7%	55.7%	63.0%	15.9%
117	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%
118	C	Below Lock 5	40.9%	0.0%	40.9%	40.9%	46.2%	0.0%
119	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
120	C	Below Lock 5	40.9%	0.0%	40.9%	40.9%	46.2%	0.0%
121	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
122	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
123	N	Below Lock 5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

HUDSON RIVER PCBs REASSESSMENT FS
Engineering Modeling Scenarios Input Specifications

The procedure used to specify input to HUDTOX for the Engineering modeling scenarios are described in this section. The input tables are also provided these scenarios.

In this phase of the modeling, actual potential remedial alternatives were modeled. The main differences between the model input for these alternatives and the Preliminary scenarios are the basic assumptions for delineating areas for sediment removal or capping. Preliminary scenarios are based on theoretical removal to a target PCB concentration; whereas Engineering scenarios take into consideration actual physical limitations due to equipment and/or access issues.

Target areas are defined as areas that have sediment sample(s) with PCB levels greater than a minimum target area criterion. (Minimum target area criteria are defined on the basis of mass per unit area [g/m^2]). Some judgment was used in determining whether to include or exclude certain areas. For example, if an area includes only one sampling point greater than the target PCB level with surrounding samples with lower PCB levels, then the area would not be included as a target area. On the other hand, if a sampling point with less than the target PCB level is found in an area with surrounding elevated PCB detections, the area would be included as a target area.

A brief description of the Engineering scenarios follows.

Alternative 1

All sediments (full section) in dredgeable areas are removed from Rogers Island to Lock 5 to a predetermined elevation. Below Lock 5, a PCB level of 3 g/m^2 was selected as the minimum target area criterion (minimum target area criterion described above). In this section of the river, target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 2

All sediments (full section) in dredgeable areas are removed from Rogers Island to Thompson Island Dam to a predetermined elevation. In sections of the river below the TIP, a PCB level of 3 g/m^2 was selected as the minimum target area criterion, and target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 3

For this alternative, a PCB level of 3 g/m^2 was selected as the minimum target area criterion, and target areas in the Upper Hudson with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 3B

This alternative includes the same components as Alternative 3 except the upstream loading is 0 ng/L.

Alternative 3C

This alternative includes the same components as Alternative 3 except the upstream loading is 30 ng/L.

Alternative 4

For this alternative, a PCB level of 10 g/m^2 was selected as the minimum target area criterion, and target areas in the Upper Hudson with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 5

For this alternative, target areas in the Thompson Island Pool with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 are removed. Below the TIP, target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 6

For this alternative, all sediments identified as cohesive sediments by side scan sonar survey are removed from Rogers Island to Lock 5. There is no sediment removal from Lock 5 to Federal Dam. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

HUDSON RIVER PCBs REASSESSMENT FS
Engineering Modeling Scenarios Input Specifications

Alternative 7

For this alternative, full section remediation is planned for the Thompson Island Pool (i.e., the minimum target area criterion is assumed to be 0 g/m^2), and 3 g/m^2 was selected as the minimum target area criterion for the next section of the river (Thompson Island Dam to Lock 5). There is no sediment remediation from Lock 5 to Federal Dam. All sediments in dredgeable areas are removed from the Thompson Island Pool to a predetermined elevation. In the Lock 5 pool, target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 8

For this alternative, target areas from Rogers Island to Federal Dam with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 with associated water depths greater than 6 feet and less than 12 feet will be capped.

Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 3 g/m^2 with associated water depths greater than 12 feet will be removed or capped. The 12-foot water depth contour is assumed to represent the edge of the navigation channel. Capping will not be conducted within the navigation channel, except in portions of the river where the navigation channel is located within a land cut adjacent to the river. Therefore, target areas with associated water depths greater than 12 feet will be dredged; except in portions of the river where the navigation channel is located within a land cut, target areas with associated water depths greater than 12 feet will be capped.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 8B

This alternative includes the same components as Alternative 8 except the upstream loading is 0 ng/L.

Alternative 9

For this alternative, target areas from Rogers Island to Federal Dam with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 10

For this alternative, 3 g/m^2 was selected as the minimum target area criterion for the Thompson Island Pool (TIP), and 10 g/m^2 was selected as the minimum target area criterion for the rest of the river. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 11

For this alternative, full section remediation is planned for the Thompson Island Pool (i.e., the minimum target area criterion is assumed to be 0 g/m^2), and 3 g/m^2 was selected as the minimum target area criterion for the next section of the river (Thompson Island Dam to Lock 5). There is no sediment remediation from Lock 5 to Federal Dam. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 12

For this alternative, full section remediation is planned for the Thompson Island Pool (i.e., the minimum target area criterion is assumed to be 0 g/m^2). No remediation is planned for the river sediments below Thompson Island Dam. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 13

For this alternative, 3 g/m^2 was selected as the minimum target area criterion for the TIP. No remediation is planned for the river sediments below Thompson Island Dam. Target areas in the TIP with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 14

For this alternative, full section remediation is planned for both the Thompson Island Pool and for the next section of the river from Thompson Island Dam to Lock 5 (i.e., the minimum target area criterion is assumed to be 0 g/m^2). There is no sediment remediation from Lock 5 to Federal Dam. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 15

For this alternative, 3 g/m^2 was selected as the minimum target area criterion for the Thompson Island Pool and for the next section of the river from Thompson Island Dam to Lock 5. There is no sediment remediation from Lock 5 to Federal Dam. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Alternative 16

For this alternative, full section remediation is planned for the Thompson Island Pool (i.e., the minimum target area criterion is assumed to be 0 g/m^2), and 10 g/m^2 was selected as the minimum target area criterion for the next section of the river (Thompson Island Dam to Lock 5).

There is no sediment remediation from Lock 5 to Federal Dam. All sediments in dredgeable areas are removed from the Thompson Island Pool to a predetermined elevation. In the Lock 5 pool, target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 17

For this alternative, full section remediation is planned for the Thompson Island Pool (i.e., the minimum target area criterion is assumed to be 0 g/m^2), and 10 g/m^2 was selected as the minimum target area criterion for the next 2 sections of the river (Thompson Island Dam to Lock 5 and Lock 5 to Federal Dam). All sediments in dredgeable areas are removed from the Thompson Island Pool to a predetermined elevation. Below Thompson Island Dam, target areas with sediments (cohesive and non-cohesive) with PCB levels greater than 10 g/m^2 are removed. The upstream loading for this alternative is assumed to be 10 ng/L. The residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments.

Alternative 18

For this alternative, full section remediation is planned for the Thompson Island Pool (i.e., the minimum target area criterion is assumed to be 0 g/m^2), and 10 g/m^2 was selected as the minimum target area criterion for the rest of the river. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths less than 6 feet will be removed and subsequently capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 6 feet and less than 12 feet will be capped. Target areas with sediments (cohesive and non-cohesive) with PCB levels greater than the minimum target area criterion with associated water depths greater than 12 feet will be removed or capped. The dredging and capping criteria in the navigational channel described in Alternative 8 will be followed for this alternative.

The upstream loading for this alternative is assumed to be 10 ng/L. It is assumed that the residual sediment concentration in the capped areas will be 0 mg/kg for the top 26 cm of sediment, and the residual sediment concentration in the areas where sediments are removed (and not capped) will be 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below.

Data Provided to LTI

For each removal alternative, a table was provided which includes for each sediment segment: a PCB percent mass remaining to be applied to the model output cores in 2004 (or 2005, 2006, etc., as appropriate), and the percent of the area in the sediment segment that the PCB percent mass remaining is applied to (i.e., the percent of the segment that is non-dredged area). The core profile for all dredged areas (i.e., area where sediments are removed) is assumed to be 0.25 mg/kg for the entire core length represented in the model (26 cm) for cohesive sediment segments, and 0.5 mg/kg for the entire core length for non-cohesive sediment segments. A new area-weighted core profile was calculated for each sediment segment using the new cores in the non-dredged area and in the dredged area in the segment. An example calculation for a core profile after remediation is provided. The schedule for sediment removal is provided in the input tables.

For each capping alternative, a table was provided which includes for each sediment segment: a PCB percent mass remaining to be applied to the model output cores in 2004 (or 2005, 2006, etc., as appropriate), and the percent of the area in the sediment segment that the PCB percent mass remaining is applied to (i.e., the percent of the segment area that is not remediated). The percent of the area in the sediment segment that is capped and the percent of the area that is dredged is also provided. The core profile for all capped areas is assumed to be 0 mg/kg for the entire core length represented in the model (26 cm). The core profile for dredged areas that are not subsequently capped is 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below. A new area-weighted core profile was calculated for each sediment segment using the new cores in the non-remediated area and in the remediated (capped and dredged) area in the segment. An example calculation for a core profile after remediation is provided. The schedule for sediment remediation is provided in the input tables.

If PCB concentration in the core after remediation is higher than the PCB concentration before remediation, the model output at the time when remediation is completed was used rather than the area-weighted calculated core profile.

Sensitivity Analysis

Three sensitivity analyses were conducted for the removal scenarios. The sensitivity analyses used the input for Alternative 3 with the following changes:

- Three different residual PCB concentrations: 1 ppm (Scenario E3S1), 2 ppm (E3S2), and 5 ppm (E3S5), versus the original Alternative 3 residual concentration of 0.25 ppm. The residual concentrations take into account that a foot of clean backfill material has been placed over the dredged areas (i.e., the 1 ppm residual assumes that the PCB concentration was 4 ppm in the top 3 inches of the dredged surface prior to backfilling. The clean backfill material results in depth-averaged concentration of 1 ppm in the top foot of sediments)
- The residual PCBs were used in the "PCB mass remaining" calculations for each sediment segment.

Three sensitivity analyses were conducted for the capping scenarios. The sensitivity analyses used the input for Alternative 8 with the following changes:

- In the area where the cap is planned, a percent of the area is assumed to be not capped (this may be due to omission of the area during placement for some reason, or damage to the cap after placement). The 3 cases that were modeled were: 5% (Scenario E8S5), 10% (E8S10), and 25% (E3S25) of the areas planned for capping were not capped.

- To represent the missing cap portions, random areas were selected in the to-be-capped areas to represent 5, 10, and 25% of the area that are not capped. Random areas were selected by placing a grid (with 120' x 120' squares) over the river, assigning a number to each square, run a random number selector in Excel to select grid squares to be removed to achieve the percent area required. The mass of PCBs remaining (i.e., not capped or removed) was calculated for each of the capping sensitivity analysis runs, as well as the percent of area remediated.

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E1					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.56%	0.56%	C	0.25
57	Aug-04	22.72%	5.23%	N	0.5
58	Aug-04	1.65%	3.63%	N	0.5
59	Aug-04	0.00%	0.00%	C	0.25
60	Aug-04	0.00%	0.00%	N	0.5
61	Aug-04	0.00%	0.00%	C	0.25
62	Aug-04	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	2.04%	2.04%	C	0.25
67	Aug-05	1.38%	1.00%	N	0.5
68	Aug-05	7.54%	7.54%	C	0.25
69	Aug-05	0.41%	1.71%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	0.00%	0.00%	N	0.5
72	Aug-05	1.60%	1.60%	C	0.25
73	Aug-05	3.27%	2.38%	N	0.5
74	Aug-05	7.64%	7.60%	N	0.5
75	Aug-05	82.05%	41.30%	C	0.25
76	Aug-05	36.65%	7.22%	N	0.5
77	Aug-05	0.00%	0.00%	N	0.5
78	Aug-05	6.35%	6.35%	C	0.25
79	Aug-05	14.03%	7.41%	N	0.5
80	Aug-05	1.59%	2.68%	C	0.25
81	Aug-05	0.00%	0.00%	C	0.25
82	Aug-05	0.00%	0.00%	N	0.5
83	Aug-06	62.52%	10.92%	N	0.5
84	Aug-06	1.92%	8.71%	C	0.25
85	Aug-06	24.59%	19.01%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-06	0.81%	0.59%	N	0.5
88	Aug-06	0.00%	0.00%	C	0.25
89	Aug-06	3.25%	2.36%	N	0.5
90	Aug-06	10.40%	11.59%	C	0.25
91	Aug-06	7.05%	5.18%	N	0.5
92	Aug-07	3.21%	5.10%	C	0.25
93	Aug-07	8.59%	6.34%	N	0.5
94	Aug-07	2.01%	2.01%	C	0.25
95	Aug-08	0.15%	5.73%	N	0.5
96	Aug-08	98.19%	97.51%	N	0.5
97			No change		
98			No change		
99			No change		
100			No change		
101			No change		
102	Aug-08	86.58%	90.25%	C	0.25
103	Aug-08	90.07%	97.57%	N	0.5
104	Aug-08	85.30%	97.21%	C	0.25
105	Aug-08	99.17%	99.66%	N	0.5
106	Aug-08	31.16%	32.77%	C	0.25
107	Aug-08	86.25%	96.81%	N	0.5
108			No change		
109			No change		
110			No change		
111			No change		
112	Aug-08	21.28%	67.58%	C	0.25
113	Aug-08	12.15%	74.36%	N	0.5
114			No change		
115			No change		
116	Aug-08	23.62%	72.86%	C	0.25
117	Aug-08	32.01%	68.82%	N	0.5
118			No change		
119			No change		
120			No change		
121			No change		
122			No change		
123			No change		

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E2					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.56%	0.56%	C	0.25
57	Aug-04	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	2.04%	2.04%	C	0.25
67	Aug-05	1.38%	1.00%	N	0.5
68	Aug-05	7.54%	7.54%	C	0.25
69	Aug-05	0.41%	1.71%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	36.65%	7.22%	N	0.5
77	Aug-06	0.00%	0.00%	N	0.5
78	Aug-06	6.35%	6.35%	C	0.25
79	Aug-06	14.03%	7.41%	N	0.5
80	Aug-06	1.59%	2.68%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	0.00%	0.00%	N	0.5
83	Aug-06	62.52%	10.92%	N	0.5
84	Aug-06	1.92%	8.71%	C	0.25
85	Aug-06	24.59%	19.01%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-06	0.81%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	3.25%	2.36%	N	0.5
90	Aug-07	20.36%	29.14%	C	0.25
91	Aug-07	97.56%	96.98%	N	0.5
92	Aug-07	0.43%	19.53%	C	0.25
93	Aug-07	86.98%	93.05%	N	0.5
94	Aug-07	6.91%	38.55%	C	0.25
95	Aug-07	63.81%	87.77%	N	0.5
96	No change				
97	No change				
98	No change				
99	No change				
100	No change				
101	No change				
102	Aug-08	86.58%	90.25%	C	0.25
103	Aug-08	90.07%	97.57%	N	0.5
104	Aug-08	85.30%	97.21%	C	0.25
105	Aug-08	99.17%	99.66%	N	0.5
106	Aug-08	31.16%	32.77%	C	0.25
107	Aug-08	86.25%	96.81%	N	0.5
108	No change				
109	No change				
110	No change				
111	No change				
112	Aug-08	21.28%	67.58%	C	0.25
113	Aug-08	12.15%	74.36%	N	0.5
114	No change				
115	No change				
116	Aug-08	23.62%	72.86%	C	0.25
117	Aug-08	32.01%	68.82%	N	0.5
118	No change				
119	No change				
120	No change				
121	No change				
122	No change				
123	No change				

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIOS E3 AND E3B						
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)	
48	Aug-04	98.12%	88.60%	N	0.5	
49	Aug-04	100.00%	100.00%	N	0.5	
50	Aug-04	87.19%	73.83%	N	0.5	
51	Aug-04	1.90%	23.74%	N	0.5	
52	Aug-04	2.82%	20.12%	C	0.25	
53	Aug-04	53.91%	54.80%	N	0.5	
54	Aug-04	69.63%	60.89%	N	0.5	
55	Aug-04	95.29%	93.51%	N	0.5	
56	Aug-04	0.60%	0.60%	C	0.25	
57	Aug-04	22.66%	5.33%	N	0.5	
58	Aug-04	1.65%	3.64%	N	0.5	
59	Aug-04	0.00%	0.00%	C	0.25	
60	Aug-04	0.00%	0.00%	N	0.5	
61	Aug-04	2.57%	15.22%	C	0.25	
62	Aug-04	62.53%	71.16%	N	0.5	
63	Aug-05	36.96%	41.45%	N	0.5	
64	Aug-05	0.00%	0.00%	C	0.25	
65	Aug-05	0.00%	0.00%	N	0.5	
66	Aug-05	36.79%	60.34%	C	0.25	
67	Aug-05	47.92%	74.63%	N	0.5	
68	Aug-05	15.94%	55.70%	C	0.25	
69	Aug-05	63.12%	71.95%	N	0.5	
70	Aug-05	0.00%	0.00%	C	0.25	
71	Aug-05	0.00%	0.00%	N	0.5	
72	Aug-05	6.03%	14.61%	C	0.25	
73	Aug-05	6.56%	18.69%	N	0.5	
74	Aug-05	45.86%	48.88%	N	0.5	
75	Aug-05	63.78%	57.52%	C	0.25	
76	Aug-05	17.59%	23.46%	N	0.5	
77	Aug-05	21.03%	57.62%	N	0.5	
78	Aug-05	7.09%	7.09%	C	0.25	
79	Aug-05	66.15%	60.67%	N	0.5	
80	Aug-05	5.07%	5.06%	C	0.25	
81	Aug-06	3.94%	34.48%	C	0.25	
82	Aug-06	93.25%	69.75%	N	0.5	
83	Aug-06	94.68%	69.64%	N	0.5	
84	Aug-06	1.89%	10.39%	C	0.25	
85	Aug-06	37.23%	29.93%	N	0.5	
86	Aug-06	25.59%	55.59%	N	0.5	
87	Aug-06	55.79%	75.98%	N	0.5	
88	Aug-06	9.11%	32.26%	C	0.25	
89	Aug-06	50.24%	73.92%	N	0.5	
90	Aug-06	20.36%	29.14%	C	0.25	
91	Aug-06	97.56%	96.98%	N	0.5	
92	Aug-06	0.43%	19.53%	C	0.25	
93	Aug-07	86.98%	93.05%	N	0.5	
94	Aug-07	6.91%	38.55%	C	0.25	
95	Aug-07	63.81%	87.77%	N	0.5	
96	No change					
97	No change					
98	No change					
99	No change					
100	No change					
101	No change					
102	Aug-07	86.58%	90.25%	C	0.25	
103	Aug-07	90.07%	97.57%	N	0.5	
104	Aug-07	85.30%	97.21%	C	0.25	
105	Aug-07	99.17%	99.66%	N	0.5	
106	Aug-07	31.16%	32.77%	C	0.25	
107	Aug-08	66.25%	96.81%	N	0.5	
108	No change					
109	No change					
110	No change					
111	No change					
112	Aug-08	21.28%	67.58%	C	0.25	
113	Aug-08	12.15%	74.36%	N	0.5	
114	No change					
115	No change					
116	Aug-08	23.62%	72.86%	C	0.25	
117	Aug-08	32.01%	68.82%	N	0.5	
118	No change					
119	No change					
120	No change					
121	No change					
122	No change					
123	No change					

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E4					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	No Change	No Change	No Change	No Change	No Change
49	No Change	No Change	No Change	No Change	No Change
50	Aug-04	95.97%	79.67%	N	0.5
51	No Change	No Change	No Change	No Change	No Change
52	Aug-04	2.81%	20.02%	C	0.25
53	Aug-04	64.05%	54.76%	N	0.5
54	Aug-04	88.06%	86.89%	N	0.5
55	No Change	No Change	No Change	No Change	No Change
56	Aug-04	0.53%	2.78%	C	0.25
57	Aug-04	65.77%	69.37%	N	0.5
58	Aug-04	91.86%	89.42%	N	0.5
59	Aug-04	4.07%	7.77%	C	0.25
60	Aug-04	5.01%	17.24%	N	0.5
61	Aug-04	5.73%	24.88%	C	0.25
62	Aug-04	73.84%	76.60%	N	0.5
63	Aug-05	94.53%	93.55%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	17.07%	27.62%	N	0.5
66	Aug-05	46.62%	75.24%	C	0.25
67	Aug-05	55.80%	79.20%	N	0.5
68	Aug-05	17.86%	57.71%	C	0.25
69	Aug-05	74.17%	91.36%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	38.45%	15.49%	N	0.5
72	Aug-05	6.82%	31.85%	C	0.25
73	Aug-05	64.03%	72.39%	N	0.5
74	Aug-05	90.22%	88.22%	N	0.5
75	Aug-05	96.23%	96.60%	C	0.25
76	No Change	No Change	No Change	No Change	No Change
77	No Change	No Change	No Change	No Change	No Change
78	Aug-05	7.65%	7.65%	C	0.25
79	Aug-05	99.63%	99.40%	N	0.5
80	Aug-06	15.47%	9.90%	C	0.25
81	Aug-06	17.18%	72.70%	C	0.25
82	Aug-06	96.75%	94.87%	N	0.5
83	Aug-06	99.30%	95.52%	N	0.5
84	Aug-06	4.24%	11.86%	C	0.25
85	No Change	No Change	No Change	No Change	No Change
86	Aug-06	66.36%	87.99%	N	0.5
87	Aug-06	83.02%	93.70%	N	0.5
88	Aug-06	17.54%	48.41%	C	0.25
89	Aug-06	63.81%	81.00%	N	0.5
90	Aug-06	32.92%	52.64%	C	0.25
91	Aug-06	99.76%	99.62%	N	0.5
92	Aug-07	3.30%	49.53%	C	0.25
93	Aug-07	99.73%	99.57%	N	0.5
94	Aug-07	14.59%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	C	0.25
113	Aug-08	18.49%	74.35%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	C	0.25
117	Aug-08	60.37%	90.20%	N	0.5
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

TAMS

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E5					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	98.12%	88.60%	N	0.5
49	Aug-04	100.00%	100.00%	N	0.5
50	Aug-04	87.19%	73.83%	N	0.5
51	Aug-04	1.90%	23.74%	N	0.5
52	Aug-04	2.82%	20.12%	C	0.25
53	Aug-04	53.91%	54.80%	N	0.5
54	Aug-04	69.63%	60.89%	N	0.5
55	Aug-04	95.29%	93.51%	N	0.5
56	Aug-04	0.60%	0.60%	C	0.25
57	Aug-04	22.66%	5.33%	N	0.5
58	Aug-04	1.65%	3.64%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	2.57%	15.22%	C	0.25
62	Aug-05	62.53%	71.16%	N	0.5
63	Aug-05	36.96%	41.45%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	36.79%	60.34%	C	0.25
67	Aug-05	47.92%	74.63%	N	0.5
68	Aug-05	15.94%	55.70%	C	0.25
69	Aug-05	63.12%	71.95%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	6.03%	14.61%	C	0.25
73	Aug-06	6.56%	18.69%	N	0.5
74	Aug-06	45.86%	48.88%	N	0.5
75	Aug-06	63.78%	57.52%	C	0.25
76	Aug-06	17.59%	23.46%	N	0.5
77	Aug-06	21.03%	57.62%	N	0.5
78	Aug-06	7.09%	7.09%	C	0.25
79	Aug-06	66.15%	60.67%	N	0.5
80	Aug-06	5.07%	5.06%	C	0.25
81	Aug-06	3.94%	34.48%	C	0.25
82	Aug-06	93.25%	69.75%	N	0.5
83	Aug-06	94.68%	69.64%	N	0.5
84	Aug-06	1.89%	10.39%	C	0.25
85	Aug-07	37.23%	29.93%	N	0.5
86	Aug-07	25.59%	55.59%	N	0.5
87	Aug-07	55.79%	75.98%	N	0.5
88	Aug-07	9.11%	32.26%	C	0.25
89	Aug-07	50.24%	73.92%	N	0.5
90	Aug-07	32.92%	52.64%	C	0.25
91	Aug-07	99.76%	99.62%	N	0.5
92	Aug-07	3.30%	49.53%	C	0.25
93	Aug-07	99.73%	99.57%	N	0.5
94	Aug-08	14.59%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	C	0.25
113	Aug-08	18.49%	74.35%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	C	0.25
117	Aug-08	60.37%	90.20%	N	0.5
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E6					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	97.38%	97.74%	N	0.5
49	Aug-04	85.85%	93.76%	N	0.5
50	Aug-04	96.03%	79.93%	N	0.5
51	Aug-04	96.28%	84.86%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	94.06%	89.88%	N	0.5
54	Aug-04	98.83%	98.82%	N	0.5
55	Aug-04	100.00%	100.00%	N	0.5
56	Aug-04	0.32%	0.59%	C	0.25
57	Aug-04	99.30%	98.88%	N	0.5
58	Aug-04	92.36%	91.70%	N	0.5
59	Aug-04	0.00%	0.00%	C	0.25
60	Aug-04	100.00%	100.00%	N	0.5
61	Aug-04	0.00%	0.00%	C	0.25
62	Aug-04	100.00%	100.00%	N	0.5
63	Aug-04	96.84%	89.61%	N	0.5
64	Aug-04	0.00%	0.44%	C	0.25
65	Aug-04	100.00%	100.00%	N	0.5
66	Aug-04	1.41%	2.04%	C	0.25
67	Aug-05	25.94%	51.01%	N	0.5
68	Aug-05	2.94%	7.56%	C	0.25
69	Aug-05	64.24%	88.01%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	29.79%	14.86%	N	0.5
72	Aug-05	2.02%	2.02%	C	0.25
73	Aug-05	57.18%	67.44%	N	0.5
74	Aug-05	99.94%	98.48%	N	0.5
75	Aug-05	88.74%	48.25%	C	0.25
76	Aug-05	100.00%	100.00%	N	0.5
77	Aug-05	92.47%	71.44%	N	0.5
78	Aug-05	7.36%	7.36%	C	0.25
79	Aug-05	95.17%	96.30%	N	0.5
80	Aug-05	20.53%	7.85%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	98.39%	97.43%	N	0.5
83	Aug-06	98.80%	92.49%	N	0.5
84	Aug-06	1.86%	10.22%	C	0.25
85	Aug-06	83.40%	75.70%	N	0.5
86	Aug-06	70.07%	85.81%	N	0.5
87	Aug-06	86.59%	91.90%	N	0.5
88	Aug-06	0.00%	0.00%	C	0.25
89	Aug-06	99.31%	98.26%	N	0.5
90	Aug-06	7.60%	15.88%	C	0.25
91	Aug-06	95.84%	97.97%	N	0.5
92	Aug-07	0.21%	4.22%	C	0.25
93	Aug-07	98.58%	96.11%	N	0.5
94	Aug-08	0.48%	1.01%	C	0.25
95	Aug-08	95.22%	96.19%	N	0.5
96	No change	No change	No change	No change	No change
97	No change	No change	No change	No change	No change
98	No change	No change	No change	No change	No change
99	No change	No change	No change	No change	No change
100	No change	No change	No change	No change	No change
101	No change	No change	No change	No change	No change
102	No change	No change	No change	No change	No change
103	No change	No change	No change	No change	No change
104	No change	No change	No change	No change	No change
105	No change	No change	No change	No change	No change
106	No change	No change	No change	No change	No change
107	No change	No change	No change	No change	No change
108	No change	No change	No change	No change	No change
109	No change	No change	No change	No change	No change
110	No change	No change	No change	No change	No change
111	No change	No change	No change	No change	No change
112	No change	No change	No change	No change	No change
113	No change	No change	No change	No change	No change
114	No change	No change	No change	No change	No change
115	No change	No change	No change	No change	No change
116	No change	No change	No change	No change	No change
117	No change	No change	No change	No change	No change
118	No change	No change	No change	No change	No change
119	No change	No change	No change	No change	No change
120	No change	No change	No change	No change	No change
121	No change	No change	No change	No change	No change
122	No change	No change	No change	No change	No change
123	No change	No change	No change	No change	No change

TAMS

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E7					
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-05	0.56%	0.56%	C	0.25
57	Aug-05	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-06	2.04%	2.04%	C	0.25
67	Aug-06	1.38%	1.00%	N	0.5
68	Aug-06	7.54%	7.54%	C	0.25
69	Aug-06	0.41%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	9.76%	7.22%	N	0.5
77	Aug-06	0.00%	0.00%	N	0.5
78	Aug-06	6.35%	6.35%	C	0.25
79	Aug-06	14.03%	7.41%	N	0.5
80	Aug-07	2.68%	2.68%	C	0.25
81	Aug-07	0.00%	0.00%	C	0.25
82	Aug-07	0.00%	0.00%	N	0.5
83	Aug-07	62.52%	10.92%	N	0.5
84	Aug-07	1.92%	8.71%	C	0.25
85	Aug-07	24.59%	19.01%	N	0.5
86	Aug-07	0.00%	0.00%	N	0.5
87	Aug-07	0.81%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-08	3.25%	2.36%	N	0.5
90	Aug-08	20.36%	29.14%	C	0.25
91	Aug-08	97.56%	96.98%	N	0.5
92	Aug-08	0.43%	19.53%	C	0.25
93	Aug-08	86.98%	93.05%	N	0.5
94	Aug-08	6.91%	38.55%	C	0.25
95	Aug-08	63.81%	87.77%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIOS 8 AND 8B

SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	98.12%	88.60%	11.40%	0	0.00%	1	N
49	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
50	Aug-04	87.19%	73.83%	24.83%	0	1.34%	1	N
51	Aug-04	1.90%	23.74%	66.56%	0	9.70%	1	N
52	Aug-04	2.82%	20.12%	66.29%	0	13.59%	1	C
53	Aug-04	53.91%	54.80%	36.35%	0	8.85%	1	N
54	Aug-04	69.63%	60.89%	7.31%	0	31.81%	1	N
55	Aug-04	95.29%	93.51%	5.31%	0	1.18%	1	N
56	Aug-04	0.60%	0.60%	99.40%	0	0.00%	1	C
57	Aug-04	22.66%	5.33%	94.67%	0	0.00%	1	N
58	Aug-04	1.65%	3.64%	55.71%	0	40.64%	1	N
59	Aug-04	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-04	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-04	2.57%	15.22%	76.59%	0	8.19%	1	C
62	Aug-04	62.53%	71.16%	28.60%	0	0.24%	1	N
63	Aug-05	36.96%	41.45%	40.94%	0	17.61%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-05	36.79%	60.34%	39.54%	0	0.13%	1	C
67	Aug-05	47.92%	74.63%	25.37%	0	0.00%	1	N
68	Aug-05	15.94%	55.70%	4.24%	0	40.05%	1	C
69	Aug-05	63.12%	71.95%	12.64%	0	15.41%	1	N
70	Aug-05	0.00%	0.00%	86.12%	0	13.87%	1	C
71	Aug-05	0.00%	0.00%	94.80%	0	5.20%	1	N
72	Aug-05	6.03%	14.61%	75.06%	0	10.32%	1	C
73	Aug-05	6.56%	18.69%	73.18%	0	8.13%	1	N
74	Aug-05	45.86%	48.88%	12.38%	0	38.74%	1	N
75	Aug-05	63.78%	57.52%	33.95%	0	8.53%	1	C
76	Aug-05	17.59%	23.46%	66.04%	0	10.49%	1	N
77	Aug-05	21.03%	57.62%	35.13%	0	7.25%	1	N
78	Aug-05	7.09%	7.09%	82.66%	0	10.25%	1	C
79	Aug-05	66.15%	60.67%	30.34%	0	8.99%	1	N
80	Aug-05	5.07%	5.06%	90.37%	0	4.56%	1	C
81	Aug-06	3.94%	34.48%	59.67%	0	5.85%	1	C
82	Aug-06	93.25%	69.75%	9.94%	0	20.31%	1	N
83	Aug-06	94.68%	69.64%	3.31%	0	27.05%	1	N
84	Aug-06	1.89%	10.39%	82.85%	0	6.76%	1	C
85	Aug-06	37.23%	29.93%	49.55%	0	20.52%	1	N
86	Aug-06	25.59%	55.59%	40.69%	0	3.72%	1	N
87	Aug-06	55.79%	75.98%	13.91%	0	10.12%	1	N
88	Aug-06	9.11%	32.26%	54.68%	0	13.05%	1	C
89	Aug-06	50.24%	73.92%	19.32%	0	6.76%	1	N
90	Aug-06	20.36%	29.14%	70.86%	0	0.00%	1	C
91	Aug-06	97.56%	96.98%	3.02%	0	0.00%	1	N
92	Aug-06	0.43%	19.53%	66.22%	0	14.26%	1	C
93	Aug-07	86.98%	93.05%	1.73%	0	5.21%	1	N
94	Aug-07	6.91%	38.55%	50.48%	0	10.97%	1	C
95	Aug-07	63.81%	87.77%	4.23%	0	8.00%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	Aug-07	86.58%	90.25%	9.75%	0	0.00%	1	C
103	Aug-07	90.07%	97.57%	0.93%	0	1.50%	1	N
104	Aug-07	85.30%	97.21%	2.79%	0	0.00%	1	C
105	Aug-07	99.17%	99.66%	0.30%	0	0.04%	1	N
106	Aug-07	31.16%	32.77%	65.63%	0	1.60%	1	C
107	Aug-08	86.25%	96.81%	3.19%	0	0.00%	1	N
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	Aug-08	21.28%	67.58%	32.42%	0	0.00%	1	C
113	Aug-08	12.15%	74.36%	25.64%	0	0.00%	1	N
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.62%	72.86%	27.14%	0	0.00%	1	C
117	Aug-08	32.01%	68.82%	30.25%	0	0.93%	1	N
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E9								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
49	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
50	Aug-04	95.97%	79.67%	18.99%	0	1.34%	1	N
51	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
52	Aug-04	2.81%	20.02%	66.40%	0	13.58%	1	C
53	Aug-04	64.05%	54.76%	36.47%	0	8.78%	1	N
54	Aug-04	88.06%	86.89%	5.73%	0	7.38%	1	N
55	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
56	Aug-04	0.53%	2.78%	97.22%	0	0.00%	1	C
57	Aug-04	65.77%	69.37%	30.63%	0	0.00%	1	N
58	Aug-04	91.86%	89.42%	8.11%	0	2.47%	1	N
59	Aug-04	4.07%	7.77%	77.62%	0	14.61%	1	C
60	Aug-04	5.01%	17.24%	82.76%	0	0.00%	1	N
61	Aug-04	5.73%	24.88%	66.95%	0	8.17%	1	C
62	Aug-04	73.84%	76.60%	23.37%	0	0.03%	1	N
63	Aug-05	94.53%	93.55%	6.41%	0	0.05%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	17.07%	27.62%	72.38%	0	0.00%	1	N
66	Aug-05	46.62%	75.24%	24.76%	0	0.00%	1	C
67	Aug-05	55.80%	79.20%	20.80%	0	0.00%	1	N
68	Aug-05	17.86%	57.71%	4.22%	0	38.07%	1	C
69	Aug-05	74.17%	91.36%	5.01%	0	3.63%	1	N
70	Aug-05	0.00%	0.00%	86.14%	0	13.85%	1	C
71	Aug-05	38.45%	15.49%	80.71%	0	3.80%	1	N
72	Aug-05	6.82%	31.85%	60.74%	0	7.41%	1	C
73	Aug-05	64.03%	72.39%	19.69%	0	7.92%	1	N
74	Aug-05	90.22%	88.22%	1.04%	0	10.74%	1	N
75	Aug-05	96.23%	96.60%	3.40%	0	0.00%	1	C
76	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
77	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
78	Aug-05	7.65%	7.65%	82.39%	0	9.96%	1	C
79	Aug-05	99.63%	99.40%	0.42%	0	0.18%	1	N
80	Aug-06	15.47%	9.90%	86.80%	0	3.30%	1	C
81	Aug-06	17.18%	72.70%	27.28%	0	0.01%	1	C
82	Aug-06	96.75%	94.87%	3.64%	0	1.49%	1	N
83	Aug-06	99.30%	95.52%	1.36%	0	3.12%	1	N
84	Aug-06	4.24%	11.86%	82.25%	0	5.89%	1	C
85	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
86	Aug-06	66.36%	87.99%	8.91%	0	3.11%	1	N
87	Aug-06	83.02%	93.70%	4.01%	0	2.30%	1	N
88	Aug-06	17.54%	48.41%	39.24%	0	12.36%	1	C
89	Aug-06	63.81%	81.00%	17.01%	0	1.99%	1	N
90	Aug-06	32.92%	52.64%	47.36%	0	0.00%	1	C
91	Aug-06	99.76%	99.62%	0.38%	0	0.00%	1	N
92	Aug-07	3.30%	49.53%	39.55%	0	10.91%	1	C
93	Aug-07	99.73%	99.57%	0.11%	0	0.32%	1	N
94	Aug-07	14.59%	57.42%	39.49%	0	3.09%	1	C
95	Aug-08	81.64%	92.87%	4.67%	0	2.46%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	32.42%	0	0.00%	1	C
113	Aug-08	18.49%	74.35%	25.65%	0	0.00%	1	N
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	27.66%	0	0.00%	1	C
117	Aug-08	60.37%	90.20%	9.80%	0	0.00%	1	N
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E10								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	98.12%	88.60%	11.40%	0	0.00%	1	N
49	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
50	Aug-04	87.19%	73.83%	24.83%	0	1.34%	1	N
51	Aug-04	1.90%	23.74%	66.56%	0	9.70%	1	N
52	Aug-04	2.82%	20.12%	66.29%	0	13.59%	1	C
53	Aug-04	53.91%	54.80%	36.35%	0	8.85%	1	N
54	Aug-04	69.63%	60.89%	7.31%	0	31.81%	1	N
55	Aug-04	95.29%	93.51%	5.31%	0	1.18%	1	N
56	Aug-04	0.60%	0.60%	99.40%	0	0.00%	1	C
57	Aug-04	22.66%	5.33%	94.67%	0	0.00%	1	N
58	Aug-04	1.65%	3.64%	55.71%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	2.57%	15.22%	76.59%	0	8.19%	1	C
62	Aug-05	62.53%	71.16%	28.60%	0	0.24%	1	N
63	Aug-05	36.96%	41.45%	40.94%	0	17.61%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-05	36.79%	60.34%	39.54%	0	0.13%	1	C
67	Aug-05	47.92%	74.63%	25.37%	0	0.00%	1	N
68	Aug-05	15.94%	55.70%	4.24%	0	40.05%	1	C
69	Aug-05	63.12%	71.95%	12.64%	0	15.41%	1	N
70	Aug-05	0.00%	0.00%	86.12%	0	13.87%	1	C
71	Aug-06	0.00%	0.00%	94.80%	0	5.20%	1	N
72	Aug-06	6.03%	14.61%	75.06%	0	10.32%	1	C
73	Aug-06	6.56%	18.69%	73.18%	0	8.13%	1	N
74	Aug-06	45.86%	48.88%	12.38%	0	38.74%	1	N
75	Aug-06	63.78%	57.52%	33.95%	0	8.53%	1	C
76	Aug-06	17.59%	23.46%	66.04%	0	10.49%	1	N
77	Aug-06	21.03%	57.62%	35.13%	0	7.25%	1	N
78	Aug-06	7.09%	7.09%	82.66%	0	10.25%	1	C
79	Aug-06	66.15%	60.67%	30.34%	0	8.99%	1	N
80	Aug-06	5.07%	5.06%	90.37%	0	4.56%	1	C
81	Aug-06	3.94%	34.48%	59.67%	0	5.85%	1	C
82	Aug-06	93.25%	69.75%	9.94%	0	20.31%	1	N
83	Aug-06	94.68%	69.64%	3.31%	0	27.05%	1	N
84	Aug-06	1.89%	10.39%	82.85%	0	6.76%	1	C
85	Aug-07	37.23%	29.93%	49.55%	0	20.52%	1	N
86	Aug-07	25.59%	55.59%	40.69%	0	3.72%	1	N
87	Aug-07	55.79%	75.98%	13.91%	0	10.12%	1	N
88	Aug-07	9.11%	32.26%	54.68%	0	13.05%	1	C
89	Aug-07	50.24%	73.92%	19.32%	0	6.76%	1	N
90	Aug-07	32.92%	52.64%	47.36%	0	0.00%	1	C
91	Aug-07	99.76%	99.62%	0.38%	0	0.00%	1	N
92	Aug-07	3.30%	49.53%	39.55%	0	10.91%	1	C
93	Aug-07	99.73%	99.57%	0.11%	0	0.32%	1	N
94	Aug-08	14.59%	57.42%	39.49%	0	3.09%	1	C
95	Aug-08	81.64%	92.87%	4.67%	0	2.46%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	32.42%	0	0.00%	1	C
113	Aug-08	18.49%	74.35%	25.65%	0	0.00%	1	N
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	27.66%	0	0.00%	1	C
117	Aug-08	60.37%	90.20%	9.80%	0	0.00%	1	N
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E11								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	2.61%	1.89%	98.11%	0	0.00%	1	N
49	Aug-04	0.00%	0.00%	97.73%	0	2.27%	1	N
50	Aug-04	3.80%	2.77%	92.43%	0	4.81%	1	N
51	Aug-04	9.34%	3.30%	77.07%	0	19.63%	1	N
52	Aug-04	0.00%	0.00%	82.54%	0	17.46%	1	C
53	Aug-04	0.00%	0.00%	73.12%	0	26.88%	1	N
54	Aug-04	0.00%	0.00%	10.86%	0	89.14%	1	N
55	Aug-04	0.00%	0.00%	62.97%	0	37.03%	1	N
56	Aug-05	0.56%	0.56%	99.44%	0	0.00%	1	C
57	Aug-05	22.72%	5.23%	94.77%	0	0.00%	1	N
58	Aug-05	1.65%	3.63%	55.73%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	0.00%	0.00%	91.07%	0	8.93%	1	C
62	Aug-05	0.00%	0.00%	63.62%	0	36.38%	1	N
63	Aug-05	0.00%	0.00%	57.84%	0	42.16%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-06	2.04%	2.04%	86.07%	0	11.89%	1	C
67	Aug-06	1.38%	1.00%	89.25%	0	9.75%	1	N
68	Aug-06	7.54%	7.54%	4.24%	0	88.22%	1	C
69	Aug-06	0.41%	1.71%	27.19%	0	71.10%	1	N
70	Aug-06	0.00%	0.00%	86.13%	0	13.87%	1	C
71	Aug-06	0.00%	0.00%	94.41%	0	5.59%	1	N
72	Aug-06	1.60%	1.60%	78.49%	0	19.91%	1	C
73	Aug-06	3.27%	2.38%	85.01%	0	12.61%	1	N
74	Aug-06	7.64%	7.60%	20.05%	0	72.36%	1	N
75	Aug-06	82.05%	41.30%	34.25%	0	24.45%	1	C
76	Aug-06	9.76%	7.22%	81.22%	0	11.56%	1	N
77	Aug-06	0.00%	0.00%	70.63%	0	29.37%	1	N
78	Aug-06	6.35%	6.35%	82.70%	0	10.95%	1	C
79	Aug-06	14.03%	7.41%	34.91%	0	57.68%	1	N
80	Aug-07	2.68%	2.68%	91.16%	0	6.16%	1	C
81	Aug-07	0.00%	0.00%	92.31%	0	7.69%	1	C
82	Aug-07	0.00%	0.00%	19.90%	0	80.10%	1	N
83	Aug-07	62.52%	10.92%	4.58%	0	84.49%	1	N
84	Aug-07	1.92%	8.71%	83.77%	0	7.52%	1	C
85	Aug-07	24.59%	19.01%	49.52%	0	31.47%	1	N
86	Aug-07	0.00%	0.00%	88.33%	0	11.67%	1	N
87	Aug-07	0.81%	0.59%	61.56%	0	37.85%	1	N
88	Aug-07	0.00%	0.00%	86.95%	0	13.05%	1	C
89	Aug-08	3.25%	2.36%	88.88%	0	8.75%	1	N
90	Aug-08	20.36%	29.14%	70.86%	0	0.00%	1	C
91	Aug-08	97.56%	96.98%	3.02%	0	0.00%	1	N
92	Aug-08	0.43%	19.53%	66.22%	0	14.26%	1	C
93	Aug-08	86.98%	93.05%	1.73%	0	5.21%	1	N
94	Aug-08	6.91%	38.55%	50.48%	0	10.97%	1	C
95	Aug-08	63.81%	87.77%	4.23%	0	8.00%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E12								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	2.61%	1.89%	98.11%	0	0.00%	1	N
49	Aug-04	0.00%	0.00%	97.73%	0	2.27%	1	N
50	Aug-04	3.80%	2.77%	92.43%	0	4.81%	1	N
51	Aug-04	9.34%	3.30%	77.07%	0	19.63%	1	N
52	Aug-04	0.00%	0.00%	82.54%	0	17.46%	1	C
53	Aug-04	0.00%	0.00%	73.12%	0	26.88%	1	N
54	Aug-05	0.00%	0.00%	10.86%	0	89.14%	1	N
55	Aug-05	0.00%	0.00%	62.97%	0	37.03%	1	N
56	Aug-05	0.56%	0.56%	99.44%	0	0.00%	1	C
57	Aug-05	22.72%	5.23%	94.77%	0	0.00%	1	N
58	Aug-05	1.65%	3.63%	55.73%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	0.00%	0.00%	91.07%	0	8.93%	1	C
62	Aug-05	0.00%	0.00%	63.62%	0	36.38%	1	N
63	Aug-06	0.00%	0.00%	57.84%	0	42.16%	1	N
64	Aug-06	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-06	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-06	2.04%	2.04%	86.07%	0	11.89%	1	C
67	Aug-06	1.38%	1.00%	89.25%	0	9.75%	1	N
68	Aug-06	7.54%	7.54%	4.24%	0	88.22%	1	C
69	Aug-06	0.41%	1.71%	27.19%	0	71.10%	1	N
70	Aug-06	0.00%	0.00%	86.13%	0	13.87%	1	C
71	Aug-07	0.00%	0.00%	94.41%	0	5.59%	1	N
72	Aug-07	1.60%	1.60%	78.49%	0	19.91%	1	C
73	Aug-07	3.27%	2.38%	85.01%	0	12.61%	1	N
74	Aug-07	7.64%	7.60%	20.05%	0	72.36%	1	N
75	Aug-07	82.05%	41.30%	34.25%	0	24.45%	1	C
76	Aug-07	9.76%	7.22%	81.22%	0	11.56%	1	N
77	Aug-07	0.00%	0.00%	70.63%	0	29.37%	1	N
78	Aug-07	6.35%	6.35%	82.70%	0	10.95%	1	C
79	Aug-07	14.03%	7.41%	34.91%	0	57.68%	1	N
80	Aug-07	2.68%	2.68%	91.16%	0	6.16%	1	C
81	Aug-07	0.00%	0.00%	92.31%	0	7.69%	1	C
82	Aug-07	0.00%	0.00%	19.90%	0	80.10%	1	N
83	Aug-08	62.52%	10.92%	4.58%	0	84.49%	1	N
84	Aug-08	1.92%	8.71%	83.77%	0	7.52%	1	C
85	Aug-08	24.59%	19.01%	49.52%	0	31.47%	1	N
86	Aug-08	0.00%	0.00%	88.33%	0	11.67%	1	N
87	Aug-08	0.81%	0.59%	61.56%	0	37.85%	1	N
88	Aug-08	0.00%	0.00%	86.95%	0	13.05%	1	C
89	Aug-08	3.25%	2.36%	88.88%	0	8.75%	1	N
90	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
91	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
92	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
93	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
94	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
95	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E13								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	98.12%	88.60%	11.40%	0	0.00%	1	N
49	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
50	Aug-04	87.19%	73.83%	24.83%	0	1.34%	1	N
51	Aug-04	1.90%	23.74%	66.56%	0	9.70%	1	N
52	Aug-04	2.82%	20.12%	66.29%	0	13.59%	1	C
53	Aug-04	53.91%	54.80%	36.35%	0	8.85%	1	N
54	Aug-04	69.63%	60.89%	7.31%	0	31.81%	1	N
55	Aug-04	95.29%	93.51%	5.31%	0	1.18%	1	N
56	Aug-04	0.60%	0.60%	99.40%	0	0.00%	1	C
57	Aug-05	22.66%	5.33%	94.67%	0	0.00%	1	N
58	Aug-05	1.65%	3.64%	55.71%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	2.57%	15.22%	76.59%	0	8.19%	1	C
62	Aug-05	62.53%	71.16%	28.60%	0	0.24%	1	N
63	Aug-06	36.96%	41.45%	40.94%	0	17.61%	1	N
64	Aug-06	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-06	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-06	36.79%	60.34%	39.54%	0	0.13%	1	C
67	Aug-06	47.92%	74.63%	25.37%	0	0.00%	1	N
68	Aug-06	15.94%	55.70%	4.24%	0	40.05%	1	C
69	Aug-06	63.12%	71.95%	12.64%	0	15.41%	1	N
70	Aug-06	0.00%	0.00%	86.12%	0	13.87%	1	C
71	Aug-07	0.00%	0.00%	94.80%	0	5.20%	1	N
72	Aug-07	6.03%	14.61%	75.06%	0	10.32%	1	C
73	Aug-07	6.56%	18.69%	73.18%	0	8.13%	1	N
74	Aug-07	45.86%	48.88%	12.38%	0	38.74%	1	N
75	Aug-07	63.78%	57.52%	33.95%	0	8.53%	1	C
76	Aug-07	17.59%	23.46%	66.04%	0	10.49%	1	N
77	Aug-07	21.03%	57.62%	35.13%	0	7.25%	1	N
78	Aug-07	7.09%	7.09%	82.66%	0	10.25%	1	C
79	Aug-07	66.15%	60.67%	30.34%	0	8.99%	1	N
80	Aug-07	5.07%	5.06%	90.37%	0	4.56%	1	C
81	Aug-08	3.94%	34.48%	59.67%	0	5.85%	1	C
82	Aug-08	93.25%	69.75%	9.94%	0	20.31%	1	N
83	Aug-08	94.68%	69.64%	3.31%	0	27.05%	1	N
84	Aug-08	1.89%	10.39%	82.85%	0	6.76%	1	C
85	Aug-08	37.23%	29.93%	49.55%	0	20.52%	1	N
86	Aug-08	25.59%	55.59%	40.69%	0	3.72%	1	N
87	Aug-08	55.79%	75.98%	13.91%	0	10.12%	1	N
88	Aug-08	9.11%	32.26%	54.68%	0	13.05%	[illegible]	C
89	Aug-08	50.24%	73.92%	19.32%	0	6.76%	1	N
90	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
91	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
92	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
93	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
94	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
95	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E14								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	2.61%	1.89%	98.11%	0	0.00%	1	N
49	Aug-04	0.00%	0.00%	97.73%	0	2.27%	1	N
50	Aug-04	3.80%	2.77%	92.43%	0	4.81%	1	N
51	Aug-04	9.34%	3.30%	77.07%	0	19.63%	1	N
52	Aug-04	0.00%	0.00%	82.54%	0	17.46%	1	C
53	Aug-04	0.00%	0.00%	73.12%	0	26.88%	1	N
54	Aug-04	0.00%	0.00%	10.86%	0	89.14%	1	N
55	Aug-04	0.00%	0.00%	62.97%	0	37.03%	1	N
56	Aug-04	0.56%	0.56%	99.44%	0	0.00%	1	C
57	Aug-04	22.72%	5.23%	94.77%	0	0.00%	1	N
58	Aug-04	1.65%	3.63%	55.73%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	0.00%	0.00%	91.07%	0	8.93%	1	C
62	Aug-05	0.00%	0.00%	63.62%	0	36.38%	1	N
63	Aug-05	0.00%	0.00%	57.84%	0	42.16%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-05	2.04%	2.04%	86.07%	0	11.89%	1	C
67	Aug-05	1.38%	1.00%	89.25%	0	9.75%	1	N
68	Aug-05	7.54%	7.54%	4.24%	0	88.22%	1	C
69	Aug-05	0.41%	1.71%	27.19%	0	71.10%	1	N
70	Aug-05	0.00%	0.00%	86.13%	0	13.87%	1	C
71	Aug-05	0.00%	0.00%	94.41%	0	5.59%	1	N
72	Aug-05	1.60%	1.60%	78.49%	0	19.91%	1	C
73	Aug-05	3.27%	2.38%	85.01%	0	12.61%	1	N
74	Aug-05	7.64%	7.60%	20.05%	0	72.36%	1	N
75	Aug-06	82.05%	41.30%	34.25%	0	24.45%	1	C
76	Aug-06	9.76%	7.22%	81.22%	0	11.56%	1	N
77	Aug-06	0.00%	0.00%	70.63%	0	29.37%	1	N
78	Aug-06	6.35%	6.35%	82.70%	0	10.95%	1	C
79	Aug-06	14.03%	7.41%	34.91%	0	57.68%	1	N
80	Aug-06	2.68%	2.68%	91.16%	0	6.16%	1	C
81	Aug-06	0.00%	0.00%	92.31%	0	7.69%	1	C
82	Aug-06	0.00%	0.00%	19.90%	0	80.10%	1	N
83	Aug-06	62.52%	10.92%	4.58%	0	84.49%	1	N
84	Aug-06	1.92%	8.71%	83.77%	0	7.52%	1	C
85	Aug-06	24.59%	19.01%	49.52%	0	31.47%	1	N
86	Aug-06	0.00%	0.00%	88.33%	0	11.67%	1	N
87	Aug-06	0.81%	0.59%	61.56%	0	37.85%	1	N
88	Aug-06	0.00%	0.00%	86.95%	0	13.05%	1	C
89	Aug-06	3.25%	2.36%	88.88%	0	8.75%	1	N
90	Aug-07	11.59%	11.59%	88.41%	0	0.00%	1	C
91	Aug-07	7.05%	5.18%	94.82%	0	0.00%	1	N
92	Aug-07	5.10%	5.10%	74.01%	0	20.88%	1	C
93	Aug-08	8.59%	6.34%	43.36%	0	50.31%	1	N
94	Aug-08	2.01%	2.01%	78.35%	0	19.64%	1	C
95	Aug-08	7.79%	5.73%	12.10%	0	82.17%	1	N
96	Aug-08	98.19%	97.51%	1.28%	0	1.22%	1	N
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E15								
SedSeg#	Year to Remediate	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	98.12%	88.60%	11.40%	0	0.00%	1	N
49	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
50	Aug-04	87.19%	73.83%	24.83%	0	1.34%	1	N
51	Aug-04	1.90%	23.74%	66.56%	0	9.70%	1	N
52	Aug-04	2.82%	20.12%	66.29%	0	13.59%	1	C
53	Aug-04	53.91%	54.80%	36.35%	0	8.85%	1	N
54	Aug-04	69.63%	60.89%	7.31%	0	31.81%	1	N
55	Aug-04	95.29%	93.51%	5.31%	0	1.18%	1	N
56	Aug-04	0.60%	0.60%	99.40%	0	0.00%	1	C
57	Aug-04	22.66%	5.33%	94.67%	0	0.00%	1	N
58	Aug-04	1.65%	3.64%	55.71%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	2.57%	15.22%	76.59%	0	8.19%	1	C
62	Aug-05	62.53%	71.16%	28.60%	0	0.24%	1	N
63	Aug-05	36.96%	41.45%	40.94%	0	17.61%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-05	36.79%	60.34%	39.54%	0	0.13%	1	C
67	Aug-05	47.92%	74.63%	25.37%	0	0.00%	1	N
68	Aug-05	15.94%	55.70%	4.24%	0	40.05%	1	C
69	Aug-05	63.12%	71.95%	12.64%	0	15.41%	1	N
70	Aug-06	0.00%	0.00%	86.12%	0	13.87%	1	C
71	Aug-06	0.00%	0.00%	94.80%	0	5.20%	1	N
72	Aug-06	6.03%	14.61%	75.06%	0	10.32%	1	C
73	Aug-06	6.56%	18.69%	73.18%	0	8.13%	1	N
74	Aug-06	45.86%	48.88%	12.38%	0	38.74%	1	N
75	Aug-06	63.78%	57.52%	33.95%	0	8.53%	1	C
76	Aug-06	17.59%	23.46%	66.04%	0	10.49%	1	N
77	Aug-06	21.03%	57.62%	35.13%	0	7.25%	1	N
78	Aug-06	7.09%	7.09%	82.66%	0	10.25%	1	C
79	Aug-06	66.15%	60.67%	30.34%	0	8.99%	1	N
80	Aug-06	5.07%	5.06%	90.37%	0	4.56%	1	C
81	Aug-06	3.94%	34.48%	59.67%	0	5.85%	1	C
82	Aug-06	93.25%	69.75%	9.94%	0	20.31%	1	N
83	Aug-06	94.68%	69.64%	3.31%	0	27.05%	1	N
84	Aug-07	1.89%	10.39%	82.85%	0	6.76%	1	C
85	Aug-07	37.23%	29.93%	49.55%	0	20.52%	1	N
86	Aug-07	25.59%	55.59%	40.69%	0	3.72%	1	N
87	Aug-07	55.79%	75.98%	13.91%	0	10.12%	1	N
88	Aug-07	9.11%	32.26%	54.68%	0	13.05%	1	C
89	Aug-07	50.24%	73.92%	19.32%	0	6.76%	1	N
90	Aug-07	20.36%	29.14%	70.86%	0	0.00%	1	C
91	Aug-07	97.56%	96.98%	3.02%	0	0.00%	1	N
92	Aug-08	0.43%	19.53%	66.22%	0	14.26%	1	C
93	Aug-08	86.98%	93.05%	1.73%	0	5.21%	1	N
94	Aug-08	6.91%	38.55%	50.48%	0	10.97%	1	C
95	Aug-08	63.81%	87.77%	4.23%	0	8.00%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E16					
SedSeg#	Year to Remediate	% PCB Mass Remains to LTI	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-05	0.00%	0.00%	N	0.5
56	Aug-05	0.56%	0.56%	C	0.25
57	Aug-05	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-06	0.00%	0.00%	C	0.25
65	Aug-06	0.00%	0.00%	N	0.5
66	Aug-06	2.04%	2.04%	C	0.25
67	Aug-06	1.38%	1.00%	N	0.5
68	Aug-06	7.54%	7.54%	C	0.25
69	Aug-06	0.41%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	9.76%	7.22%	N	0.5
77	Aug-07	0.00%	0.00%	N	0.5
78	Aug-07	6.35%	6.35%	C	0.25
79	Aug-07	14.03%	7.41%	N	0.5
80	Aug-07	2.68%	2.68%	C	0.25
81	Aug-07	0.00%	0.00%	C	0.25
82	Aug-07	0.00%	0.00%	N	0.5
83	Aug-07	62.52%	10.92%	N	0.5
84	Aug-07	1.92%	8.71%	C	0.25
85	Aug-07	24.59%	19.01%	N	0.5
86	Aug-07	0.00%	0.00%	N	0.5
87	Aug-07	0.81%	0.59%	N	0.5
88	Aug-08	0.00%	0.00%	C	0.25
89	Aug-08	3.25%	2.36%	N	0.5
90	Aug-08	32.92%	52.64%	C	0.25
91	Aug-08	99.76%	99.62%	N	0.5
92	Aug-08	3.30%	49.53%	C	0.25
93	Aug-08	99.73%	99.57%	N	0.5
94	Aug-08	14.59%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E17

SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.56%	0.56%	C	0.25
57	Aug-04	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	2.04%	2.04%	C	0.25
67	Aug-05	1.38%	1.00%	N	0.5
68	Aug-05	7.54%	7.54%	C	0.25
69	Aug-05	0.41%	1.71%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	36.65%	7.22%	N	0.5
77	Aug-06	0.00%	0.00%	N	0.5
78	Aug-06	6.35%	6.35%	C	0.25
79	Aug-06	14.03%	7.41%	N	0.5
80	Aug-06	1.59%	2.68%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	0.00%	0.00%	N	0.5
83	Aug-06	62.52%	10.92%	N	0.5
84	Aug-06	1.92%	8.71%	C	0.25
85	Aug-06	24.59%	19.01%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-06	0.81%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	3.25%	2.36%	N	0.5
90	Aug-07	32.92%	52.64%	C	0.25
91	Aug-07	99.76%	99.62%	N	0.5
92	Aug-07	3.30%	49.53%	C	0.25
93	Aug-07	99.73%	99.57%	N	0.5
94	Aug-07	14.59%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	C	0.25
113	Aug-08	18.49%	74.35%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	C	0.25
117	Aug-08	60.37%	90.20%	N	0.5
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

INPUT GIVEN TO LTI FOR ENGINEERING SCENARIO E18

SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not remediated	% sedseg area capped	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	2.61%	1.89%	98.11%	0	0.00%	1	N
49	Aug-04	0.00%	0.00%	97.73%	0	2.27%	1	N
50	Aug-04	3.80%	2.77%	92.43%	0	4.81%	1	N
51	Aug-04	9.34%	3.30%	77.07%	0	19.63%	1	N
52	Aug-04	0.00%	0.00%	82.54%	0	17.46%	1	C
53	Aug-04	0.00%	0.00%	73.12%	0	26.88%	1	N
54	Aug-04	0.00%	0.00%	10.86%	0	89.14%	1	N
55	Aug-04	0.00%	0.00%	62.97%	0	37.03%	1	N
56	Aug-04	0.56%	0.56%	99.44%	0	0.00%	1	C
57	Aug-04	22.72%	5.23%	94.77%	0	0.00%	1	N
58	Aug-05	1.65%	3.63%	55.73%	0	40.64%	1	N
59	Aug-05	0.00%	0.00%	85.39%	0	14.61%	1	C
60	Aug-05	0.00%	0.00%	99.99%	0	0.01%	1	N
61	Aug-05	0.00%	0.00%	91.07%	0	8.93%	1	C
62	Aug-05	0.00%	0.00%	63.62%	0	36.38%	1	N
63	Aug-05	0.00%	0.00%	57.84%	0	42.16%	1	N
64	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	C
65	Aug-05	0.00%	0.00%	100.00%	0	0.00%	1	N
66	Aug-05	2.04%	2.04%	86.07%	0	11.89%	1	C
67	Aug-05	1.38%	1.00%	89.25%	0	9.75%	1	N
68	Aug-05	7.54%	7.54%	4.24%	0	88.22%	1	C
69	Aug-05	0.41%	1.71%	27.19%	0	71.10%	1	N
70	Aug-05	0.00%	0.00%	86.13%	0	13.87%	1	C
71	Aug-05	0.00%	0.00%	94.41%	0	5.59%	1	N
72	Aug-06	1.60%	1.60%	78.49%	0	19.91%	1	C
73	Aug-06	3.27%	2.38%	85.01%	0	12.61%	1	N
74	Aug-06	7.64%	7.60%	20.05%	0	72.36%	1	N
75	Aug-06	82.05%	41.30%	34.25%	0	24.45%	1	C
76	Aug-06	9.76%	7.22%	81.22%	0	11.56%	1	N
77	Aug-06	0.00%	0.00%	70.63%	0	29.37%	1	N
78	Aug-06	6.35%	6.35%	82.70%	0	10.95%	1	C
79	Aug-06	14.03%	7.41%	34.91%	0	57.68%	1	N
80	Aug-06	2.68%	2.68%	91.16%	0	6.16%	1	C
81	Aug-06	0.00%	0.00%	92.31%	0	7.69%	1	C
82	Aug-06	0.00%	0.00%	19.90%	0	80.10%	1	N
83	Aug-06	62.52%	10.92%	4.58%	0	84.49%	1	N
84	Aug-06	1.92%	8.71%	83.77%	0	7.52%	1	C
85	Aug-06	24.59%	19.01%	49.52%	0	31.47%	1	N
86	Aug-06	0.00%	0.00%	88.33%	0	11.67%	1	N
87	Aug-06	0.81%	0.59%	61.56%	0	37.85%	1	N
88	Aug-07	0.00%	0.00%	86.95%	0	13.05%	1	C
89	Aug-07	3.25%	2.36%	88.88%	0	8.75%	1	N
90	Aug-07	32.92%	52.64%	47.36%	0	0.00%	1	C
91	Aug-07	99.76%	99.62%	0.38%	0	0.00%	1	N
92	Aug-07	3.30%	49.53%	39.55%	0	10.91%	1	C
93	Aug-07	99.73%	99.57%	0.11%	0	0.32%	1	N
94	Aug-07	14.59%	57.42%	39.49%	0	3.09%	1	C
95	Aug-08	81.64%	92.87%	4.67%	0	2.46%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	32.42%	0	0.00%	1	C
113	Aug-08	18.49%	74.35%	25.65%	0	0.00%	1	N
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	27.66%	0	0.00%	1	C
117	Aug-08	60.37%	90.20%	9.80%	0	0.00%	1	N
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

Sediment Capping Sensitivity Analysis Input to LTI - Second Set of Input (5, 10, and 25% of capped area missing)

Input Same as For Scenario E8 Except for Highlighted Columns

SedSeg#	Year to Remediate	% PCB Mass Remains	% PCB Mass Remains to LTI (5% of cap area breached)	% PCB Mass Remains to LTI (10% of cap area breached)	% PCB Mass Remains to LTI (25% of cap area breached)	% sedseg area not remediated	% sedseg area not remediated (5% of cap area breached)	% sedseg area not remediated (10% of cap area breached)	% sedseg area not remediated (25% of cap area breached)	% sedseg area capped	% sedseg area capped (5% of cap area breached)	% sedseg area capped (10% of cap area breached)	% sedseg area capped (25% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged	% sedseg area dredged (5% of cap area breached)	% sedseg area dredged (10% of cap area breached)	% sedseg area dredged (25% of cap area breached)	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	98.12%	98.12%	98.38%	98.63%	88.60%	88.60%	90.14%	91.65%	11.40%	11.40%	9.86%	8.35%	0	0.00%	0.00%	0.00%	0.00%	1	N
49	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
50	Aug-04	87.19%	87.99%	87.99%	88.87%	73.83%	75.65%	75.65%	77.66%	24.83%	23.01%	23.01%	21.00%	0	1.34%	1.34%	1.34%	1.34%	1	N
51	Aug-04	1.90%	3.79%	5.45%	9.02%	23.74%	31.28%	38.01%	52.65%	66.56%	59.02%	52.29%	37.65%	0	9.70%	9.70%	9.70%	9.70%	1	N
52	Aug-04	2.82%	10.28%	10.30%	18.25%	20.12%	29.67%	29.69%	39.86%	66.29%	56.75%	56.73%	46.56%	0	13.59%	13.59%	13.59%	13.59%	1	C
53	Aug-04	53.91%	69.18%	74.56%	81.46%	54.80%	66.08%	70.35%	76.06%	36.35%	25.07%	20.80%	15.09%	0	8.85%	8.85%	8.85%	8.85%	1	C
54	Aug-04	69.63%	69.95%	70.46%	70.51%	60.89%	61.88%	63.45%	63.63%	7.31%	6.31%	4.74%	4.56%	0	31.81%	31.81%	31.81%	31.81%	1	N
55	Aug-04	95.29%	95.29%	95.29%	95.29%	93.51%	93.51%	93.51%	93.51%	5.31%	5.31%	5.31%	5.31%	0	1.18%	1.18%	1.18%	1.18%	1	N
56	Aug-04	0.60%	4.33%	15.92%	45.67%	0.60%	4.73%	17.57%	50.53%	99.40%	95.27%	82.43%	49.47%	0	0.00%	0.00%	0.00%	0.00%	1	C
57	Aug-04	22.66%	27.22%	36.25%	63.60%	5.33%	10.86%	22.25%	61.07%	94.67%	89.14%	77.75%	38.93%	0	0.00%	0.00%	0.00%	0.00%	1	N
58	Aug-04	1.65%	10.40%	16.07%	29.83%	3.64%	10.79%	15.62%	28.03%	55.71%	48.57%	43.74%	31.32%	0	40.64%	40.64%	40.64%	40.64%	1	N
59	Aug-04	0.00%	0.00%	0.00%	3.97%	0.00%	0.00%	0.00%	3.97%	85.39%	85.39%	85.39%	81.43%	0	14.61%	14.61%	14.61%	14.61%	1	C
60	Aug-04	0.00%	6.74%	6.74%	34.32%	0.00%	4.75%	4.75%	26.25%	99.99%	95.24%	95.24%	73.74%	0	0.01%	0.01%	0.01%	0.01%	1	N
61	Aug-04	2.57%	10.71%	10.71%	10.71%	15.22%	22.30%	22.30%	22.30%	76.59%	69.51%	69.51%	69.51%	0	8.19%	8.19%	8.19%	8.19%	1	C
62	Aug-04	62.53%	64.67%	70.56%	84.40%	71.16%	72.58%	76.61%	86.75%	28.60%	27.18%	23.15%	13.01%	0	0.24%	0.24%	0.24%	0.24%	1	N
63	Aug-05	36.96%	40.83%	47.06%	59.40%	41.45%	45.47%	52.14%	66.18%	40.94%	36.92%	30.25%	16.21%	0	17.61%	17.61%	17.61%	17.61%	1	N
64	Aug-05	0.00%	1.87%	17.18%	50.85%	0.00%	1.50%	13.79%	40.80%	100.00%	98.50%	86.21%	59.20%	0	0.00%	0.00%	0.00%	0.00%	1	C
65	Aug-05	0.00%	29.32%	51.08%	76.92%	0.00%	19.76%	36.86%	60.64%	100.00%	80.24%	63.14%	39.36%	0	0.00%	0.00%	0.00%	0.00%	1	N
66	Aug-05	36.79%	42.04%	57.52%	70.25%	60.34%	62.95%	70.68%	77.04%	39.54%	36.92%	29.19%	22.84%	0	0.13%	0.13%	0.13%	0.13%	1	C
67	Aug-05	47.92%	52.50%	56.67%	71.52%	74.63%	76.51%	78.27%	84.98%	25.37%	23.49%	21.73%	15.02%	0	0.00%	0.00%	0.00%	0.00%	1	N
68	Aug-05	15.94%	19.07%	19.07%	19.07%	55.70%	57.23%	57.23%	57.23%	4.24%	2.72%	2.72%	2.72%	0	40.05%	40.05%	40.05%	40.05%	1	C
69	Aug-05	63.12%	65.62%	67.91%	77.43%	71.95%	73.03%	74.04%	78.41%	12.64%	11.56%	10.55%	6.18%	0	15.41%	15.41%	15.41%	15.41%	1	N
70	Aug-05	0.00%	5.75%	16.98%	29.53%	0.00%	8.14%	24.02%	41.79%	86.12%	77.99%	62.10%	44.34%	0	13.87%	13.87%	13.87%	13.87%	1	C
71	Aug-05	0.00%	25.63%	46.13%	68.16%	0.00%	19.86%	38.11%	60.60%	94.80%	74.94%	56.69%	34.21%	0	5.20%	5.20%	5.20%	5.20%	1	N
72	Aug-05	6.03%	20.20%	34.15%	52.12%	14.61%	27.84%	40.85%	57.62%	75.06%	61.84%	48.83%	32.06%	0	10.32%	10.32%	10.32%	10.32%	1	C
73	Aug-05	6.56%	9.16%	16.44%	39.71%	18.69%	20.20%	24.53%	39.72%	73.18%	71.67%	67.34%	52.15%	0	8.13%	8.13%	8.13%	8.13%	1	C
74	Aug-05	45.86%	46.21%	46.40%	49.23%	48.88%	49.30%	49.53%	53.00%	12.38%	11.96%	11.73%	8.25%	0	38.74%	38.74%	38.74%	38.74%	1	N
75	Aug-05	63.78%	63.78%	63.80%	64.80%	57.52%	57.53%	57.64%	65.30%	33.95%	33.95%	33.83%	26.17%	0	8.53%	8.53%	8.53%	8.53%	1	C
76	Aug-05	17.59%	27.27%	34.50%	63.97%	23.46%	30.49%	36.01%	61.34%	66.04%	59.01%	53.49%	28.17%	0	10.49%	10.49%	10.49%	10.49%	1	C
77	Aug-05	21.03%	21.03%	21.03%	23.19%	57.62%	57.62%	57.62%	59.21%	35.13%	35.13%	35.13%	33.55%	0	7.25%	7.25%	7.25%	7.25%	1	N
78	Aug-05	7.09%	7.80%	17.19%	46.98%	7.09%	7.87%	18.17%	50.88%	82.66%	81.88%	71.58%	38.87%	0	10.25%	10.25%	10.25%	10.25%	1	C
79	Aug-05	66.15%	71.61%	73.47%	85.63%	60.67%	66.08%	67.98%	80.98%	30.34%	24.93%	23.04%	10.03%	0	8.99%	8.99%	8.99%	8.99%	1	N
80	Aug-05	5.07%	22.50%	30.40%	72.07%	5.06%	21.07%	28.31%	66.55%	90.37%	74.37%	67.13%	28.89%	0	4.56%	4.56%	4.56%	4.56%	1	C
81	Aug-06	3.94%	6.79%	10.89%	22.24%	34.48%	36.30%	38.91%	46.13%	59.67%	57.85%	55.24%	48.02%	0	5.85%	5.85%	5.85%	5.85%	1	C
82	Aug-06	93.25%	93.25%	93.25%	93.25%	69.75%	69.75%	69.75%	69.75%	9.94%	9.94%	9.94%	9.94%	0	20.31%	20.31%	20.31%	20.31%	1	N
83	Aug-06	94.68%	94.74%	94.74%	94.77%	69.64%	70.48%	70.59%	70.98%	3.31%	2.47%	2.36%	1.97%	0	27.05%	27.05%	27.05%	27.05%	1	N
84	Aug-06	1.89%	14.23%	18.22%	45.77%	10.39%	20.31%	23.52%	45.66%	82.85%	72.93%	69.72%	47.58%	0	6.76%	6.76%	6.76%	6.76%	1	C
85	Aug-06	37.23%	37.99%	37.99%	37.99%	29.93%	30.76%	30.76%	30.76%	49.55%	48.72%	48.72%	48.72%	0	20.52%	20.52%	20.52%	20.52%	1	N
86	Aug-06	25.59%	29.10%	37.50%	58.94%	55.59%	57.67%	62.84%	77.36%	40.69%	38.61%	33.44%	18.93%	0	3.72%	3.72%	3.72%	3.72%	1	N
87	Aug-06	55.79%	60.93%	62.94%	68.18%	75.98%	78.38%	79.35%	81.92%	13.91%	11.50%	10.54%	7.96%	0	10.12%	10.12%	10.12%	10.12%	1	N
88	Aug-06	9.11%	16.61%	19.14%	48.12%	32.26%	37.40%	39.13%	58.99%	54.68%	49.55%	47.81%	27.96%	0	13.05%	13.05%	13.05%	13.05%	1	C
89	Aug-06	50.24%	55.34%	55.34%	62.83%	73.92%	76.71%	76.71%	80.98%	19.32%	16.54%	16.54%	12.26%	0	6.76%	6.76%	6.76%	6.76%	1	N
90	Aug-06	20.36%	21.35%	22.17%	29.84%	29.14%	30.07%	30.85%	38.09%	70.86%	69.93%	69.15%	61.91%	0	0.00%	0.00%	0.00%	0.00%	1	C
91	Aug-06	97.56%	97.56%	97.56%	97.97%	96.98%	96.98%	96.98%	97.49%	3.02%	3.02%	3.02%	2.51%	0	0.00%	0.00%	0.00%	0.00%	1	C
92	Aug-06	0.43%	0.48%	0.83%	2.04%	19.53%	19.71%	20.95%	25.29%	66.22%	66.04%	64.80%	60.45%	0	14.26%	14.26%	14.26%	14.26%	1	C
93	Aug-07	86.98%	86.98%	86.98%	86.98%	93.05%	93.05%	93.05%	93.05%	1.73%	1.73%	1.73%	1.73%	0	5.21%	5.21%	5.21%	5.21%	1	N
94	Aug-07	6.91%	9.54%	12.91%	22.50%	38.55%	39.62%	40.99%	44.90%	50.48%	49.41%	48.04%	44.13%	0	10.97%	10.97%	10.97%	10.97%	1	C
95	Aug-07	63.81%	67.75%	67.75%	72.56%	87.77%	88.26%	88.26%	88.88%	4.23%	3.74%	3.74%	3.12%	0	8.00%	8.00%	8.00%	8.00%	1	N
96	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
102	Aug-07	86.58%	86.58%	86.58%	86.86%	90.25%	90.25%	90.25%	90.50%	9.75%	9.75%	9.75%	9.50%	0	0.00%	0.00%	0.00%	0.00%	1	C
103	Aug-07	90.07%	90.07%	90.07%	90.20%	97.57%	97.57%	97.57%	97.67%	0.93%	0.93%	0.93%	0.83%	0	1.50%	1.50%	1.50%	1.50%	1	N
104	Aug-07	85.30%	85.30%	85.30%	85.30%	97.21%	97.21%	97.21%	97.21%	2.79%	2.79%	2.79%	2.79%	0	0.00%	0.00%	0.00%	0.00%	1	C
105	Aug-07	99.17%	99.17%	99.17%	99.31%	99.66%	99.66%	99.66%	99.70%	0.30%	0.30%	0.30%	0.26%	0	0.04%	0.04%	0.04%	0.04%	1	N
106	Aug-07	31.16%	33.09%	34.92%	44.81%	32.77%	33.22%	33.65%	35.97%	65.63%	65.18%	64.75%	62.43%	0	1.60%	1.60%	1.60%	1.60%	1	C
107	Aug-08	86.25%	86.25%	86.25%	117.81%	96.81%	96.81%	96.81%	97.72%	3.19%	3.19%	3.19%	2.28%	0	0.00%	0.00%	0.00%	0.00%	1	N
108	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
112	Aug-08	21.28%	24.39%	24.39%	24.69%	67.58%	68.36%	68.36%	68.44%	32.42%	31.64%	31.64%	31.56%	0	0.00%	0.00%	0.00%	0.00%	1	C
113	Aug-08	12.15%	18.93%	18.93%	35.14%	74.36%	74.90%	74.90%	76.29%	25.64%	25.10%	25.10%	23.71%	0	0.00%	0.00%	0.00%	0.00%	1	N
114	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.62%	23.62%	23.62%	23.62%	72.86%	72.86%	72.86%	72.86%	27.14%	27.14%	27.14%	27.14%	0	0.00%	0.00%	0.00%	0.00%	1	C
117	Aug-08	32.01%	32.01%	32.43%	34.29%	68.82%	68.82%	68.94%	69.47%	30.25%	30.25%	30.13%	29.60%	0	0.93%	0.93%	0.93%	0.93%	1	N
118	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change

HUDSON RIVER PCBs REASSESSMENT FS
Refined Engineering Modeling Scenarios Input Specifications

The procedure used to specify input to HUDTOX for the Refined engineering modeling scenarios are described in this section. The input tables are also provided for these scenarios in this section.

As with the Engineering modeling effort, actual potential remedial alternatives were modeled in this phase of the modeling. The primary difference between the refined engineering modeling and previous modeling runs is the change from a constant upstream boundary water column concentration to a PCB mass loading upstream boundary condition.

Two different upstream load conditions (i.e., Rogers Island boundary condition) were evaluated. The first upstream load condition assumes a load of 0.16 kg/day throughout the modeled period (1998 to 2068). The second upstream load condition assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Another difference between the Refined engineering modeling and previous modeling effort is the way percent PCB mass removal was calculated in River Section 1 for some of the scenarios.

For River Sections 2 and 3, initial average MPA conditions were calculated for a given segment by averaging the MPA of each point within the segment; this approach assumes that each point contributes equally to the initial conditions of the segment; none is more heavily weighted than the others. The average MPA was then recalculated for the segment (assuming removal of those points that fall within the target MPA area) by averaging the MPA of each remaining point. The average calculated MPA was multiplied by the associated area to get the mass of PCBs. One minus the ratio of the recalculated MPA to the initial condition MPA represents the percent mass removed for the segment during remediation. This calculated percent mass removed is assumed to be representative of the sediment segment. A PCB percent mass removed associated with the removal was provided for each sediment segment.

For River Section 1 (Thompson Island Pool), PCB percent mass removal was calculated as described above for the 15 of the refined engineering model runs. For the remaining model runs, total PCB mass, PCB mass removed (i.e., PCB mass in areas targeted for removal), and PCB mass remaining (i.e., PCB mass in areas not targeted for removal) were calculated for each segment by using the Thiessen polygon area weighted MPAs. The PCB mass values were used to calculate PCB percent mass removed for each sediment segment.

Description of Engineering Level Modeling Removal Scenarios

A brief description of the engineering level removal scenarios that were modeled appears in the following text. The corresponding name of the potential remedial alternative is included in parentheses.

Scenario R01CW (REM-0/0/3). This scenario represents the most aggressive removal action for the Upper Hudson. All sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from Rogers Island to Northumberland Dam to predetermined elevations. Below Northumberland Dam, an MPA target of greater than 3 g/m^2 Tri+ PCBs was selected as the minimum target area criterion and all target areas with cohesive and non-cohesive sediments in this section of the river are removed. Upstream loading for this scenario is assumed to be 0.16 kg/day throughout the modeled period (1998 to 2068). Residual sediment concentration is assumed to be 0.25 mg/kg for the top 26 cm of sediment for cohesive sediment segments, and 0.5 mg/kg for the top 26 cm of sediment for non-cohesive sediment segments. Percent PCB mass removed is calculated using the point-averaged method described above (instead of polygonal-weighted average) for all three river sections.

Scenario R01S2 (REM-0/0/3). This scenario includes the same components as Scenario R01CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario E02CW (REM-0/10/MNA). All sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from River Section 1 to predetermined elevations. In River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments are removed. There is no sediment removal from River Section 3, only monitored natural attenuation. This scenario is also based on the assumption that because most of the PCB contamination is in the first two sections of the river, sediment removal in the lower section may not be necessary. The upstream loading and residual sediment concentration assumptions and percent PCB mass removal calculation method are the same as for Scenario R01CW.

Scenario R02S2 (REM-0/10/MNA). This scenario includes the same components as Scenario R02CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario R03CW (REM-0/MNA/MNA). This scenario addresses active remediation only for sediments in the TI Pool. Only monitored natural attenuation is planned for River Sections 2 and 3. For this scenario, all sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from River Section 1 to predetermined elevations. There is no sediment removal from River Sections 2 and 3. The upstream loading and residual sediment concentration assumptions and percent PCB mass removal calculation method are the same as for Scenario R01CW.

Scenario R03S2 (REM-0/MNA/MNA). This scenario includes the same components as Scenario R03CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario R04CW (REM-3/10/10). For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. For River Sections 2 and 3, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Sections 2 and 3 are removed. The upstream loading and residual sediment concentration assumptions and percent PCB mass removal calculation method are the same as for Scenario R01CW.

Scenario R04S2 (REM-3/10/10). This scenario includes the same components as Scenario R04CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario R05CW (REM-3/MNA/MNA). This scenario addresses active remediation only for sediments in the TI Pool. Only monitored natural attenuation is planned for River Sections 2 and 3. For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. There is no sediment removal from River Sections 2 and 3. The upstream loading and residual sediment concentration assumptions and percent PCB mass removal calculation method are the same as for Scenario R01CW.

Scenario R05S2 (REM-3/MNA/MNA). This scenario includes the same components as Scenario R05CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario R06CW (REM-0/10/10). All sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from River Section 1 to predetermined elevations. Below the TI Dam (in River Sections 2 and 3), an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments are removed.The upstream loading and residual sediment concentration assumptions and percent PCB mass removal calculation method are the same as for Scenario R01CW.

Scenario R06S2 (REM-0/10/10). This scenario includes the same components as Scenario R06CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario R07CW (REM-10/MNA/MNA). This scenario addresses active remediation only for sediments in the TI Pool. Only monitored natural attenuation is planned for River Sections 2 and 3. For this scenario, target areas in River Section 1 with an MPA target of greater than 10 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. There is no sediment removal from River Sections 2 and 3. The upstream loading and residual sediment concentration assumptions and percent PCB mass removal calculation method are the same as for Scenario R01CW.

Scenario R07S2 (REM-10/MNA/MNA). This scenario includes the same components as Scenario R07CW, except that the upstream loading assumes a load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Scenario R08S2 (REM-0/0/3). This scenario is essentially the same as Scenario R01S2 and represents the most aggressive removal action for the Upper Hudson. All sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from Rogers Island to Northumberland Dam to predetermined elevations. Below Northumberland Dam, an MPA target of greater than 3 g/m^2 Tri+ PCBs was selected as the minimum target area criterion and all target areas with cohesive and non-cohesive sediments in this section of the river are removed. The upstream loading and residual sediment concentration assumptions are also the same as for Scenario R01S2. The only difference between this scenario and Scenario R01S2 is that the percent PCB mass removed is calculated using the polygonal-weighted average method instead of point-averaged method for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.

Scenario R09S2 (REM-3/10/10). This scenario is essentially the same as Scenario R04S2, except the percent PCB mass removed is calculated using the polygonal-weighted average method instead of point-averaged method for River Section 1. (For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.) For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. For River Sections 2 and 3, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Sections 2 and 3 are removed. The upstream loading and residual sediment concentration assumptions are the same as for Scenario R01S2.

Scenario R10S2 (REM-10/MNA/MNA). This scenario is essentially the same as Scenario R07S2, except the percent PCB mass removed is calculated using the polygonal-weighted average method instead of point-averaged method for River Section 1. (For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.) This scenario addresses active remediation only for sediments in the TI Pool. Only monitored natural attenuation is planned for River Sections 2 and 3. For this scenario, target areas in River Section 1 with an MPA target of greater than 10 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. There is no sediment removal from River Sections 2 and 3. The upstream loading and residual sediment concentration assumptions are the same as for Scenario R01S2.

Scenario R11S2 (REM-3+C/10/36-37). For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. In addition, sediments in the navigational channel not targeted for contaminant removal will be removed. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed. For River Section 3, NYSDEC-defined Hot Spots 36 and 37 are targeted for removal. The upstream loading and residual sediment concentration assumptions are the same as for Scenario R01S2. Percent PCB mass removed is calculated using the polygonal-weighted average method described above (instead of point-averaged) for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.

Scenario R12S2 (REM-0/10/36-37). For this scenario, all sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from Rogers Island to Northumberland Dam to predetermined elevations. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed. For River Section 3, NYSDEC-defined Hot Spots 36 and 37 are targeted for removal. The upstream loading and residual sediment concentration assumptions are the same as for Scenario R01S2. Percent PCB mass removed is calculated using the polygonal-weighted average method described above (instead of point-averaged) for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.

Scenario R13S2 (REM-3/10/36-37). For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed. For River Section 3, NYSDEC-defined Hot Spots 36 and 37 are targeted for removal. The upstream loading and residual sediment concentration assumptions are the same as for Scenario R01S2. Percent PCB mass removed is calculated using the polygonal-weighted average method described above (instead of point-averaged) for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.

Scenario R14S2 (REM-3/10/Select). For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed. For River Section 3, NYSDEC-defined Hot Spots 36, 37 and part of Hot Spot 39 are targeted for removal. This scenario also includes removal of navigational channel sediments as required to implement the remedy. The upstream loading and residual sediment concentration assumptions are the same as for Scenario R01S2. Percent PCB mass removed is calculated using the polygonal-weighted average method described above (instead of point-averaged) for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.

Scenario R16S2 (REM-0/0/3). This scenario is essentially the same as Scenario R08S2 and represents the most aggressive removal action for the Upper Hudson. All sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) in dredgeable areas are removed from Rogers Island to Northumberland Dam to predetermined elevations. Below Northumberland Dam, an MPA target of greater than 3 g/m^2 Tri+ PCBs was selected as the minimum target area criterion and all target areas with cohesive and non-cohesive sediments in this section of the river are removed. The difference between this scenario and Scenario R08S2 is that this scenario also includes removal of navigational channel sediments as required to implement the remedy. The upstream loading and residual sediment concentration assumptions and percent PCB removal are also the same as for Scenario R08S2.

Simulation of Containment with Select Removal

Four containment with select removal scenarios were evaluated using HUDTOX to forecast impact of these scenarios on the overall remediation of the Upper Hudson River over a 70-year period (1998 to 2068). All containment with select removal scenarios were simulated assuming upstream load of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005.

Description of Engineering Level Modeling Containment with Select Removal Scenarios

A brief description of the refined engineering level containment with select removal scenarios that were modeled appears in the following text. The corresponding name of the potential remedial alternative is included in parentheses.

Scenario R15AS2 (CAP-3/10/Select). For this scenario, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed and/or capped. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed and/or capped. For River Section 3, NYSDEC-defined Hot Spots 36, 37 and part of Hot Spot 39 are targeted for removal. This scenario also includes removal of navigational channel sediments as required to implement the remedy.

Target areas associated with water depths less than 6 feet are removed and/or capped. If contamination exists at sediment less than 2 feet, all contamination is removed and no capping is required. For deeper contamination, capping is implemented after removal. Target areas with water depths 6 to 12 feet are capped. Target areas associated with water depths greater than 12 feet are removed. The 12-foot water depth contour is assumed to represent the edge of the navigation channel. Capping is not conducted within the navigation channel, due to the necessity of routine maintenance dredging which would likely damage or destroy the cap. In portions of the river where the navigation channel is located within a land cut, target areas associated with water depths greater than 12 feet are capped.

For this scenario, it is assumed that a percentage (10%) of the area in the area targeted for capping is assumed to not have a cap (due to improper placement during construction of the cap or to subsequent damage to the cap after placement). Random areas were selected from the areas targeted for capping to represent the 10% missing portion.

Upstream loading for this scenario is assumed to be 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005. For this scenario, the vertical concentration profile for all capped areas was assumed to be 0 mg/kg for the entire sediment depth represented in the model (26 cm). The assumed vertical concentration profile for removal areas that are not subsequently capped with water depth greater than 12 feet (i.e., within the navigation channel) was 1 mg/kg for the top 10 cm of sediment and 0 mg/kg below. The assumed vertical concentration profile for removal areas that are not subsequently capped with water depth less than 12 feet was assumed to be 0.25 mg/kg for the entire sediment depth represented in the model (26 cm). Percent PCB mass removed is calculated using the polygonal-weighted average method described above (instead of point-averaged) for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent PCB mass removed.

Scenario R17S2 (CAP-0/10/36-37). For this scenario, all sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) are removed and/or capped in River Section 1. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed and/or capped. For River Section 3, NYSDEC-defined Hot Spots 36 and 37 are targeted for removal. The selection criteria for capping and removal of target areas (based on their associated water depths) in this scenario are the same as described above for Scenario R15S2. The percent area of improper cap placement, upstream loading, and method of calculating percent PCB mass removal are the same as for Scenario R15S2. Residual sediment concentration assumptions are the same as for Scenario R15AS2.

Scenario R18S2 (CAP-0/10/MNA). For this scenario, all sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) are removed and/or capped in River Section 1. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in River Section 2 are removed and/or capped. For River Section 3, only monitored natural attenuation is planned. The selection criteria for capping and removal of target areas (based on their associated water depths) in this scenario are the same as described above for Scenario R15S2. The percent area of improper cap placement, upstream loading, and method of calculating percent PCB mass removal are the same as for Scenario R15S2. Residual sediment concentration assumptions are the same as for Scenario R15AS2.

Scenario R19S2 (CAP-0/MNA/MNA). For this scenario, all sediments (the full river section corresponding to MPA greater than 0 g/m^2 Tri+ PCBs) are removed and/or capped in River Section 1. For River Sections 2 and 3, only monitored natural attenuation is planned. The selection criteria for capping and removal of target areas (based on their associated water depths) in this scenario are the same as described above for Scenario R14S2. The percent area of improper cap placement, upstream loading, and method of calculating percent PCB mass removal are the same as for Scenario R15S2. Residual sediment concentration assumptions are the same as for Scenario R15AS2.

MODEL SENSITIVITY ANALYSIS

The evaluation of removal and containment with select removal scenarios discussed above suggested additional simulations with some modifications and additions. Following the determination of the general effectiveness of the engineering scenarios in the two alternative categories (removal and containment with select removal) relative to No Action, sensitivity analysis is required to show the possible range of behavior due to assumptions of sensitive parameters. The parameters chosen for sensitivity analysis include the residual sediment concentration for removal action scenarios, and the potential partial failure of the containment or improper placement of the cap for the containment with select removal scenarios.

Model Sensitivity Testing for Removal Scenarios

The sensitivity of the model simulation of the removal scenarios was evaluated by varying the residual sediment surface concentration at the end of remediation. The purpose of this exercise was to evaluate the potential effects of incomplete removal actions (*i.e.*, higher residual PCB concentrations in surface sediments) and "perfect" removal (*i.e.*, residual PCB concentration of zero) on the resulting concentrations of PCBs in fish and surface water quality in River Sections 1, 2, and 3 of the Upper Hudson River.

Three simulations for sensitivity analyses were conducted for the removal action scenarios. The sensitivity analyses were based on the input for Scenario R14S2 (REM-3/10/Select) with the following variations: three different residual Tri+ PCB concentrations, 0 mg/kg in the entire depth of sediment modeled in dredged areas (Scenario R14S2-0), 2 mg/kg in the top 10 cm of sediment in dredged areas (Scenario R14S2-2), and 5 mg/kg in the top 10 cm of sediment in dredged areas (Scenario R14S2-5), were assumed as model inputs in place of the original Scenario R14S2 residual concentration of 0.25 mg/kg PCBs for cohesive sediments and 0.5 mg/kg for non-cohesive sediments in the entire depth of sediments in dredged areas. The PCB concentrations in residual sediments were used in adjusting the "PCB mass remaining" calculations for each sediment segment (described above).

In locations where the sediment concentration prior to remediation is less than the assumed value of 1 mg/kg, 2 mg/kg, or 5 mg/kg, the value was left unchanged. All three removal scenarios were conducted with an upstream load condition of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005. All three removal scenarios assumed that sediments targeted for remediation are removed to non-^{137}Cs-bearing depths of the deepest cores within a given target area.

Description of Removal Scenarios for Sensitivity Testing

Scenario R14S2-0 (REM-3/10/Select). This scenario includes the same components as Scenario R14S2 except that the residual PCB concentration is 0 mg/kg instead of the original R14S2 residual concentration of 0.25 mg/kg in cohesive sediments and 0.5 mg PCBs in non-cohesive sediments.

Scenario R14S2-2 (REM-3/10/Select). This scenario includes the same components as Scenario R14S2 except that the residual PCB concentration is 2 mg/kg in the top 10 cm of sediment in dredged areas instead of the original R14S2 residual concentration of 0.25 mg/kg in the entire depth cohesive sediments modeled and 0.5 mg PCBs in the entire depth of non-cohesive sediments modeled.

Scenario R14S2-5 (REM-3/10/Select). This scenario includes the same components as Scenario R14S2 except that the residual PCB concentration is 5 mg/kg in the top 10 cm of sediment in dredged areas instead of the original R14S2 residual concentration of 0.25 mg/kg in the entire depth cohesive sediments modeled and 0.5 mg PCBs in the entire depth of non-cohesive sediments modeled.

Model Sensitivity Testing for Containment with Select Removal Scenarios

The sensitivity of the model simulation of the containment with select removal scenarios was evaluated by varying the percent of the area that was capped during remediation and after completion of construction of the cap. It should be noted that the base case of the capping scenario (Scenario R15S2) assumes that 10% of the area targeted for capping is not capped due to improper cap placement. The purpose of this exercise was to evaluate the potential effect of the various degrees of failure of the containment or improper placement of the cap on the resulting concentrations of PCBs in fish and surface water quality in River Sections 1, 2, and 3 of the Upper Hudson River. After construction of the cap was completed it was assumed that a fixed percentage of the capped area would constantly be repaired during periodic maintenance and that an equal percentage of the capped area would undergo damage, as could conceivably occur from erosion, boat anchors, ice rafting, or other factors.

Two simulations for sensitivity analyses were conducted for the containment (capping) with select removal scenarios. The sensitivity analyses were based on the input for Scenario R15S2 (CAP-3/10/Select), modified by the assumption that a greater percentage of the area in the area targeted for containment (capping) is assumed to not have a cap (due to improper placement during construction of the cap or to subsequent damage to the cap after placement). The two simulations that were modeled were that 15 percent (Scenario R15S2-15), and 25 percent (Scenario R15S2-25) of the areas targeted for capping were not capped. Random areas were selected from the areas targeted for capping to represent the respective missing portions. These random areas of missing cap were selected by placing a 120-ft square grid over the Upper Hudson River and assigning a number to each square. Then a random number generator was used to identify the grid squares to be removed (*i.e.*, assumed to be not capped) to achieve the reduction in percent of capped area for each sensitivity test simulation. The mass of PCBs remaining (*i.e.*, not capped or removed) was calculated for each of the sensitivity analysis runs, as well as the percent of area remediated.

The containment with select removal sensitivity analysis scenarios were conducted with an upstream load condition of 0.16 kg/day from 1998 to 2004, reducing to a load of 0.0256 kg/day after January 1, 2005. All scenarios assumed that sediments targeted for remediation are removed to non-^{137}Cs-bearing depths of the deepest cores within a given target area.

Scenario R15S2-15 (CAP-3/10/Select). This scenario includes the same components as Scenario R15S2 except that the area targeted for capping which would not be capped due to improper cap placement is increased to 15 percent from 10 percent in the original Scenario R15S2.

Scenario R15S2-25 (CAP-3/10/Select). This scenario includes the same components as Scenario R15S2 except that the area targeted for capping which would not be capped due to improper cap placement is increased to 25 percent from 10 percent in the original Scenario R15S2.

R01CW and R01S2					
REM-0/0/3					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.56%	0.56%	C	0.25
57	Aug-05	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	2.04%	2.04%	C	0.25
67	Aug-05	1.38%	1.00%	N	0.5
68	Aug-05	7.54%	7.54%	C	0.25
69	Aug-05	0.41%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	36.65%	7.22%	N	0.5
77	Aug-06	0.00%	0.00%	N	0.5
78	Aug-06	6.35%	6.35%	C	0.25
79	Aug-06	14.03%	7.41%	N	0.5
80	Aug-06	1.59%	2.68%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	0.00%	0.00%	N	0.5
83	Aug-06	62.52%	10.92%	N	0.5
84	Aug-06	1.92%	8.71%	C	0.25
85	Aug-06	24.59%	19.01%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-07	0.81%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	3.25%	2.36%	N	0.5
90	Aug-07	10.40%	11.59%	C	0.25
91	Aug-07	7.05%	5.18%	N	0.5
92	Aug-08	3.21%	5.10%	C	0.25
93	Aug-08	8.59%	6.34%	N	0.5
94	Aug-09	2.01%	2.01%	C	0.25
95	Aug-09	0.15%	5.73%	N	0.5
96	Aug-09	98.19%	97.51%	N	0.5
97			No change		
98			No change		
99			No change		
100			No change		
101			No change		
102	Aug-09	86.58%	90.25%	C	0.25
103	Aug-09	90.07%	97.57%	N	0.5
104	Aug-09	85.30%	97.21%	C	0.25
105	Aug-10	99.17%	99.66%	N	0.5
106	Aug-10	31.16%	32.77%	C	0.25
107	Aug-10	86.25%	96.81%	N	0.5
108			No change		
109			No change		
110			No change		
111			No change		
112	Aug-10	21.28%	67.58%	C	0.25
113	Aug-10	12.15%	74.36%	N	0.5
114			No change		
115			No change		
116	Aug-10	23.62%	72.86%	C	0.25
117	Aug-10	32.01%	68.82%	N	0.5
118			No change		
119			No change		
120			No change		
121			No change		
122			No change		
123			No change		

R02CW and R02S2					
REM-0/10/MNA					
SedSeg#	Year to Remediate	% PCB Mass Remains to LTI	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-05	0.00%	0.00%	N	0.5
56	Aug-05	0.56%	0.56%	C	0.25
57	Aug-05	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-06	0.00%	0.00%	C	0.25
65	Aug-06	0.00%	0.00%	N	0.5
66	Aug-06	2.04%	2.04%	C	0.25
67	Aug-06	1.38%	1.00%	N	0.5
68	Aug-06	7.54%	7.54%	C	0.25
69	Aug-06	0.41%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	9.76%	7.22%	N	0.5
77	Aug-07	0.00%	0.00%	N	0.5
78	Aug-07	6.35%	6.35%	C	0.25
79	Aug-07	14.03%	7.41%	N	0.5
80	Aug-07	2.68%	2.68%	C	0.25
81	Aug-07	0.00%	0.00%	C	0.25
82	Aug-07	0.00%	0.00%	N	0.5
83	Aug-07	62.52%	10.92%	N	0.5
84	Aug-07	1.92%	8.71%	C	0.25
85	Aug-07	24.59%	19.01%	N	0.5
86	Aug-07	0.00%	0.00%	N	0.5
87	Aug-07	0.81%	0.59%	N	0.5
88	Aug-08	0.00%	0.00%	C	0.25
89	Aug-08	3.25%	2.36%	N	0.5
90	Aug-08	32.92%	52.64%	C	0.25
91	Aug-08	99.76%	99.62%	N	0.5
92	Aug-08	3.30%	49.53%	C	0.25
93	Aug-08	99.73%	99.57%	N	0.5
94	Aug-08	14.59%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R03CW and R03S2					
REM-0/MNA/MNA					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.56%	0.56%	C	0.25
57	Aug-05	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	2.04%	2.04%	C	0.25
67	Aug-05	1.38%	1.00%	N	0.5
68	Aug-05	7.54%	7.54%	C	0.25
69	Aug-05	0.41%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	36.65%	7.22%	N	0.5
77	Aug-06	0.00%	0.00%	N	0.5
78	Aug-06	6.35%	6.35%	C	0.25
79	Aug-06	14.03%	7.41%	N	0.5
80	Aug-06	1.59%	2.68%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	0.00%	0.00%	N	0.5
83	Aug-06	62.52%	10.92%	N	0.5
84	Aug-06	1.92%	8.71%	C	0.25
85	Aug-06	24.59%	19.01%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-07	0.81%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	3.25%	2.36%	N	0.5
90			No change		
91			No change		
92			No change		
93			No change		
94			No change		
95			No change		
96			No change		
97			No change		
98			No change		
99			No change		
100			No change		
101			No change		
102			No change		
103			No change		
104			No change		
105			No change		
106			No change		
107			No change		
108			No change		
109			No change		
110			No change		
111			No change		
112			No change		
113			No change		
114			No change		
115			No change		
116			No change		
117			No change		
118			No change		
119			No change		
120			No change		
121			No change		
122			No change		
123			No change		

R04CW and R04S2					
REM-3/10/10					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	98.12%	88.60%	N	0.5
49	Aug-04	100.00%	100.00%	N	0.5
50	Aug-04	87.19%	73.83%	N	0.5
51	Aug-04	1.90%	23.74%	N	0.5
52	Aug-04	2.82%	20.12%	C	0.25
53	Aug-04	53.91%	54.80%	N	0.5
54	Aug-04	69.63%	60.89%	N	0.5
55	Aug-04	95.29%	93.51%	N	0.5
56	Aug-04	0.60%	0.60%	C	0.25
57	Aug-04	22.66%	5.33%	N	0.5
58	Aug-04	1.65%	3.64%	N	0.5
59	Aug-04	0.00%	0.00%	C	0.25
60	Aug-04	0.00%	0.00%	N	0.5
61	Aug-05	2.57%	15.22%	C	0.25
62	Aug-05	62.53%	71.16%	N	0.5
63	Aug-05	36.96%	41.45%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	36.79%	60.34%	C	0.25
67	Aug-05	47.92%	74.63%	N	0.5
68	Aug-05	15.94%	55.70%	C	0.25
69	Aug-05	63.12%	71.95%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	0.00%	0.00%	N	0.5
72	Aug-05	6.03%	14.61%	C	0.25
73	Aug-05	6.56%	18.69%	N	0.5
74	Aug-05	45.86%	48.88%	N	0.5
75	Aug-05	63.78%	57.52%	C	0.25
76	Aug-05	17.59%	23.46%	N	0.5
77	Aug-05	21.03%	57.62%	N	0.5
78	Aug-06	7.09%	7.09%	C	0.25
79	Aug-06	66.15%	60.67%	N	0.5
80	Aug-06	5.07%	5.06%	C	0.25
81	Aug-06	3.94%	34.48%	C	0.25
82	Aug-06	93.25%	69.75%	N	0.5
83	Aug-06	94.68%	69.64%	N	0.5
84	Aug-06	1.89%	10.39%	C	0.25
85	Aug-06	37.23%	29.93%	N	0.5
86	Aug-06	25.59%	55.59%	N	0.5
87	Aug-06	55.79%	75.98%	N	0.5
88	Aug-06	9.11%	32.26%	C	0.25
89	Aug-06	50.24%	73.92%	N	0.5
90	Aug-06	32.92%	52.64%	C	0.25
91	Aug-06	99.76%	99.62%	N	0.5
92	Aug-06	3.30%	49.53%	C	0.25
93	Aug-07	99.73%	99.57%	N	0.5
94	Aug-07	14.59%	57.42%	C	0.25
95	Aug-07	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-07	51.80%	67.58%	C	0.25
113	Aug-07	18.49%	74.35%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	Aug-07	23.16%	72.34%	C	0.25
117	Aug-07	60.37%	90.20%	N	0.5
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R05CW and R05S2					
REM-3/MNA/MNA					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	98.12%	88.60%	N	0.5
49	Aug-04	100.00%	100.00%	N	0.5
50	Aug-04	87.19%	73.83%	N	0.5
51	Aug-04	1.90%	23.74%	N	0.5
52	Aug-04	2.82%	20.12%	C	0.25
53	Aug-04	53.91%	54.80%	N	0.5
54	Aug-04	69.63%	60.89%	N	0.5
55	Aug-04	95.29%	93.51%	N	0.5
56	Aug-04	0.60%	0.60%	C	0.25
57	Aug-04	22.66%	5.33%	N	0.5
58	Aug-04	1.65%	3.64%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	2.57%	15.22%	C	0.25
62	Aug-05	62.53%	71.16%	N	0.5
63	Aug-05	36.96%	41.45%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	36.79%	60.34%	C	0.25
67	Aug-05	47.92%	74.63%	N	0.5
68	Aug-05	15.94%	55.70%	C	0.25
69	Aug-05	63.12%	71.95%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	0.00%	0.00%	N	0.5
72	Aug-05	6.03%	14.61%	C	0.25
73	Aug-05	6.56%	18.69%	N	0.5
74	Aug-06	45.86%	48.88%	N	0.5
75	Aug-06	63.78%	57.52%	C	0.25
76	Aug-06	17.59%	23.46%	N	0.5
77	Aug-06	21.03%	57.62%	N	0.5
78	Aug-06	7.09%	7.09%	C	0.25
79	Aug-06	66.15%	60.67%	N	0.5
80	Aug-06	5.07%	5.06%	C	0.25
81	Aug-06	3.94%	34.48%	C	0.25
82	Aug-06	93.25%	69.75%	N	0.5
83	Aug-06	94.68%	69.64%	N	0.5
84	Aug-06	1.89%	10.39%	C	0.25
85	Aug-06	37.23%	29.93%	N	0.5
86	Aug-06	25.59%	55.59%	N	0.5
87	Aug-06	55.79%	75.98%	N	0.5
88	Aug-06	9.11%	32.26%	C	0.25
89	Aug-06	50.24%	73.92%	N	0.5
90	No Change	No Change	No Change	No Change	No Change
91	No Change	No Change	No Change	No Change	No Change
92	No Change	No Change	No Change	No Change	No Change
93	No Change	No Change	No Change	No Change	No Change
94	No Change	No Change	No Change	No Change	No Change
95	No Change	No Change	No Change	No Change	No Change
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R06CW and R06S2
REM-0-10-10

SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	2.61%	1.89%	N	0.5
49	Aug-04	0.00%	0.00%	N	0.5
50	Aug-04	3.80%	2.77%	N	0.5
51	Aug-04	9.34%	3.30%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-05	0.56%	0.56%	C	0.25
57	Aug-05	22.72%	5.23%	N	0.5
58	Aug-05	1.65%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.00%	0.00%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-06	2.04%	2.04%	C	0.25
67	Aug-06	1.38%	1.00%	N	0.5
68	Aug-06	7.54%	7.54%	C	0.25
69	Aug-06	0.41%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	1.60%	1.60%	C	0.25
73	Aug-06	3.27%	2.38%	N	0.5
74	Aug-06	7.64%	7.60%	N	0.5
75	Aug-06	82.05%	41.30%	C	0.25
76	Aug-06	9.76%	7.22%	N	0.5
77	Aug-06	0.00%	0.00%	N	0.5
78	Aug-06	6.35%	6.35%	C	0.25
79	Aug-06	14.03%	7.41%	N	0.5
80	Aug-07	1.59%	2.68%	C	0.25
81	Aug-07	0.00%	0.00%	C	0.25
82	Aug-07	0.00%	0.00%	N	0.5
83	Aug-07	62.52%	10.92%	N	0.5
84	Aug-07	1.92%	8.71%	C	0.25
85	Aug-07	24.59%	19.01%	N	0.5
86	Aug-07	0.00%	0.00%	N	0.5
87	Aug-07	0.81%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	3.25%	2.36%	N	0.5
90	Aug-08	32.92%	52.64%	C	0.25
91	Aug-08	99.76%	99.62%	N	0.5
92	Aug-08	3.30%	49.53%	C	0.25
93	Aug-08	99.73%	99.57%	N	0.5
94	Aug-08	14.59%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-08	51.80%	67.58%	C	0.25
113	Aug-08	18.49%	74.35%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	Aug-08	23.16%	72.34%	C	0.25
117	Aug-08	60.37%	90.20%	N	0.5
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R07CW and R07S2
REM-10/MNA/MNA

SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	No Change	No Change	No Change	No Change	No Change
49	No Change	No Change	No Change	No Change	No Change
50	Aug-04	95.97%	79.67%	N	0.5
51	No Change	No Change	No Change	No Change	No Change
52	Aug-04	2.81%	20.02%	C	0.25
53	Aug-04	64.05%	54.76%	N	0.5
54	Aug-04	88.06%	86.89%	N	0.5
55	No Change	No Change	No Change	No Change	No Change
56	Aug-04	0.53%	2.78%	C	0.25
57	Aug-04	65.77%	69.37%	N	0.5
58	Aug-04	91.86%	89.42%	N	0.5
59	Aug-04	4.07%	7.77%	C	0.25
60	Aug-04	5.01%	17.24%	N	0.5
61	Aug-04	5.73%	24.88%	C	0.25
62	Aug-04	73.84%	76.60%	N	0.5
63	Aug-04	94.53%	93.55%	N	0.5
64	Aug-04	0.00%	0.00%	C	0.25
65	Aug-04	17.07%	27.62%	N	0.5
66	Aug-04	46.62%	75.24%	C	0.25
67	Aug-04	55.80%	79.20%	N	0.5
68	Aug-05	17.86%	57.71%	C	0.25
69	Aug-05	74.17%	91.36%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	38.45%	15.49%	N	0.5
72	Aug-05	6.82%	31.85%	C	0.25
73	Aug-05	64.03%	72.39%	N	0.5
74	Aug-05	90.22%	88.22%	N	0.5
75	Aug-05	96.23%	96.60%	C	0.25
76	No Change	No Change	No Change	No Change	No Change
77	No Change	No Change	No Change	No Change	No Change
78	Aug-05	7.65%	7.65%	C	0.25
79	Aug-05	99.63%	99.40%	N	0.5
80	Aug-05	15.47%	9.90%	C	0.25
81	Aug-05	17.18%	72.70%	C	0.25
82	Aug-05	96.75%	94.87%	N	0.5
83	Aug-05	99.30%	95.52%	N	0.5
84	Aug-05	4.24%	11.86%	C	0.25
85	No Change	No Change	No Change	No Change	No Change
86	Aug-05	66.36%	87.99%	N	0.5
87	Aug-05	83.02%	93.70%	N	0.5
88	Aug-05	17.54%	48.41%	C	0.25
89	Aug-05	63.81%	81.00%	N	0.5
90	No Change	No Change	No Change	No Change	No Change
91	No Change	No Change	No Change	No Change	No Change
92	No Change	No Change	No Change	No Change	No Change
93	No Change	No Change	No Change	No Change	No Change
94	No Change	No Change	No Change	No Change	No Change
95	No Change	No Change	No Change	No Change	No Change
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R08S2					
REM-0/0/3					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. in dredge area (ppm)
48	Aug-04	29.85%	10.63%	N	0.5
49	Aug-04	12.32%	5.04%	N	0.5
50	Aug-04	0.31%	0.43%	N	0.5
51	Aug-04	0.19%	0.12%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.33%	0.56%	C	0.25
57	Aug-05	7.88%	5.22%	N	0.5
58	Aug-05	5.25%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.08%	0.03%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	1.04%	2.04%	C	0.25
67	Aug-05	0.56%	1.00%	N	0.5
68	Aug-05	1.96%	7.54%	C	0.25
69	Aug-05	2.31%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	0.22%	1.60%	C	0.25
73	Aug-06	3.83%	2.38%	N	0.5
74	Aug-06	8.94%	7.60%	N	0.5
75	Aug-06	48.41%	41.30%	C	0.25
76	Aug-06	3.32%	7.22%	N	0.5
77	Aug-06	0.11%	0.09%	N	0.5
78	Aug-06	6.37%	6.35%	C	0.25
79	Aug-06	15.26%	7.41%	N	0.5
80	Aug-06	1.27%	2.68%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	0.00%	0.00%	N	0.5
83	Aug-06	21.26%	11.38%	N	0.5
84	Aug-06	5.72%	8.71%	C	0.25
85	Aug-06	35.50%	20.19%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-07	0.32%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	2.01%	2.36%	N	0.5
90	Aug-07	10.40%	11.59%	C	0.25
91	Aug-07	7.05%	5.18%	N	0.5
92	Aug-08	3.21%	5.10%	C	0.25
93	Aug-08	8.59%	6.34%	N	0.5
94	Aug-09	2.01%	2.01%	C	0.25
95	Aug-09	0.15%	5.73%	N	0.5
96	Aug-09	98.19%	97.51%	N	0.5
97			No change		
98			No change		
99			No change		
100			No change		
101			No change		
102	Aug-09	86.58%	90.25%	C	0.25
103	Aug-09	90.07%	97.57%	N	0.5
104	Aug-09	85.30%	97.21%	C	0.25
105	Aug-10	99.17%	99.66%	N	0.5
106	Aug-10	31.16%	32.77%	C	0.25
107	Aug-10	86.25%	96.81%	N	0.5
108			No change		
109			No change		
110			No change		
111			No change		
112	Aug-10	21.28%	67.58%	C	0.25
113	Aug-10	12.15%	74.36%	N	0.5
114			No change		
115			No change		
116	Aug-10	23.62%	72.86%	C	0.25
117	Aug-10	32.01%	68.82%	N	0.5
118			No change		
119			No change		
120			No change		
121			No change		
122			No change		
123			No change		

R09S2					
REM-3/10/10					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	85.16%	88.60%	N	0.5
49	Aug-04	100.00%	100.00%	N	0.5
50	Aug-04	94.75%	93.78%	N	0.5
51	Aug-04	11.55%	25.54%	N	0.5
52	Aug-04	9.52%	20.12%	C	0.25
53	Aug-04	29.84%	36.16%	N	0.5
54	Aug-04	52.23%	57.76%	N	0.5
55	Aug-04	90.31%	93.51%	N	0.5
56	Aug-04	0.34%	0.60%	C	0.25
57	Aug-04	8.08%	5.33%	N	0.5
58	Aug-04	5.32%	3.67%	N	0.5
59	Aug-04	0.00%	0.00%	C	0.25
60	Aug-04	0.90%	0.69%	N	0.5
61	Aug-05	0.89%	15.22%	C	0.25
62	Aug-05	42.15%	59.96%	N	0.5
63	Aug-05	31.85%	41.32%	N	0.5
64	Aug-05	0.23%	0.39%	C	0.25
65	Aug-05	0.80%	0.24%	N	0.5
66	Aug-05	28.28%	60.34%	C	0.25
67	Aug-05	91.40%	74.63%	N	0.5
68	Aug-05	25.23%	55.70%	C	0.25
69	Aug-05	77.13%	72.16%	N	0.5
70	Aug-05	0.02%	0.01%	C	0.25
71	Aug-05	0.75%	0.43%	N	0.5
72	Aug-05	1.08%	15.15%	C	0.25
73	Aug-05	25.06%	18.70%	N	0.5
74	Aug-05	40.54%	48.76%	N	0.5
75	Aug-05	64.91%	57.52%	C	0.25
76	Aug-05	14.59%	23.25%	N	0.5
77	Aug-05	44.58%	57.62%	N	0.5
78	Aug-06	7.36%	7.09%	C	0.25
79	Aug-06	71.36%	60.67%	N	0.5
80	Aug-06	1.64%	5.06%	C	0.25
81	Aug-06	5.15%	34.48%	C	0.25
82	Aug-06	81.81%	69.75%	N	0.5
83	Aug-06	80.73%	69.64%	N	0.5
84	Aug-06	6.85%	10.39%	C	0.25
85	Aug-06	46.23%	29.93%	N	0.5
86	Aug-06	23.23%	55.96%	N	0.5
87	Aug-06	51.64%	75.78%	N	0.5
88	Aug-06	5.39%	32.26%	C	0.25
89	Aug-06	53.13%	73.73%	N	0.5
90	Aug-06	32.92%	52.64%	C	0.25
91	Aug-06	99.76%	99.62%	N	0.5
92	Aug-06	3.30%	49.53%	C	0.25
93	Aug-07	99.73%	99.57%	N	0.5
94	Aug-07	14.59%	57.42%	C	0.25
95	Aug-07	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-07	51.80%	67.58%	C	0.25
113	Aug-07	18.49%	74.35%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	Aug-07	23.16%	72.34%	C	0.25
117	Aug-07	60.37%	90.20%	N	0.5
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R10S2					
REM-10/MNA/MNA					
SedSeg#	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	No Change	No Change	No Change	No Change	No Change
49	No Change	No Change	No Change	No Change	No Change
50	Aug-04	99.87%	99.62%	N	0.5
51	No Change	No Change	No Change	No Change	No Change
52	Aug-04	10.49%	20.02%	C	0.25
53	Aug-04	33.02%	36.12%	N	0.5
54	Aug-04	83.83%	83.77%	N	0.5
55	No Change	No Change	No Change	No Change	No Change
56	Aug-04	4.04%	2.78%	C	0.25
57	Aug-04	70.44%	69.37%	N	0.5
58	Aug-04	86.17%	89.42%	N	0.5
59	Aug-04	13.71%	7.77%	C	0.25
60	Aug-04	9.48%	17.24%	N	0.5
61	Aug-04	3.04%	24.88%	C	0.25
62	Aug-04	69.19%	76.60%	N	0.5
63	Aug-04	94.89%	93.55%	N	0.5
64	Aug-04	0.68%	0.97%	C	0.25
65	Aug-04	25.28%	27.62%	N	0.5
66	Aug-04	32.33%	75.24%	C	0.25
67	Aug-04	93.91%	79.20%	N	0.5
68	Aug-05	25.32%	55.83%	C	0.25
69	Aug-05	86.27%	91.89%	N	0.5
70	Aug-05	0.27%	0.23%	C	0.25
71	Aug-05	11.01%	15.49%	N	0.5
72	Aug-05	5.11%	31.85%	C	0.25
73	Aug-05	92.64%	72.39%	N	0.5
74	Aug-05	90.51%	88.22%	N	0.5
75	Aug-05	89.44%	96.60%	C	0.25
76	No Change	No Change	No Change	No Change	No Change
77	No Change	No Change	No Change	No Change	No Change
78	Aug-05	7.44%	7.20%	C	0.25
79	Aug-05	99.75%	99.40%	N	0.5
80	Aug-05	3.47%	9.91%	C	0.25
81	Aug-05	40.29%	72.88%	C	0.25
82	Aug-05	97.45%	95.04%	N	0.5
83	Aug-05	98.24%	95.40%	N	0.5
84	Aug-05	6.86%	10.30%	C	0.25
85	No Change	No Change	No Change	No Change	No Change
86	Aug-05	58.11%	88.53%	N	0.5
87	Aug-05	80.56%	92.66%	N	0.5
88	Aug-05	21.61%	48.45%	C	0.25
89	Aug-05	79.35%	80.30%	N	0.5
90	No Change	No Change	No Change	No Change	No Change
91	No Change	No Change	No Change	No Change	No Change
92	No Change	No Change	No Change	No Change	No Change
93	No Change	No Change	No Change	No Change	No Change
94	No Change	No Change	No Change	No Change	No Change
95	No Change	No Change	No Change	No Change	No Change
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	No Change	No Change	No Change	No Change	No Change
107	No Change	No Change	No Change	No Change	No Change
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	No Change	No Change	No Change	No Change	No Change
113	No Change	No Change	No Change	No Change	No Change
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R11S2
REM-3/10/hot spots 36, 37 & part of 39, plus channel to implement remediation

SedSeg#	Year to Remediate	% PCB Mass Remains to LTI	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	85.16%	88.60%	N	0.5
49	Aug-04	91.00%	64.28%	N	0.5
50	Aug-04	93.96%	93.40%	N	0.5
51	Aug-04	1.66%	0.38%	N	0.5
52	Aug-04	9.52%	20.12%	C	0.25
53	Aug-04	29.84%	36.16%	N	0.5
54	Aug-04	19.15%	15.75%	N	0.5
55	Aug-04	46.56%	45.70%	N	0.5
56	Aug-04	0.34%	0.60%	C	0.25
57	Aug-04	8.08%	5.33%	N	0.5
58	Aug-04	5.32%	3.67%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.90%	0.69%	N	0.5
61	Aug-05	0.84%	15.17%	C	0.25
62	Aug-05	30.87%	36.10%	N	0.5
63	Aug-05	12.33%	13.05%	N	0.5
64	Aug-05	0.23%	0.39%	C	0.25
65	Aug-05	0.80%	0.24%	N	0.5
66	Aug-05	27.60%	57.23%	C	0.25
67	Aug-05	71.00%	42.34%	N	0.5
68	Aug-05	4.22%	16.09%	C	0.25
69	Aug-05	7.80%	6.30%	N	0.5
70	Aug-05	0.02%	0.01%	C	0.25
71	Aug-06	0.01%	0.04%	N	0.5
72	Aug-06	1.08%	14.99%	C	0.25
73	Aug-06	19.64%	14.94%	N	0.5
74	Aug-06	14.85%	12.19%	N	0.5
75	Aug-06	64.89%	57.50%	C	0.25
76	Aug-06	14.40%	22.53%	N	0.5
77	Aug-06	34.56%	36.21%	N	0.5
78	Aug-06	6.18%	6.14%	C	0.25
79	Aug-06	21.81%	13.95%	N	0.5
80	Aug-06	1.64%	5.06%	C	0.25
81	Aug-06	4.21%	27.88%	C	0.25
82	Aug-06	31.41%	39.42%	N	0.5
83	Aug-06	31.38%	22.79%	N	0.5
84	Aug-07	6.10%	9.03%	C	0.25
85	Aug-07	35.44%	20.16%	N	0.5
86	Aug-07	23.13%	55.77%	N	0.5
87	Aug-07	29.52%	58.79%	N	0.5
88	Aug-07	5.39%	32.26%	C	0.25
89	Aug-07	46.36%	72.64%	N	0.5
90	Aug-07	32.92%	52.64%	C	0.25
91	Aug-07	99.76%	99.62%	N	0.5
92	Aug-07	3.50%	49.53%	C	0.25
93	Aug-07	99.73%	99.57%	N	0.5
94	Aug-07	15.06%	57.42%	C	0.25
95	Aug-07	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	Aug-08	31.16%	32.77%	C	0.25
107	Aug-08	86.25%	96.81%	N	0.5
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-08	21.28%	67.58%	C	0.25
113	Aug-08	12.15%	74.36%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R12S2
REM-0/10/hot spots 36 & 37

SedSeg#	Year to Remediate	% PCB Mass Remains to LTI	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	29.85%	10.63%	N	0.5
49	Aug-04	12.32%	5.04%	N	0.5
50	Aug-04	0.31%	0.43%	N	0.5
51	Aug-04	0.19%	0.12%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-05	0.00%	0.00%	N	0.5
56	Aug-05	0.33%	0.56%	C	0.25
57	Aug-05	7.88%	5.22%	N	0.5
58	Aug-05	5.25%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.08%	0.03%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-06	0.00%	0.00%	N	0.5
66	Aug-06	1.04%	2.04%	C	0.25
67	Aug-06	0.56%	1.00%	N	0.5
68	Aug-06	1.96%	7.54%	C	0.25
69	Aug-06	2.31%	1.71%	N	0.5
70	Aug-06	0.00%	0.00%	C	0.25
71	Aug-06	0.00%	0.00%	N	0.5
72	Aug-06	0.22%	1.60%	C	0.25
73	Aug-06	3.83%	2.38%	N	0.5
74	Aug-06	8.94%	7.60%	N	0.5
75	Aug-07	48.41%	41.30%	C	0.25
76	Aug-07	3.32%	7.22%	N	0.5
77	Aug-07	0.11%	0.09%	N	0.5
78	Aug-07	6.37%	6.35%	C	0.25
79	Aug-07	15.26%	7.41%	N	0.5
80	Aug-07	1.27%	2.68%	C	0.25
81	Aug-07	0.00%	0.00%	C	0.25
82	Aug-07	0.00%	0.00%	N	0.5
83	Aug-07	21.26%	11.38%	N	0.5
84	Aug-07	5.72%	8.71%	C	0.25
85	Aug-07	35.50%	20.19%	N	0.5
86	Aug-07	0.00%	0.00%	N	0.5
87	Aug-08	0.32%	0.59%	N	0.5
88	Aug-08	0.00%	0.00%	C	0.25
89	Aug-08	2.01%	2.36%	N	0.5
90	Aug-08	32.92%	52.64%	C	0.25
91	Aug-08	99.76%	99.62%	N	0.5
92	Aug-08	3.50%	49.53%	C	0.25
93	Aug-08	99.73%	99.57%	N	0.5
94	Aug-08	15.06%	57.42%	C	0.25
95	Aug-08	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	Aug-09	31.16%	32.77%	C	0.25
107	Aug-09	86.25%	96.81%	N	0.5
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-09	21.28%	67.58%	C	0.25
113	Aug-09	12.15%	74.36%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R13S2
REM-0/10/hot spots 36 & 37

SedSeg#	Year to Remediate	% PCB Mass Remains to LTI	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	85.16%	88.60%	N	0.5
49	Aug-04	100.00%	100.00%	N	0.5
50	Aug-04	94.75%	93.78%	N	0.5
51	Aug-04	11.55%	25.54%	N	0.5
52	Aug-04	9.52%	20.12%	C	0.25
53	Aug-04	29.84%	36.16%	N	0.5
54	Aug-04	52.23%	57.76%	N	0.5
55	Aug-04	90.31%	93.51%	N	0.5
56	Aug-04	0.34%	0.60%	C	0.25
57	Aug-04	8.08%	5.33%	N	0.5
58	Aug-04	5.32%	3.67%	N	0.5
59	Aug-04	0.00%	0.00%	C	0.25
60	Aug-04	0.90%	0.69%	N	0.5
61	Aug-04	0.89%	15.22%	C	0.25
62	Aug-05	42.15%	59.96%	N	0.5
63	Aug-05	31.85%	41.32%	N	0.5
64	Aug-05	0.23%	0.39%	C	0.25
65	Aug-05	0.80%	0.24%	N	0.5
66	Aug-05	28.28%	60.34%	C	0.25
67	Aug-05	91.40%	74.63%	N	0.5
68	Aug-05	25.23%	55.70%	C	0.25
69	Aug-05	77.13%	72.16%	N	0.5
70	Aug-05	0.02%	0.01%	C	0.25
71	Aug-05	0.75%	0.43%	N	0.5
72	Aug-05	1.08%	15.15%	C	0.25
73	Aug-05	25.06%	18.70%	N	0.5
74	Aug-05	40.54%	48.76%	N	0.5
75	Aug-05	64.91%	57.52%	C	0.25
76	Aug-05	14.59%	23.25%	N	0.5
77	Aug-05	44.58%	57.62%	N	0.5
78	Aug-05	7.36%	7.09%	C	0.25
79	Aug-05	71.36%	60.67%	N	0.5
80	Aug-05	1.64%	5.06%	C	0.25
81	Aug-06	5.15%	34.48%	C	0.25
82	Aug-06	81.81%	69.75%	N	0.5
83	Aug-06	80.73%	69.64%	N	0.5
84	Aug-06	6.85%	10.39%	C	0.25
85	Aug-06	46.23%	29.93%	N	0.5
86	Aug-06	23.23%	55.96%	N	0.5
87	Aug-06	51.64%	75.78%	N	0.5
88	Aug-06	5.39%	32.26%	C	0.25
89	Aug-06	53.13%	73.73%	N	0.5
90	Aug-06	32.92%	52.64%	C	0.25
91	Aug-06	99.76%	99.62%	N	0.5
92	Aug-06	3.50%	49.53%	C	0.25
93	Aug-06	99.73%	99.57%	N	0.5
94	Aug-06	15.06%	57.42%	C	0.25
95	Aug-06	81.64%	92.87%	N	0.5
96	No Change	No Change	No Change	No Change	No Change
97	No Change	No Change	No Change	No Change	No Change
98	No Change	No Change	No Change	No Change	No Change
99	No Change	No Change	No Change	No Change	No Change
100	No Change	No Change	No Change	No Change	No Change
101	No Change	No Change	No Change	No Change	No Change
102	No Change	No Change	No Change	No Change	No Change
103	No Change	No Change	No Change	No Change	No Change
104	No Change	No Change	No Change	No Change	No Change
105	No Change	No Change	No Change	No Change	No Change
106	Aug-07	31.16%	32.77%	C	0.25
107	Aug-07	86.25%	96.81%	N	0.5
108	No Change	No Change	No Change	No Change	No Change
109	No Change	No Change	No Change	No Change	No Change
110	No Change	No Change	No Change	No Change	No Change
111	No Change	No Change	No Change	No Change	No Change
112	Aug-07	21.28%	67.58%	C	0.25
113	Aug-07	12.15%	74.36%	N	0.5
114	No Change	No Change	No Change	No Change	No Change
115	No Change	No Change	No Change	No Change	No Change
116	No Change	No Change	No Change	No Change	No Change
117	No Change	No Change	No Change	No Change	No Change
118	No Change	No Change	No Change	No Change	No Change
119	No Change	No Change	No Change	No Change	No Change
120	No Change	No Change	No Change	No Change	No Change
121	No Change	No Change	No Change	No Change	No Change
122	No Change	No Change	No Change	No Change	No Change
123	No Change	No Change	No Change	No Change	No Change

R14S2
REM-3/10/hot spots 36, 37 & part of 39, plus channel to implement remediation

SedSeg#	Year to Remediate	% PCB Mass Remains to LTI	% sedseg area not remediated	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	85.2%	88.6%	N	0.5
49	Aug-04	100.0%	100.0%	N	0.5
50	Aug-04	94.7%	93.8%	N	0.5
51	Aug-04	9.2%	18.0%	N	0.5
52	Aug-04	9.6%	20.1%	C	0.25
53	Aug-04	29.8%	36.2%	N	0.5
54	Aug-04	52.2%	57.8%	N	0.5
55	Aug-04	90.3%	93.5%	N	0.5
56	Aug-04	0.4%	0.6%	C	0.25
57	Aug-04	11.7%	5.3%	N	0.5
58	Aug-04	5.8%	3.7%	N	0.5
59	Aug-04	0.0%	0.0%	C	0.25
60	Aug-04	0.7%	0.7%	N	0.5
61	Aug-04	0.9%	15.2%	C	0.25
62	Aug-04	42.2%	60.0%	N	0.5
63	Aug-05	28.6%	34.4%	N	0.5
64	Aug-05	0.2%	0.4%	C	0.25
65	Aug-05	2.2%	0.2%	N	0.5
66	Aug-05	28.3%	60.3%	C	0.25
67	Aug-05	91.4%	74.6%	N	0.5
68	Aug-05	24.6%	55.2%	C	0.25
69	Aug-05	59.1%	44.7%	N	0.5
70	Aug-05	0.0%	0.0%	C	0.25
71	Aug-05	0.8%	0.4%	N	0.5
72	Aug-05	0.6%	2.8%	C	0.25
73	Aug-05	24.2%	16.4%	N	0.5
74	Aug-05	8.3%	8.0%	N	0.5
75	Aug-05	66.9%	57.5%	C	0.25
76	Aug-06	14.6%	23.2%	N	0.5
77	Aug-06	44.6%	57.6%	N	0.5
78	Aug-06	7.4%	6.2%	C	0.25
79	Aug-06	64.5%	56.6%	N	0.5
80	Aug-06	1.0%	5.1%	C	0.25
81	Aug-06	8.9%	34.5%	C	0.25
82	Aug-06	81.8%	69.7%	N	0.5
83	Aug-06	80.7%	69.6%	N	0.5
84	Aug-06	7.0%	10.4%	C	0.25
85	Aug-06	46.2%	29.9%	N	0.5
86	Aug-06	22.1%	55.3%	N	0.5
87	Aug-06	51.5%	75.8%	N	0.5
88	Aug-06	5.7%	32.3%	C	0.25
89	Aug-06	53.1%	73.7%	N	0.5
90	Aug-07	43.0%	52.4%	C	0.25
91	Aug-07	99.5%	99.8%	N	0.5
92	Aug-07	18.2%	49.3%	C	0.25
93	Aug-07	96.9%	99.6%	N	0.5
94	Aug-07	10.8%	58.3%	C	0.25
95	Aug-07	63.4%	85.6%	N	0.5
96	Aug-07	100.0%	100.0%	N	0.5
97	Aug-07	100.0%	100.0%	N	0.5
98	Aug-07	100.0%	100.0%	C	0.25
99	Aug-07	100.0%	100.0%	N	0.5
100	Aug-07	100.0%	100.0%	C	0.25
101	Aug-07	100.0%	100.0%	N	0.5
102	Aug-07	99.9%	99.9%	C	0.25
103	Aug-07	98.7%	98.2%	N	0.5
104	Aug-07	100.0%	100.0%	C	0.25
105	Aug-07	98.1%	97.4%	N	0.5
106	Aug-08	5.4%	29.4%	C	0.25
107	Aug-08	68.3%	89.8%	N	0.5
108	Aug-08	100.0%	100.0%	C	0.25
109	Aug-08	100.0%	100.0%	N	0.5
110	Aug-08	99.7%	99.3%	C	0.25
111	Aug-08	99.0%	98.7%	N	0.5
112	Aug-08	9.4%	61.8%	C	0.25
113	Aug-08	18.4%	68.0%	N	0.5
114	Aug-08	100.0%	100.0%	C	0.25
115	Aug-08	97.6%	96.7%	N	0.5
116	Aug-08	85.1%	95.9%	C	0.25
117	Aug-08	84.1%	89.3%	N	0.5
118	Aug-08	100.0%	100.0%	C	0.25
119	Aug-08	99.6%	99.4%	N	0.5
120	Aug-08	88.0%	88.0%	C	0.25
121	Aug-08	99.9%	99.9%	N	0.5
122	Aug-08	98.7%	98.3%	N	0.5
123	Aug-08	100.0%	100.0%	N	0.5

TAMS

Sediment Capping Base Case Alternative - 10% of cap missing

Scenario R15AS2 CAP/SR-3/10/S + channel

SedSeg#	Year to Remediate	% PCB Mass Remains -(10% of cap area breached)	% sedseg area not remediated-(10% of cap area breached)	% sedseg area capped-(10% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% of SedSeg area Dredged with >12' water depth	PCB conc. in dredged area w/ >12' water depth (top 10 cm of core) (ppm)	% of SedSeg area Dredged with <12' water depth	PCB conc. in dredged area w/ <12' water depth (26 cm of core) (ppm)	sediment type
48	Aug-04	85.16%	88.60%	0.00%	0	0.00%	1	11.40%	0.25	N
49	Aug-04	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N
50	Aug-04	94.75%	93.78%	0.00%	0	0.00%	1	6.22%	0.25	N
51	Aug-04	10.61%	25.43%	24.73%	0	9.70%	1	40.14%	0.25	N
52	Aug-04	17.64%	29.40%	57.01%	0	13.59%	1	0.00%	0.25	C
53	Aug-04	36.30%	41.28%	31.24%	0	11.39%	1	16.10%	0.25	N
54	Aug-04	52.63%	58.41%	5.08%	0	32.95%	1	3.56%	0.25	N
55	Aug-04	90.31%	93.51%	0.00%	0	1.18%	1	5.31%	0.25	N
56	Aug-04	10.72%	17.22%	80.67%	0	0.00%	1	2.12%	0.25	C
57	Aug-04	13.88%	10.19%	63.09%	0	0.00%	1	26.72%	0.25	N
58	Aug-04	12.06%	4.74%	17.04%	0	40.64%	1	37.57%	0.25	N
59	Aug-04	0.86%	1.45%	76.18%	0	14.60%	1	7.77%	0.25	C
60	Aug-04	5.02%	3.60%	79.82%	0	0.01%	1	16.57%	0.25	N
61	Aug-04	11.38%	23.21%	58.88%	0	8.19%	1	9.73%	0.25	C
62	Aug-04	42.16%	59.97%	23.38%	0	0.24%	1	16.41%	0.25	N
63	Aug-05	29.63%	34.95%	9.95%	0	17.68%	1	37.42%	0.25	N
64	Aug-05	8.21%	15.69%	84.25%	0	0.00%	1	0.06%	0.25	C
65	Aug-05	4.19%	1.95%	91.95%	0	0.00%	1	6.10%	0.25	N
66	Aug-05	30.23%	61.33%	26.56%	0	0.13%	1	11.98%	0.25	C
67	Aug-05	93.51%	80.75%	18.97%	0	0.00%	1	0.28%	0.25	N
68	Aug-05	25.42%	55.97%	3.44%	0	40.55%	1	0.04%	0.25	C
69	Aug-05	59.37%	44.73%	9.06%	0	35.76%	1	10.44%	0.25	N
70	Aug-05	10.80%	13.54%	72.00%	0	14.39%	1	0.07%	0.25	C
71	Aug-05	14.56%	7.34%	85.92%	0	5.15%	1	1.59%	0.25	N
72	Aug-05	16.08%	19.03%	58.56%	0	19.60%	1	2.80%	0.25	C
73	Aug-05	24.97%	17.58%	39.91%	0	10.43%	1	32.09%	0.25	N
74	Aug-05	9.50%	8.81%	2.77%	0	70.69%	1	17.73%	0.25	N
75	Aug-05	66.89%	57.83%	12.25%	0	8.57%	1	21.35%	0.25	C
76	Aug-06	14.59%	23.26%	57.45%	0	10.50%	1	8.79%	0.25	N
77	Aug-06	44.58%	57.63%	0.35%	0	7.24%	1	34.78%	0.25	N
78	Aug-06	18.61%	13.07%	73.89%	0	10.44%	1	2.59%	0.25	C
79	Aug-06	65.35%	58.71%	6.16%	0	12.42%	1	22.71%	0.25	N
80	Aug-06	7.45%	14.44%	81.00%	0	4.56%	1	0.01%	0.25	C
81	Aug-06	9.93%	36.81%	29.54%	0	5.85%	1	27.80%	0.25	C
82	Aug-06	81.81%	69.75%	8.13%	0	20.31%	1	1.81%	0.25	N
83	Aug-06	80.73%	69.81%	1.36%	0	26.87%	1	1.96%	0.25	N
84	Aug-06	7.83%	12.04%	79.20%	0	6.75%	1	2.01%	0.25	C
85	Aug-06	46.23%	30.00%	1.02%	0	20.57%	1	48.40%	0.25	N
86	Aug-06	27.73%	58.28%	25.78%	0	3.72%	1	12.22%	0.25	N
87	Aug-06	55.10%	77.18%	7.81%	0	10.12%	1	4.89%	0.25	N
88	Aug-06	7.73%	35.41%	36.02%	0	13.06%	1	15.51%	0.25	C
89	Aug-06	53.27%	73.96%	16.67%	0	7.05%	1	2.31%	0.25	N
90	Aug-07	43.04%	52.37%	0.00%	0	17.12%	1	30.51%	0.25	C
91	Aug-07	99.50%	99.81%	0.00%	0	0.16%	1	0.03%	0.25	N
92	Aug-07	25.00%	52.97%	35.67%	0	11.35%	1	0.01%	0.25	C
93	Aug-07	96.87%	99.56%	0.11%	0	0.34%	1	0.00%	0.25	N
94	Aug-07	19.84%	62.80%	33.81%	0	3.31%	1	0.08%	0.25	C
95	Aug-07	63.75%	85.77%	4.57%	0	9.39%	1	0.28%	0.25	N
96	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N
97	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N
98	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	C
99	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N
100	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	C
101	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N
102	Aug-07	99.90%	99.90%	0.00%	0	0.09%	1	0.01%	0.25	C
103	Aug-07	98.69%	98.19%	0.00%	0	1.59%	1	0.22%	0.25	N
104	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	C
105	Aug-07	98.11%	97.40%	0.00%	0	2.04%	1	0.56%	0.25	N
106	Aug-08	5.39%	29.40%	0.00%	0	2.23%	1	68.37%	0.25	C
107	Aug-08	68.28%	89.76%	0.00%	0	7.27%	1	2.98%	0.25	N
108	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	C
109	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N
110	Aug-08	99.69%	99.32%	0.00%	0	0.66%	1	0.01%	0.25	C
111	Aug-08	99.03%	98.66%	0.00%	0	1.18%	1	0.16%	0.25	N
112	Aug-08	9.43%	61.79%	0.00%	0	4.32%	1	33.90%	0.25	C
113	Aug-08	18.38%	67.98%	0.00%	0	5.55%	1	26.47%	0.25	N
114	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	C
115	Aug-08	97.57%	96.66%	0.00%	0	3.25%	1	0.09%	0.25	N
116	Aug-08	85.11%	95.94%	0.00%	0	0.00%	1	4.06%	0.25	C
117	Aug-08	84.07%	91.41%	0.00%	0	1.69%	1	6.90%	0.25	N
118	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	C
119	Aug-08	99.56%	99.39%	0.00%	0	0.61%	1	0.00%	0.25	N
120	Aug-08	88.03%	88.03%	0.00%	0	8.76%	1	3.21%	0.25	C
121	Aug-08	99.93%	99.90%	0.00%	0	0.09%	1	0.02%	0.25	N
122	Aug-08	98.74%	98.26%	0.00%	0	1.31%	1	0.43%	0.25	N
123	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	0.00%	0.25	N

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R16S2					
REM-0/0/3 plus channel to implement					
SedSeg #	Year to Dredge	% PCB Mass Remains	% sedseg area not dredged	sediment type	PCB conc. In dredge area (ppm)
48	Aug-04	29.85%	10.63%	N	0.5
49	Aug-04	12.32%	5.04%	N	0.5
50	Aug-04	0.31%	0.43%	N	0.5
51	Aug-04	0.19%	0.12%	N	0.5
52	Aug-04	0.00%	0.00%	C	0.25
53	Aug-04	0.00%	0.00%	N	0.5
54	Aug-04	0.00%	0.00%	N	0.5
55	Aug-04	0.00%	0.00%	N	0.5
56	Aug-04	0.33%	0.56%	C	0.25
57	Aug-04	7.88%	5.22%	N	0.5
58	Aug-05	5.25%	3.63%	N	0.5
59	Aug-05	0.00%	0.00%	C	0.25
60	Aug-05	0.00%	0.00%	N	0.5
61	Aug-05	0.00%	0.00%	C	0.25
62	Aug-05	0.08%	0.03%	N	0.5
63	Aug-05	0.00%	0.00%	N	0.5
64	Aug-05	0.00%	0.00%	C	0.25
65	Aug-05	0.00%	0.00%	N	0.5
66	Aug-05	1.04%	2.04%	C	0.25
67	Aug-05	0.56%	1.00%	N	0.5
68	Aug-05	1.96%	7.54%	C	0.25
69	Aug-05	2.31%	1.71%	N	0.5
70	Aug-05	0.00%	0.00%	C	0.25
71	Aug-05	0.00%	0.00%	N	0.5
72	Aug-06	0.22%	1.60%	C	0.25
73	Aug-06	3.83%	2.38%	N	0.5
74	Aug-06	8.94%	7.60%	N	0.5
75	Aug-06	48.41%	41.30%	C	0.25
76	Aug-06	3.32%	7.22%	N	0.5
77	Aug-06	0.11%	0.09%	N	0.5
78	Aug-06	6.37%	6.35%	C	0.25
79	Aug-06	15.26%	7.41%	N	0.5
80	Aug-06	1.27%	2.68%	C	0.25
81	Aug-06	0.00%	0.00%	C	0.25
82	Aug-06	0.00%	0.00%	N	0.5
83	Aug-06	21.26%	11.38%	N	0.5
84	Aug-06	5.72%	8.71%	C	0.25
85	Aug-06	35.50%	20.19%	N	0.5
86	Aug-06	0.00%	0.00%	N	0.5
87	Aug-07	0.32%	0.59%	N	0.5
88	Aug-07	0.00%	0.00%	C	0.25
89	Aug-07	2.01%	2.36%	N	0.5
90	Aug-07	11.59%	11.59%	C	0.25
91	Aug-07	8.09%	5.18%	N	0.5
92	Aug-08	5.10%	5.10%	C	0.25
93	Aug-08	9.84%	6.34%	N	0.5
94	Aug-09	2.01%	2.01%	C	0.25
95	Aug-09	8.93%	5.73%	N	0.5
96	Aug-09	100.00%	100.00%	N	0.5
97	Aug-09	100.00%	100.00%	N	0.5
98	Aug-09	100.00%	100.00%	C	0.25
99	Aug-09	100.00%	100.00%	N	0.5
100	Aug-09	100.00%	100.00%	C	0.25
101	Aug-09	100.00%	100.00%	N	0.5
102	Aug-09	90.20%	90.15%	C	0.25
103	Aug-09	97.11%	95.76%	N	0.5
104	Aug-09	85.29%	97.21%	C	0.25
105	Aug-09	92.18%	97.06%	N	0.5
106	Aug-10	5.39%	29.40%	C	0.25
107	Aug-10	68.28%	89.76%	N	0.5
108	Aug-10	100.00%	100.00%	C	0.25
109	Aug-10	100.00%	100.00%	N	0.5
110	Aug-10	99.69%	99.32%	C	0.25
111	Aug-10	99.03%	98.66%	N	0.5
112	Aug-10	9.43%	61.79%	C	0.25
113	Aug-10	18.39%	67.99%	N	0.5
114	Aug-10	100.00%	100.00%	C	0.25
115	Aug-10	97.57%	96.66%	N	0.5
116	Aug-10	46.42%	72.86%	C	0.25
117	Aug-10	43.31%	66.91%	N	0.5
118	Aug-10	100.00%	100.00%	C	0.25
119	Aug-10	99.56%	99.39%	N	0.5
120	Aug-10	88.03%	88.03%	C	0.25
121	Aug-10	99.93%	99.90%	N	0.5
122	Aug-10	98.74%	98.26%	N	0.5
123	Aug-10	100.00%	100.00%	N	0.5

Scenario R17 CAP-0/10/Hot Spots 36 and 37										
SedSeg#	Year to Remediate	% PCB Mass Remains - (10% of cap area breached)	% sedseg area not remediated (10% of cap area breached)	% sedseg area capped- (10% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% of SedSeg area Dredged with >12' water depth	PCB conc. in dredged area w/ >12' water depth (top 10 cm of core) (ppm)	% of SedSeg area Dredged with <12' water depth	PCB conc. in dredged area w/ <12' water depth (26 cm of core) (ppm)	sediment type
48	Aug-04	29.93%	10.69%	0.00%	0	0.00%	1	89.31%	0.25	N
49	Aug-04	12.32%	5.04%	0.00%	0	2.27%	1	92.69%	0.25	N
50	Aug-04	3.63%	0.90%	0.14%	0	4.81%	1	94.16%	0.25	N
51	Aug-04	3.08%	0.00%	22.76%	0	21.12%	1	56.13%	0.25	N
52	Aug-04	16.53%	15.45%	60.73%	0	17.46%	1	6.36%	0.25	C
53	Aug-04	3.74%	3.10%	38.78%	0	26.88%	1	31.24%	0.25	N
54	Aug-04	0.19%	0.24%	5.69%	0	89.14%	1	4.93%	0.25	N
55	Aug-05	0.01%	0.01%	0.00%	0	37.03%	1	62.96%	0.25	N
56	Aug-05	9.05%	10.66%	87.22%	0	0.00%	1	2.12%	0.25	C
57	Aug-05	8.15%	5.43%	67.87%	0	0.00%	1	26.70%	0.25	N
58	Aug-05	5.78%	4.03%	17.76%	0	40.64%	1	37.57%	0.25	N
59	Aug-05	8.43%	11.52%	66.10%	0	14.60%	1	7.77%	0.25	C
60	Aug-05	16.42%	7.93%	75.47%	0	0.01%	1	16.59%	0.25	N
61	Aug-05	0.09%	0.10%	67.10%	0	8.93%	1	23.87%	0.25	C
62	Aug-05	33.96%	9.46%	14.06%	0	36.36%	1	40.12%	0.25	N
63	Aug-05	1.50%	0.59%	9.92%	0	42.16%	1	47.32%	0.25	N
64	Aug-06	7.30%	6.21%	93.73%	0	0.00%	1	0.06%	0.25	C
65	Aug-06	11.85%	6.81%	87.09%	0	0.00%	1	6.10%	0.25	N
66	Aug-06	11.59%	11.21%	44.55%	0	11.89%	1	32.35%	0.25	C
67	Aug-06	19.79%	8.19%	51.73%	0	9.75%	1	30.33%	0.25	N
68	Aug-06	1.96%	7.54%	4.20%	0	88.22%	1	0.04%	0.25	C
69	Aug-06	4.34%	3.00%	7.85%	0	71.08%	1	18.07%	0.25	N
70	Aug-06	8.44%	3.64%	81.49%	0	14.79%	1	0.07%	0.25	C
71	Aug-06	3.42%	2.58%	90.28%	0	5.55%	1	1.59%	0.25	N
72	Aug-06	4.62%	8.79%	71.30%	0	19.91%	1	0.00%	0.25	C
73	Aug-06	5.74%	5.35%	40.38%	0	12.61%	1	41.66%	0.25	N
74	Aug-06	10.75%	8.37%	3.15%	0	72.34%	1	16.13%	0.25	N
75	Aug-07	48.50%	41.45%	12.05%	0	24.44%	1	22.06%	0.25	C
76	Aug-07	20.50%	12.93%	51.83%	0	11.55%	1	23.69%	0.25	N
77	Aug-07	2.26%	0.95%	0.35%	0	29.37%	1	69.32%	0.25	N
78	Aug-07	6.96%	6.99%	79.39%	0	10.95%	1	2.67%	0.25	C
79	Aug-07	15.36%	7.53%	7.68%	0	57.69%	1	27.11%	0.25	N
80	Aug-07	5.14%	9.14%	83.95%	0	6.16%	1	0.74%	0.25	C
81	Aug-07	16.02%	4.64%	27.74%	0	7.69%	1	59.92%	0.25	C
82	Aug-07	6.34%	3.82%	6.11%	0	80.10%	1	9.97%	0.25	N
83	Aug-07	21.28%	11.39%	1.36%	0	84.03%	1	3.23%	0.25	N
84	Aug-07	7.78%	13.89%	75.89%	0	7.53%	1	2.70%	0.25	C
85	Aug-07	36.62%	20.94%	1.02%	0	30.29%	1	47.75%	0.25	N
86	Aug-07	7.46%	6.94%	49.51%	0	9.15%	1	34.40%	0.25	N
87	Aug-08	1.12%	2.46%	27.97%	0	35.79%	1	33.78%	0.25	N
88	Aug-08	17.27%	4.83%	34.45%	0	13.05%	1	47.66%	0.25	C
89	Aug-08	5.08%	5.69%	33.71%	0	8.87%	1	51.73%	0.25	N
90	Aug-08	43.04%	52.37%	0.00%	0	17.12%	1	30.51%	0.25	C
91	Aug-08	99.88%	99.81%	0.00%	0	0.16%	1	0.03%	0.25	N
92	Aug-08	24.76%	49.30%	39.34%	0	11.35%	1	0.01%	0.25	C
93	Aug-08	99.72%	99.56%	0.11%	0	0.34%	1	0.00%	0.25	N
94	Aug-08	15.90%	57.66%	39.05%	0	3.26%	1	0.04%	0.25	C
95	Aug-08	79.15%	92.41%	4.73%	0	2.87%	1	0.00%	0.25	N
96	No Change									N
97	No Change									N
98	No Change									C
99	No Change									N
100	No Change									C
101	No Change									N
102	No Change									C
103	No Change									N
104	No Change									C
105	No Change									N
106	Aug-09	31.16%	32.77%	0.00%	0	0.00%	1	67.23%	0.25	C
107	Aug-09	86.25%	96.81%	0.00%	0	0.00%	1	3.19%	0.25	N
108	No Change									C
109	No Change									N
110	No Change									C
111	No Change									N
112	Aug-09	21.28%	67.58%	0.00%	0	0.00%	1	32.42%	0.25	C
113	Aug-09	12.15%	74.36%	0.00%	0	0.00%	1	25.64%	0.25	N
114	No Change									C
115	No Change									N
116	No Change									C
117	No Change									N
118	No Change									C
119	No Change									N
120	No Change									C
121	No Change									N
122	No Change									N
123	No Change									N

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Scenario R18 CAP-0/10/MNA										
SedSeg#	Year to Remediate	% PCB Mass Remains - (10% of cap area breached)	% sedseg area not remediated (10% of cap area breached)	% sedseg area capped- (10% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% of SedSeg area Dredged with >12' water depth	PCB conc. in dredged area w/ >12' water depth (top 10 cm of core) (ppm)	% of SedSeg area Dredged with <12' water depth	PCB conc. in dredged area w/ <12' water depth (26 cm of core) (ppm)	sediment type
48	Aug-04	29.93%	10.69%	0.00%	0	0.00%	1	89.31%	0.25	N
49	Aug-04	12.32%	5.04%	0.00%	0	2.27%	1	92.69%	0.25	N
50	Aug-04	3.63%	0.90%	0.14%	0	4.81%	1	94.16%	0.25	N
51	Aug-04	3.08%	0.00%	22.76%	0	21.12%	1	56.13%	0.25	N
52	Aug-04	16.53%	15.45%	60.73%	0	17.46%	1	6.36%	0.25	C
53	Aug-04	3.74%	3.10%	38.78%	0	26.88%	1	31.24%	0.25	N
54	Aug-04	0.19%	0.24%	5.69%	0	89.14%	1	4.93%	0.25	N
55	Aug-05	0.01%	0.01%	0.00%	0	37.03%	1	62.96%	0.25	N
56	Aug-05	9.05%	10.66%	87.22%	0	0.00%	1	2.12%	0.25	C
57	Aug-05	8.15%	5.43%	67.87%	0	0.00%	1	26.70%	0.25	N
58	Aug-05	5.78%	4.03%	17.76%	0	40.64%	1	37.57%	0.25	N
59	Aug-05	8.43%	11.52%	66.10%	0	14.60%	1	7.77%	0.25	C
60	Aug-05	16.42%	7.93%	75.47%	0	0.01%	1	16.59%	0.25	N
61	Aug-05	0.09%	0.10%	67.10%	0	8.93%	1	23.87%	0.25	C
62	Aug-05	33.96%	9.46%	14.06%	0	36.36%	1	40.12%	0.25	N
63	Aug-05	1.50%	0.59%	9.92%	0	42.16%	1	47.32%	0.25	N
64	Aug-06	7.30%	6.21%	93.73%	0	0.00%	1	0.06%	0.25	C
65	Aug-06	11.85%	6.81%	87.09%	0	0.00%	1	6.10%	0.25	N
66	Aug-06	11.59%	11.21%	44.55%	0	11.89%	1	32.35%	0.25	C
67	Aug-06	19.79%	8.19%	51.73%	0	9.75%	1	30.33%	0.25	N
68	Aug-06	1.96%	7.54%	4.20%	0	88.22%	1	0.04%	0.25	C
69	Aug-06	4.34%	3.00%	7.85%	0	71.08%	1	18.07%	0.25	N
70	Aug-06	8.44%	3.64%	81.49%	0	14.79%	1	0.07%	0.25	C
71	Aug-06	3.42%	2.58%	90.28%	0	5.55%	1	1.59%	0.25	N
72	Aug-06	4.62%	8.79%	71.30%	0	19.91%	1	0.00%	0.25	C
73	Aug-06	5.74%	5.35%	40.38%	0	12.61%	1	41.66%	0.25	N
74	Aug-06	10.75%	8.37%	3.15%	0	72.34%	1	16.13%	0.25	N
75	Aug-06	48.50%	41.45%	12.05%	0	24.44%	1	22.06%	0.25	C
76	Aug-06	20.50%	12.93%	51.83%	0	11.55%	1	23.69%	0.25	N
77	Aug-07	2.26%	0.95%	0.35%	0	29.37%	1	69.32%	0.25	N
78	Aug-07	6.96%	6.99%	79.39%	0	10.95%	1	2.67%	0.25	C
79	Aug-07	15.36%	7.53%	7.68%	0	57.69%	1	27.11%	0.25	N
80	Aug-07	5.14%	9.14%	83.95%	0	6.16%	1	0.74%	0.25	C
81	Aug-07	16.02%	4.64%	27.74%	0	7.69%	1	59.92%	0.25	C
82	Aug-07	6.34%	3.82%	6.11%	0	80.10%	1	9.97%	0.25	N
83	Aug-07	21.28%	11.39%	1.36%	0	84.03%	1	3.23%	0.25	N
84	Aug-07	7.78%	13.89%	75.89%	0	7.53%	1	2.70%	0.25	C
85	Aug-07	36.62%	20.94%	1.02%	0	30.29%	1	47.75%	0.25	N
86	Aug-07	7.46%	6.94%	49.51%	0	9.15%	1	34.40%	0.25	N
87	Aug-07	1.12%	2.46%	27.97%	0	35.79%	1	33.78%	0.25	N
88	Aug-08	17.27%	4.83%	34.45%	0	13.05%	1	47.66%	0.25	C
89	Aug-08	5.08%	5.69%	33.71%	0	8.87%	1	51.73%	0.25	N
90	Aug-08	43.04%	52.37%	0.00%	0	17.12%	1	30.51%	0.25	C
91	Aug-08	99.88%	99.81%	0.00%	0	0.16%	1	0.03%	0.25	N
92	Aug-08	24.76%	49.30%	39.34%	0	11.35%	1	0.01%	0.25	C
93	Aug-08	99.72%	99.56%	0.11%	0	0.34%	1	0.00%	0.25	N
94	Aug-08	15.90%	57.66%	39.05%	0	3.26%	1	0.04%	0.25	C
95	Aug-08	79.15%	92.41%	4.73%	0	2.87%	1	0.00%	0.25	N
96	No Change									N
97	No Change									N
98	No Change									C
99	No Change									N
100	No Change									C
101	No Change									N
102	No Change									C
103	No Change									N
104	No Change									C
105	No Change									N
106	No Change									C
107	No Change									N
108	No Change									C
109	No Change									N
110	No Change									C
111	No Change									N
112	No Change									C
113	No Change									N
114	No Change									C
115	No Change									N
116	No Change									C
117	No Change									N
118	No Change									C
119	No Change									N
120	No Change									C
121	No Change									N
122	No Change									N
123	No Change									N

Scenario R19 CAP-0/MNA/MNA										
SedSeg#	Year to Remediate	% PCB Mass Remains - (10% of cap area breached)	% sedseg area not remediated (10% of cap area breached)	% sedseg area capped- (10% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% of SedSeg area Dredged with >12' water depth	PCB conc. in dredged area w/ >12' water depth (top 10 cm of core) (ppm)	% of SedSeg area Dredged with <12' water depth	PCB conc. in dredged area w/ <12' water depth (26 cm of core) (ppm)	sediment type
48	Aug-04	29.93%	10.69%	0.00%	0	0.00%	1	89.31%	0.25	N
49	Aug-04	12.32%	5.04%	0.00%	0	2.27%	1	92.69%	0.25	N
50	Aug-04	3.63%	0.90%	0.14%	0	4.81%	1	94.16%	0.25	N
51	Aug-04	3.08%	0.00%	22.76%	0	21.12%	1	56.13%	0.25	N
52	Aug-04	16.53%	15.45%	60.73%	0	17.46%	1	6.36%	0.25	C
53	Aug-04	3.74%	3.10%	38.78%	0	26.88%	1	31.24%	0.25	N
54	Aug-04	0.19%	0.24%	5.69%	0	89.14%	1	4.93%	0.25	N
55	Aug-04	0.01%	0.01%	0.00%	0	37.03%	1	62.96%	0.25	N
56	Aug-05	9.05%	10.66%	87.22%	0	0.00%	1	2.12%	0.25	C
57	Aug-05	8.15%	5.43%	67.87%	0	0.00%	1	26.70%	0.25	N
58	Aug-05	5.78%	4.03%	17.76%	0	40.64%	1	37.57%	0.25	N
59	Aug-05	8.43%	11.52%	66.10%	0	14.60%	1	7.77%	0.25	C
60	Aug-05	16.42%	7.93%	75.47%	0	0.01%	1	16.59%	0.25	N
61	Aug-05	0.09%	0.10%	67.10%	0	8.93%	1	23.87%	0.25	C
62	Aug-05	33.96%	9.46%	14.06%	0	36.36%	1	40.12%	0.25	N
63	Aug-05	1.50%	0.59%	9.92%	0	42.16%	1	47.32%	0.25	N
64	Aug-05	7.30%	6.21%	93.73%	0	0.00%	1	0.06%	0.25	C
65	Aug-05	11.85%	6.81%	87.09%	0	0.00%	1	6.10%	0.25	N
66	Aug-06	11.59%	11.21%	44.55%	0	11.89%	1	32.35%	0.25	C
67	Aug-06	19.79%	8.19%	51.73%	0	9.75%	1	30.33%	0.25	N
68	Aug-06	1.96%	7.54%	4.20%	0	88.22%	1	0.04%	0.25	C
69	Aug-06	4.34%	3.00%	7.85%	0	71.08%	1	18.07%	0.25	N
70	Aug-06	8.44%	3.64%	81.49%	0	14.79%	1	0.07%	0.25	C
71	Aug-06	3.42%	2.58%	90.28%	0	5.55%	1	1.59%	0.25	N
72	Aug-06	4.62%	8.79%	71.30%	0	19.91%	1	0.00%	0.25	C
73	Aug-06	5.74%	5.35%	40.38%	0	12.61%	1	41.66%	0.25	N
74	Aug-06	10.75%	8.37%	3.15%	0	72.34%	1	16.13%	0.25	N
75	Aug-06	48.50%	41.45%	12.05%	0	24.44%	1	22.06%	0.25	C
76	Aug-06	20.50%	12.93%	51.83%	0	11.55%	1	23.69%	0.25	N
77	Aug-06	2.26%	0.95%	0.35%	0	29.37%	1	69.32%	0.25	N
78	Aug-06	6.96%	6.99%	79.39%	0	10.95%	1	2.67%	0.25	C
79	Aug-06	15.36%	7.53%	7.68%	0	57.69%	1	27.11%	0.25	N
80	Aug-07	5.14%	9.14%	83.95%	0	6.16%	1	0.74%	0.25	C
81	Aug-07	16.02%	4.64%	27.74%	0	7.69%	1	59.92%	0.25	C
82	Aug-07	6.34%	3.82%	6.11%	0	80.10%	1	9.97%	0.25	N
83	Aug-07	21.28%	11.39%	1.36%	0	84.03%	1	3.23%	0.25	N
84	Aug-07	7.78%	13.89%	75.89%	0	7.53%	1	2.70%	0.25	C
85	Aug-07	36.62%	20.94%	1.02%	0	30.29%	1	47.75%	0.25	N
86	Aug-07	7.46%	6.94%	49.51%	0	9.15%	1	34.40%	0.25	N
87	Aug-07	1.12%	2.46%	27.97%	0	35.79%	1	33.78%	0.25	N
88	Aug-07	17.27%	4.83%	34.45%	0	13.05%	1	47.66%	0.25	C
89	Aug-07	5.08%	5.69%	33.71%	0	8.87%	1	51.73%	0.25	N
90	No Change									C
91	No Change									N
92	No Change									C
93	No Change									N
94	No Change									C
95	No Change									N
96	No Change									N
97	No Change									N
98	No Change									C
99	No Change									N
100	No Change									C
101	No Change									N
102	No Change									C
103	No Change									N
104	No Change									C
105	No Change									N
106	No Change									C
107	No Change									N
108	No Change									C
109	No Change									N
110	No Change									C
111	No Change									N
112	No Change									C
113	No Change									N
114	No Change									C
115	No Change									N
116	No Change									C
117	No Change									N
118	No Change									C
119	No Change									N
120	No Change									C
121	No Change									N
122	No Change									N
123	No Change									N

401632

Sediment Capping Sensitivity Analysis - 15% of cap defective

Scenario R15S15 CAP/SR-3/10/S + channel (15% defective cap)

SedSeg#	Year to Remediate	% PCB Mass Remains (15% of cap area breached)	% sedseg area not remediated (15% of cap area breached)	% sedseg area capped (15% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged (15% of cap area breached)	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	85.16%	88.60%	0.00%	0	11.40%	1	N
49	Aug-04	100.00%	100.00%	0.00%	0	0.00%	1	N
50	Aug-04	94.75%	93.78%	0.00%	0	6.22%	1	N
51	Aug-04	11.05%	27.28%	22.89%	0	49.84%	1	N
52	Aug-04	19.45%	35.79%	50.63%	0	13.59%	1	C
53	Aug-04	38.08%	42.25%	30.26%	0	27.49%	1	N
54	Aug-04	53.22%	59.81%	3.68%	0	36.51%	1	N
55	Aug-04	90.31%	93.51%	0.00%	0	6.49%	1	N
56	Aug-04	21.61%	28.69%	69.19%	0	2.12%	1	C
57	Aug-04	16.12%	13.60%	59.68%	0	26.72%	1	N
58	Aug-04	12.48%	5.17%	16.61%	0	78.22%	1	N
59	Aug-04	0.86%	1.45%	76.18%	0	22.38%	1	C
60	Aug-04	5.14%	3.85%	79.57%	0	16.58%	1	N
61	Aug-04	20.43%	30.41%	51.67%	0	17.92%	1	C
62	Aug-04	47.45%	62.23%	21.12%	0	16.65%	1	N
63	Aug-05	30.74%	35.71%	9.19%	0	55.10%	1	N
64	Aug-05	10.53%	21.49%	78.45%	0	0.06%	1	C
65	Aug-05	18.45%	11.40%	82.50%	0	6.10%	1	N
66	Aug-05	40.22%	66.91%	20.99%	0	12.11%	1	C
67	Aug-05	93.52%	80.78%	18.94%	0	0.28%	1	N
68	Aug-05	25.42%	55.97%	3.44%	0	40.59%	1	C
69	Aug-05	59.37%	44.73%	9.06%	0	46.21%	1	N
70	Aug-05	14.35%	24.29%	61.25%	0	14.46%	1	C
71	Aug-05	18.16%	9.20%	84.06%	0	6.74%	1	N
72	Aug-05	16.30%	21.40%	56.19%	0	22.41%	1	C
73	Aug-05	25.91%	19.26%	38.23%	0	42.52%	1	N
74	Aug-05	9.50%	8.81%	2.77%	0	88.42%	1	N
75	Aug-05	66.89%	57.83%	12.25%	0	29.92%	1	C
76	Aug-06	14.59%	23.26%	57.45%	0	19.29%	1	N
77	Aug-06	44.58%	57.63%	0.35%	0	42.02%	1	N
78	Aug-06	18.73%	13.18%	73.79%	0	13.03%	1	C
79	Aug-06	65.96%	59.86%	5.01%	0	35.13%	1	N
80	Aug-06	7.77%	14.72%	80.72%	0	4.56%	1	C
81	Aug-06	13.25%	38.05%	28.29%	0	33.66%	1	C
82	Aug-06	81.81%	69.75%	8.13%	0	22.13%	1	N
83	Aug-06	80.73%	69.81%	1.36%	0	28.83%	1	N
84	Aug-06	7.83%	12.04%	79.20%	0	8.76%	1	C
85	Aug-06	46.23%	30.00%	1.02%	0	68.98%	1	N
86	Aug-06	30.45%	60.33%	23.73%	0	15.94%	1	N
87	Aug-06	55.10%	77.18%	7.81%	0	15.01%	1	N
88	Aug-06	7.73%	35.41%	36.02%	0	28.57%	1	C
89	Aug-06	53.27%	73.96%	16.67%	0	9.36%	1	N
90	Aug-07	43.04%	52.37%	0.00%	0	47.63%	1	C
91	Aug-07	99.50%	99.81%	0.00%	0	0.19%	1	N
92	Aug-07	30.91%	56.16%	32.48%	0	11.36%	1	C
93	Aug-07	96.87%	99.56%	0.11%	0	0.34%	1	N
94	Aug-07	21.09%	63.30%	33.31%	0	3.39%	1	C
95	Aug-07	64.44%	85.84%	4.49%	0	9.67%	1	N
96	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
97	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
98	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	C
99	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
100	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	C
101	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
102	Aug-07	99.90%	99.90%	0.00%	0	0.10%	1	C
103	Aug-07	98.69%	98.19%	0.00%	0	1.81%	1	N
104	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	C
105	Aug-07	98.11%	97.40%	0.00%	0	2.60%	1	N
106	Aug-08	5.39%	29.40%	0.00%	0	70.60%	1	C
107	Aug-08	68.28%	89.76%	0.00%	0	10.24%	1	N
108	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	C
109	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	N
110	Aug-08	99.69%	99.32%	0.00%	0	0.68%	1	C
111	Aug-08	99.03%	98.66%	0.00%	0	1.34%	1	N
112	Aug-08	9.43%	61.79%	0.00%	0	38.21%	1	C
113	Aug-08	18.38%	67.98%	0.00%	0	32.02%	1	N
114	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	C
115	Aug-08	97.57%	96.66%	0.00%	0	3.34%	1	N
116	Aug-08	85.11%	95.94%	0.00%	0	4.06%	1	C
117	Aug-08	84.07%	91.41%	0.00%	0	8.59%	1	N
118	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	C
119	Aug-08	99.56%	99.39%	0.00%	0	0.61%	1	N
120	Aug-08	88.03%	88.03%	0.00%	0	11.97%	1	C
121	Aug-08	99.93%	99.90%	0.00%	0	0.10%	1	N
122	Aug-08	98.74%	98.26%	0.00%	0	1.74%	1	N
123	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	N

Sediment Capping Sensitivity Analysis - 25% of cap defective

Scenario R15S25 CAP/SR-3/10/S + channel (25% defective cap)

SedSeg#	Year to Remediate	% PCB Mass Remains (25% of cap area breached)	% sedseg area not remediated (25% of cap area breached)	% sedseg area capped (25% of cap area breached)	PCB conc. in capped area (26 cm of core) (ppm)	% sedseg area dredged (25% of cap area breached)	PCB conc. in dredged area (top 10 cm of core) (ppm)	sediment type
48	Aug-04	85.16%	88.60%	0.00%	0	11.40%	1	N
49	Aug-04	100.00%	100.00%	0.00%	0	0.00%	1	N
50	Aug-04	94.75%	93.78%	0.00%	0	6.22%	1	N
51	Aug-04	11.06%	27.29%	22.87%	0	49.84%	1	N
52	Aug-04	20.13%	41.37%	45.05%	0	13.59%	1	C
53	Aug-04	47.93%	45.64%	26.87%	0	27.49%	1	N
54	Aug-04	54.62%	61.22%	2.27%	0	36.51%	1	N
55	Aug-04	90.31%	93.51%	0.00%	0	6.49%	1	N
56	Aug-04	33.01%	45.63%	52.25%	0	2.12%	1	C
57	Aug-04	26.09%	20.45%	52.83%	0	26.72%	1	N
58	Aug-04	14.90%	6.78%	15.00%	0	78.22%	1	N
59	Aug-04	27.13%	20.92%	56.70%	0	22.38%	1	C
60	Aug-04	23.74%	16.42%	67.00%	0	16.58%	1	N
61	Aug-04	24.12%	33.22%	48.86%	0	17.92%	1	C
62	Aug-04	59.78%	65.25%	18.10%	0	16.65%	1	N
63	Aug-05	31.10%	35.94%	8.96%	0	55.10%	1	N
64	Aug-05	23.48%	40.48%	59.46%	0	0.06%	1	C
65	Aug-05	41.12%	20.65%	73.25%	0	6.10%	1	N
66	Aug-05	40.22%	66.91%	20.99%	0	12.11%	1	C
67	Aug-05	93.52%	80.79%	18.94%	0	0.28%	1	N
68	Aug-05	27.44%	56.35%	3.06%	0	40.59%	1	C
69	Aug-05	60.89%	45.61%	8.18%	0	46.21%	1	N
70	Aug-05	22.19%	29.69%	55.85%	0	14.46%	1	C
71	Aug-05	24.34%	19.30%	73.96%	0	6.74%	1	N
72	Aug-05	17.28%	24.37%	53.23%	0	22.41%	1	C
73	Aug-05	30.83%	26.12%	31.36%	0	42.52%	1	N
74	Aug-05	9.63%	9.13%	2.44%	0	88.42%	1	N
75	Aug-05	66.98%	57.97%	12.11%	0	29.92%	1	C
76	Aug-06	15.55%	25.84%	54.87%	0	19.29%	1	N
77	Aug-06	44.59%	57.66%	0.32%	0	42.02%	1	N
78	Aug-06	29.41%	20.33%	66.64%	0	13.03%	1	C
79	Aug-06	65.96%	59.86%	5.01%	0	35.13%	1	N
80	Aug-06	19.48%	28.16%	67.27%	0	4.56%	1	C
81	Aug-06	25.35%	44.35%	22.00%	0	33.66%	1	C
82	Aug-06	82.37%	70.70%	7.17%	0	22.13%	1	N
83	Aug-06	80.73%	69.81%	1.36%	0	28.83%	1	N
84	Aug-06	14.47%	21.29%	69.95%	0	8.76%	1	C
85	Aug-06	46.23%	30.00%	1.02%	0	68.98%	1	N
86	Aug-06	33.03%	61.12%	22.94%	0	15.94%	1	N
87	Aug-06	55.60%	77.47%	7.53%	0	15.01%	1	N
88	Aug-06	10.10%	37.51%	33.92%	0	28.57%	1	C
89	Aug-06	53.42%	74.01%	16.63%	0	9.36%	1	N
90	Aug-07	43.04%	52.37%	0.00%	0	47.63%	1	C
91	Aug-07	99.50%	99.81%	0.00%	0	0.19%	1	N
92	Aug-07	37.51%	59.53%	29.11%	0	11.36%	1	C
93	Aug-07	97.31%	99.61%	0.05%	0	0.34%	1	N
94	Aug-07	27.11%	67.60%	29.01%	0	3.39%	1	C
95	Aug-07	65.19%	85.98%	4.36%	0	9.67%	1	N
96	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
97	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
98	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	C
99	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
100	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	C
101	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	N
102	Aug-07	99.90%	99.90%	0.00%	0	0.10%	1	C
103	Aug-07	98.69%	98.19%	0.00%	0	1.81%	1	N
104	Aug-07	100.00%	100.00%	0.00%	0	0.00%	1	C
105	Aug-07	98.11%	97.40%	0.00%	0	2.60%	1	N
106	Aug-08	5.39%	29.40%	0.00%	0	70.60%	1	C
107	Aug-08	68.28%	89.76%	0.00%	0	10.24%	1	N
108	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	C
109	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	N
110	Aug-08	99.69%	99.32%	0.00%	0	0.68%	1	C
111	Aug-08	99.03%	98.66%	0.00%	0	1.34%	1	N
112	Aug-08	9.43%	61.79%	0.00%	0	38.21%	1	C
113	Aug-08	18.38%	67.98%	0.00%	0	32.02%	1	N
114	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	C
115	Aug-08	97.57%	96.66%	0.00%	0	3.34%	1	N
116	Aug-08	85.11%	95.94%	0.00%	0	4.06%	1	C
117	Aug-08	84.07%	91.41%	0.00%	0	8.59%	1	N
118	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	C
119	Aug-08	99.56%	99.39%	0.00%	0	0.61%	1	N
120	Aug-08	88.03%	88.03%	0.00%	0	11.97%	1	C
121	Aug-08	99.93%	99.90%	0.00%	0	0.10%	1	N
122	Aug-08	98.74%	98.26%	0.00%	0	1.74%	1	N
123	Aug-08	100.00%	100.00%	0.00%	0	0.00%	1	N

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HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX D

MODEL INTERPRETATION, SPECIFICATIONS AND RESULTS

D.3 Model Results

REFINED ENGINEERING MODELING

Figure Number	Title	Model Runs Included
RE1	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Constant Upstream Load Conditions	-Constant Load No Action-Scenario P3NAcw -Scenarios R01cw through R07cw
RE2	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE3	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE4	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE5	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE6	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE7	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE8	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE9	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions	same as above
RE10	Comparison between Water Column Forecasts at Thompson Island Dam - Constant Upstream Load Conditions	same as above
RE11	Comparison between Water Column Forecasts at Northumberland Dam - Constant Upstream Load Conditions	same as above
RE12	Comparison between Water Column Forecasts at Stillwater - Constant Upstream Load Conditions	same as above

RE13	Comparison between Water Column Forecasts at Waterford - Constant Upstream Load Conditions	same as above
RE14	Comparison between Water Column Forecasts at Federal Dam - Constant Upstream Load Conditions	same as above
RE15	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Step Down Upstream Load Conditions	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -No Action w/ Load 0.16 kg/d to 0 kg/d - Scenario P3NAs0 -Scenarios R01s2 through R07s2 -Scenarios R01s0
RE16	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE17	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE18	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE19	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE20	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE21	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE22	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE23	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions	same as above
RE24	Comparison between Water Column Forecasts at Thompson Island Dam - Step Down Upstream Load Conditions	same as above
RE25	Comparison between Water Column Forecasts at Northumberland Dam - Step Down Upstream Load Conditions	same as above

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RE26	Comparison between Water Column Forecasts at Stillwater - Step Down Upstream Load Conditions	same as above
RE27	Comparison between Water Column Forecasts at Waterford - Step Down Upstream Load Conditions	same as above
RE28	Comparison between Water Column Forecasts at Federal Dam - Step Down Upstream Load Conditions	same as above
RE29	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	-Scenarios R07s2, R10s2, R04s2, R09s2, R01s2, R08s2
RE30	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE31	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE32	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE33	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE34	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE35	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE36	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE37	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE38	Comparison between Water Column Forecasts at Thompson Island Dam - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE39	Comparison between Water Column Forecasts at Northumberland Dam - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above

RE40	Comparison between Water Column Forecasts at Stillwater - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE41	Comparison between Water Column Forecasts at Waterford - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE42	Comparison between Water Column Forecasts at Federal Dam - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE43	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R11s2, R12s2, R06s2, R13s2, R09s2
RE44	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE45	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE46	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE47	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE48	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE49	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE50	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE51	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE52	Comparison between Water Column Forecasts at Thompson Island Dam - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE53	Comparison between Water Column Forecasts at Northumberland Dam - Channel Dredging in River Section 1/River Section 3 Removal	same as above

RE54	Comparison between Water Column Forecasts at Stillwater - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE55	Comparison between Water Column Forecasts at Waterford - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE56	Comparison between Water Column Forecasts at Federal Dam - Channel Dredging in River Section 1/River Section 3 Removal	same as above
RE57	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Cap Scenarios	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R017s2, R18s2, R19s2
RE58	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Cap Scenarios	same as above
RE59	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Cap Scenarios	same as above
RE60	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Cap Scenarios	same as above
RE61	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Cap Scenarios	same as above
RE62	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Cap Scenarios	same as above
RE63	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Cap Scenarios	same as above
RE64	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Cap Scenarios	same as above
RE65	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Cap Scenarios	same as above
RE66	Comparison between Water Column Forecasts at Thompson Island Dam - Cap Scenarios	same as above
RE67	Comparison between Water Column Forecasts at Northumberland Dam - Cap Scenarios	same as above
RE68	Comparison between Water Column Forecasts at Stillwater - Cap Scenarios	same as above

RE69	Comparison between Water Column Forecasts at Waterford - Cap Scenarios	same as above
RE70	Comparison between Water Column Forecasts at Federal Dam - Cap Scenarios	same as above
RE71	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R015As2, R14s2, R16s2
RE72	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE73	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE74	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE75	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE76	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE77	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE78	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE79	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analysis	same as above
RE80	Comparison between Water Column Forecasts at Thompson Island Dam - Alternatives Retained for Detailed Analysis	same as above
RE81	Comparison between Water Column Forecasts at Northumberland Dam - Alternatives Retained for Detailed Analysis	same as above
RE82	Comparison between Water Column Forecasts at Stillwater - Alternatives Retained for Detailed Analysis	same as above
RE83	Comparison between Water Column Forecasts at Waterford - Alternatives Retained for Detailed Analysis7	same as above

RE84	Comparison between Water Column Forecasts at Federal Dam - Alternatives Retained for Detailed Analysis	same as above
RE85	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R14s2-0, R14s2, R14s2-2, R14s2-5
RE86	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE87	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE88	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE89	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE90	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE91	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE92	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE93	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis	same as above
RE94	Comparison between Water Column Forecasts at Thompson Island Dam - Removal Scenarios Sensitivity Analysis	same as above
RE95	Comparison between Water Column Forecasts at Northumberland Dam - Removal Scenarios Sensitivity Analysis	same as above
RE96	Comparison between Water Column Forecasts at Stillwater - Removal Scenarios Sensitivity Analysis	same as above
RE97	Comparison between Water Column Forecasts at Waterford - Removal Scenarios Sensitivity Analysis	same as above

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RE98	Comparison between Water Column Forecasts at Federal Dam - Removal Scenarios Sensitivity Analysis	same as above
RE99	Comparison between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R14s2-0, R15As2, R15s2-15, R15s2-25
RE100	Comparison between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE101	Comparison between Forecasts for Schuylerville Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE102	Comparison between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE103	Comparison between Forecasts for Stillwater Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE104	Comparison between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE105	Comparison between Forecasts for Waterford Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE106	Comparison between Forecasts for Waterford Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE107	Comparison between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis	same as above
RE108	Comparison between Water Column Forecasts at Thompson Island Dam - Cap Scenarios Sensitivity Analysis	same as above
RE109	Comparison between Water Column Forecasts at Northumberland Dam - Cap Scenarios Sensitivity Analysis	same as above
RE110	Comparison between Water Column Forecasts at Stillwater - Cap Scenarios Sensitivity Analysis	same as above
RE111	Comparison between Water Column Forecasts at Waterford - Cap Scenarios Sensitivity Analysis	same as above

RE112	Comparison between Water Column Forecasts at Federal Dam - Cap Scenarios Sensitivity Analysis	same as above
RE113	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Constant Upstream Load Conditions	-Constant Load No Action-Scenario P3NAcw -Scenarios R01cw through R07cw
RE114	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Constant Upstream Load Conditions	same as above
RE115	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Constant Upstream Load Conditions	same as above
RE116	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Step Down Upstream Load Conditions	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -No Action w/ Load 0.16 kg/d to 0 kg/d - Scenario P3NAs0 -Scenarios R01s2 through R07s2 -Scenarios R01s0
RE117	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Step Down Upstream Load Conditions	same as above
RE118	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Step Down Upsteam Load Conditions	same as above
RE119	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	-Scenarios R07s2, R10s2, R04s2, R09s2, R01s2, R08s2
RE120	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE121	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal	same as above
RE122	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Channel Dredging in River Section 1/Removal in River Section 2	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R11s2, R12s2, R06s2, R13s2, R09s2
RE123	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Channel Dredging in River Section 1/Removal in River Section 2	same as above

RE124	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Channel Dredging in River Section 1/Removal in River Section 2	same as above
RE125	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Cap Scenarios	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R017s2, R18s2, R19s2
RE126	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Cap Scenarios	same as above
RE127	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Cap Scenarios	same as above
RE128	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Alternatives Retained for Detailed Analysis	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R015As2, R14s2, R16s2
RE129	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Alternatives Retained for Detailed Analysis	same as above
RE130	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Alternatives Retained for Detailed Analysis	same as above
RE131	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Removal Scenarios Sensitivity Analysis	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R14s2-0, R14s2, R14s2-2, R14s2-5
RE132	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Removal Scenarios Sensitivity Analysis	same as above
RE133	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Removal Scenarios Sensitivity Analysis	same as above
RE134	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Cap Scenarios Sensitivity Analysis	-Constant Load No Action-Scenario P3NAcw -No Action w/ Load 0.16 kg/d to 0.0256 kg/d-Scenario P3NAs2 -Scenarios R14s2-0, R15As2, R15s2-15, R15s2-25
RE135	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Cap Scenarios Sensitivity Analysis	same as above
RE136	Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Cap Scenarios Sensitivity Analysis	same as above

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Table RE1
Tri+ PCB Load Over Thompson Island Dam

Year	Two Step Upstream Boundary Assumption (0.16 kg/day>0.0256 kg/day)												
	P3NAs2 (No Action)	r01s2 (0/0/3)	r02s2 (0/10/mna)	r03s2 (0/mna/mna)	r04s2 (3/10/10)	r05s2 (3/mna/mna)	r06s2 (0/10/10)	r07s2 (10/mna/mna)	r08s2 (0/0/3)	r09s2 (3/10/10)	r10s2 (10/mna/mna)	r11s2 (3 plus channel/10/ Hot Spots 36 & 37)	r12s2 (0/10/Hot Spots 36 & 37)
1998	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82
1999	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34
2000	123.43	123.43	123.43	123.43	123.43	123.43	123.43	123.43	123.43	123.43	123.43	123.43	123.43
2001	135.08	135.08	135.08	135.08	135.08	135.08	135.08	135.08	135.08	135.08	135.08	135.08	135.08
2002	106.04	106.04	106.04	106.04	106.04	106.04	106.04	106.04	106.04	106.04	106.04	106.04	106.04
2003	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50	103.50
2004	90.99	88.01	88.50	88.01	88.70	88.98	88.30	89.25	88.14	88.59	89.25	88.59	88.64
2005	51.81	38.95	41.24	38.95	42.10	43.36	40.44	44.41	39.37	41.79	44.42	41.75	41.49
2006	57.19	28.06	34.03	28.06	36.14	37.61	32.42	42.25	28.45	35.80	42.25	34.69	34.20
2007	56.80	17.49	23.91	17.49	29.17	29.19	22.14	40.93	17.52	28.71	41.03	26.03	24.87
2008	38.11	12.68	13.31	12.68	21.52	21.54	12.69	29.23	12.64	21.14	29.22	17.19	13.97
2009	37.68	12.67	12.75	12.67	21.19	21.20	12.68	28.66	12.65	20.84	28.66	17.05	12.78
2010	50.72	15.09	15.18	15.08	27.21	27.23	15.10	37.67	15.16	26.83	37.77	21.62	15.33
2011	43.72	13.74	13.82	13.74	23.69	23.71	13.76	32.33	13.78	23.38	32.46	19.06	13.92
2012	40.47	13.31	13.38	13.31	22.33	22.35	13.32	30.16	13.35	22.04	30.29	18.12	13.48
2013	40.35	13.34	13.40	13.34	22.29	22.31	13.35	30.02	13.42	22.05	30.19	18.18	13.54
2014	33.15	12.27	12.32	12.27	19.29	19.31	12.28	25.35	12.35	19.11	25.44	16.04	12.44
2015	31.06	11.98	12.02	11.97	18.45	18.46	11.98	24.02	12.05	18.29	24.10	15.46	12.14
2016	23.84	10.55	10.58	10.54	15.21	15.22	10.55	19.25	10.57	15.06	19.29	12.97	10.63
2017	23.25	10.58	10.61	10.57	15.00	15.01	10.58	18.83	10.60	14.87	18.87	12.89	10.66
2018	26.37	10.96	11.00	10.96	15.90	15.91	10.97	20.18	11.03	15.81	20.30	13.62	11.09
2019	20.77	9.94	9.96	9.93	13.68	13.69	9.94	16.90	9.97	13.59	16.94	11.91	10.02
2020	22.33	10.59	10.62	10.59	14.70	14.70	10.60	18.16	10.65	14.61	18.22	12.81	10.70
2021	20.46	10.15	10.17	10.15	13.72	13.72	10.15	16.74	10.20	13.65	16.80	12.09	10.24
2022	17.57	9.57	9.59	9.57	12.42	12.43	9.57	14.84	9.60	12.36	14.87	11.10	9.64
2023	16.86	9.48	9.49	9.48	12.12	12.12	9.48	14.34	9.51	12.06	14.38	10.91	9.54
2024	20.75	10.44	10.46	10.44	13.86	13.87	10.44	16.73	10.52	13.82	16.81	12.38	10.55
2025	17.02	9.67	9.68	9.67	12.26	12.26	9.67	14.42	9.72	12.21	14.46	11.11	9.74
2026	16.74	9.66	9.67	9.65	12.11	12.11	9.66	14.15	9.71	12.07	14.20	11.04	9.73
2027	15.27	9.35	9.36	9.35	11.46	11.46	9.35	13.20	9.39	11.41	13.24	10.53	9.41
2028	15.76	9.57	9.58	9.57	11.73	11.73	9.57	13.51	9.62	11.69	13.56	10.80	9.64
2029	15.19	9.50	9.51	9.49	11.49	11.50	9.50	13.14	9.54	11.46	13.18	10.64	9.56
2030	14.95	9.71	9.72	9.71	11.59	11.59	9.72	13.12	9.76	11.56	13.16	10.79	9.78
2031	16.04	9.75	9.76	9.75	11.79	11.80	9.75	13.47	9.81	11.78	13.56	10.95	9.83
2032	14.26	9.37	9.38	9.37	11.03	11.03	9.38	12.37	9.42	11.00	12.43	10.34	9.44
2033	13.31	9.18	9.18	9.18	10.61	10.61	9.18	11.77	9.22	10.59	11.81	10.02	9.23
2034	13.51	9.50	9.51	9.50	10.95	10.95	9.50	12.10	9.54	10.93	12.14	10.36	9.55
2035	13.49	9.47	9.47	9.47	10.90	10.90	9.47	12.04	9.51	10.88	12.08	10.33	9.53
2036	13.61	9.43	9.44	9.43	10.79	10.80	9.43	11.89	9.48	10.78	11.96	10.25	9.49
2037	13.75	9.37	9.38	9.37	10.63	10.63	9.37	11.66	9.42	10.62	11.77	10.13	9.43
2038	12.07	8.99	9.00	8.99	10.00	10.00	9.00	10.80	9.03	9.98	10.86	9.60	9.03
2039	14.17	9.69	9.70	9.69	10.92	10.92	9.69	11.92	9.74	10.91	12.06	10.45	9.75
2040	11.62	8.86	8.87	8.86	9.71	9.71	8.86	10.39	8.89	9.69	10.45	9.38	8.90
2041	11.52	9.19	9.19	9.19	10.00	10.00	9.19	10.64	9.22	9.99	10.68	9.68	9.23
2042	9.98	8.36	8.36	8.36	8.96	8.96	8.36	9.43	8.38	8.94	9.44	8.72	8.38
2043	12.92	9.72	9.72	9.72	10.66	10.67	9.72	11.42	9.76	10.65	11.50	10.31	9.76
2044	12.39	9.46	9.47	9.46	10.30	10.30	9.47	10.96	9.50	10.29	11.05	9.99	9.50
2045	11.63	9.07	9.07	9.07	9.80	9.80	9.07	10.37	9.10	9.79	10.45	9.52	9.10
2046	10.62	8.95	8.95	8.95	9.54	9.54	8.95	9.99	8.97	9.53	10.02	9.32	8.98
2047	10.64	8.81	8.82	8.81	9.36	9.36	8.81	9.78	8.84	9.36	9.82	9.16	8.85
2048	11.74	8.83	8.83	8.83	9.34	9.34	8.83	9.76	8.91	9.40	9.83	9.21	8.91
2049	10.78	8.49	8.49	8.49	8.91	8.91	8.49	9.26	8.55	8.96	9.30	8.80	8.55
2050	12.07	9.02	9.02	9.02	9.53	9.53	9.02	9.95	9.10	9.60	10.02	9.41	9.11
2051	11.90	9.21	9.21	9.21	9.67	9.67	9.21	10.05	9.29	9.74	10.11	9.57	9.29
2052	10.29	8.60	8.60	8.59	8.95	8.95	8.60	9.23	8.64	8.98	9.26	8.85	8.64
2053	9.97	8.45	8.45	8.45	8.77	8.77	8.45	9.02	8.49	8.79	9.04	8.68	8.49
2054	9.83	8.45	8.45	8.44	8.74	8.74	8.45	8.98	8.48	8.77	9.00	8.66	8.48
2055	10.76	8.96	8.96	8.96	9.33	9.33	8.96	9.61	9.01	9.36	9.64	9.24	9.02
2056	8.90	8.19	8.19	8.19	8.41	8.41	8.19	8.58	8.20	8.41	8.58	8.34	8.21
2057	9.58	8.71	8.71	8.71	8.95	8.95	8.71	9.13	8.73	8.96	9.14	8.87	8.73
2058	9.53	8.63	8.63	8.63	8.89	8.90	8.63	9.09	8.65	8.90	9.10	8.81	8.65
2059	9.34	8.52	8.52	8.52	8.74	8.74	8.52	8.91	8.55	8.75	8.92	8.68	8.55
2060	10.29	9.17	9.17	9.17	9.43	9.43	9.17	9.63	9.20	9.45	9.64	9.36	9.20
2061	10.60	9.45	9.45	9.45	9.73	9.73	9.45	9.94	9.48	9.75	9.95	9.66	9.49
2062	9.08	8.47	8.47	8.47	8.65	8.65	8.47	8.78	8.50	8.65	8.79	8.59	8.50
2063	9.03	8.49	8.47	8.47	8.64	8.64	8.47	8.76	8.54	8.64	8.77	8.59	8.55
2064	8.94	8.42	8.39	8.39	8.55	8.55	8.39	8.67	8.47	8.56	8.67	8.50	8.47
2065	9.42	8.96	8.94	8.94	9.11	9.11	8.94	9.22	9.00	9.11	9.23	9.05	9.00
2066	9.04	8.60	8.59	8.59	8.74	8.74	8.59	8.84	8.64	8.74	8.85	8.69	8.64
2067	8.83	8.42	8.40	8.40	8.53	8.53	8.40	8.63	8.46	8.53	8.63	8.49	8.46
Total Loads	2076.82	1560.69	1577.31	1560.52	1727.06	1730.38	1571.54	1869.07	1564.20	1722.78	1872.10	1658.17	1582.85

401646

Table RE1
Tri+ PCB Load Over Thompson Island Dam

Year	Two Step Upstream Boundary Assumption (0.16 kg/day>0.0256 kg/day)											
	r13s2 (3/10/Hot Spots 36 & 37)	r14 (REM-3/10/S + Channel)	r14sn0 (REM-3/10/S + channel, assumes residual of 0 ppm)	r14sn2 (REM-3/10/S + channel, assumes max residual of 2 ppm)	r14sn5 (REM-3/10/S + channel, assumes max residual of 5 ppm)	r15a (CAP-3/10/Select Areas, assumes 10% deffective cap)	r15sn15 (CAP 3/10/S + channel, assumes 15% deffective cap)	r15sn25 (CAP 3/10/S + channel, assumes 25% deffective cap)	r16 (REM-0/0/3 + channel)	r17 (CAP-0/10/36-37)	r18 (CAP-0/10/mna)	r19 (CAP-0/mna/mna)
1998	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82	224.82
1999	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34
2000	123.43	123.65	123.65	123.65	123.65	123.65	123.65	123.65	123.65	123.65	123.65	123.65
2001	135.08	135.20	135.20	135.20	135.20	135.20	135.20	135.20	135.20	135.20	135.20	135.20
2002	106.04	105.88	105.88	105.88	105.88	105.88	105.88	105.88	105.88	105.88	105.88	105.88
2003	103.50	103.71	103.71	103.71	103.71	103.71	103.71	103.71	103.71	103.71	103.71	103.71
2004	88.48	88.22	87.93	89.19	90.68	88.28	88.51	88.73	87.99	88.64	88.64	88.44
2005	40.41	40.56	39.41	44.38	50.29	40.86	41.73	42.54	38.31	41.62	41.62	40.85
2006	32.86	34.68	32.42	42.14	53.20	35.37	36.95	38.43	27.13	35.51	35.43	33.89
2007	28.70	27.24	24.47	36.71	49.74	28.11	29.94	32.03	17.48	26.36	25.69	24.04
2008	21.14	20.24	18.42	26.24	34.28	20.81	22.00	23.18	12.68	15.21	14.51	13.95
2009	20.84	19.90	18.15	25.73	33.62	20.45	21 61	22.81	12.63	13.94	13.91	13.87
2010	26.83	25.60	23.21	33.60	44.73	26.29	27.88	29.70	15.15	16.92	16.88	16.83
2011	23.37	22.31	20.34	28.97	38.26	22.91	24.22	25.84	13.77	15.30	15.26	15.22
2012	22.04	21.14	19.36	27.04	35.29	21.67	22.84	24.37	13.38	14.76	14.73	14.69
2013	22.04	21.10	19.38	26.77	34.73	21.59	22.74	24.28	13.41	14.75	14.72	14.68
2014	19.11	18.36	17.02	22.76	28.89	18.74	19.64	20.72	12.34	13.36	13.33	13.31
2015	18.28	17.60	16.38	21.61	27.22	17.95	18.77	19.75	12.05	12.98	12.96	12.93
2016	15.06	14.87	13.94	17.91	22.11	15.14	15.77	16.43	10.73	11.42	11.40	11.38
2017	14.87	14.10	13.29	16.74	20.41	14.33	14.88	15.45	10.48	11.08	11.07	11.05
2018	15.81	15.28	14.34	18.37	22.77	15.55	16.18	17.05	11.01	11.77	11.75	11.73
2019	13.59	13.16	12.46	15.46	18.68	13.36	13.84	14.37	9.95	10.48	10.47	10.45
2020	14.61	14.24	13.49	16.68	20.14	14.44	14.95	15.53	10.69	11.25	11.24	11.22
2021	13.65	13.47	12.80	15.67	18.80	13.65	14.11	14.66	10.28	10.79	10.78	10.77
2022	12.35	12.05	11.53	13.74	16.13	12.19	12.55	12.93	9.60	9.99	9.98	9.97
2023	12.05	11.59	11.13	13.08	15.20	11.71	12.03	12.36	9.41	9.76	9.75	9.74
2024	13.82	13.52	12.91	15.53	18.45	13.68	14.10	14.67	10.54	11.01	11.00	10.99
2025	12.21	11.95	11.49	13.44	15.59	12.07	12.39	12.75	9.71	10.05	10.05	10.04
2026	12.07	11.96	11.52	13.40	15.49	12.07	12.38	12.76	9.77	10.11	10.10	10.09
2027	11.41	11.06	10.70	12.21	13.87	11.15	11.40	11.70	9.30	9.57	9.57	9.56
2028	11.69	11.51	11.14	12.71	14.46	11.60	11.86	12.21	9.64	9.93	9.92	9.92
2029	11.46	11.34	11.00	12.44	14.05	11.42	11.66	11.98	9.60	9.87	9.86	9.86
2030	11.56	11.34	11.03	12.35	13.84	11.41	11.64	11.92	9.72	9.96	9.96	9.95
2031	11.78	11.57	11.23	12.68	14.34	11.65	11.89	12.32	9.79	10.08	10.08	10.07
2032	11.00	10.90	10.62	11.79	13.12	10.97	11.16	11.47	9.46	9.69	9.69	9.68
2033	10.59	10.44	10.20	11.21	12.35	10.50	10.67	10.91	9.20	9.39	9.38	9.38
2034	10.93	10.83	10.60	11.59	12.71	10.89	11.05	11.28	9.57	9.76	9.75	9.75
2035	10.88	10.74	10.51	11.48	12.60	10.79	10.95	11.18	9.49	9.67	9.67	9.66
2036	10.78	10.68	10.46	11.38	12.45	10.73	10.89	11.18	9.49	9.69	9.69	9.68
2037	10.62	10.49	10.28	11.13	12.10	10.53	10.68	11.09	9.39	9.61	9.61	9.61
2038	9.98	9.91	9.75	10.41	11.16	9.94	10.05	10.30	9.03	9.18	9.18	9.18
2039	10.91	10.83	10.63	11.43	12.36	10.87	11.00	11.48	9.75	9.98	9.98	9.98
2040	9.69	9.70	9.56	10.11	10.75	9.73	9.82	10.07	8.96	9.10	9.10	9.10
2041	9.99	9.89	9.76	10.28	10.87	9.91	10.00	10.17	9.19	9.30	9.29	9.29
2042	8.94	8.86	8.77	9.15	9.59	8.88	8.95	9.05	8.35	8.42	8.42	8.42
2043	10.65	10.59	10.44	11.03	11.72	10.61	10.72	11.03	9.76	9.92	9.92	9.91
2044	10.29	10.24	10.11	10.63	11.23	10.26	10.35	10.66	9.52	9.66	9.66	9.66
2045	9.79	9.72	9.61	10.05	10.58	9.74	9.82	10.10	9.09	9.22	9.22	9.22
2046	9.53	9.49	9.40	9.75	10.17	9.50	9.56	9.69	8.97	9.05	9.05	9.05
2047	9.36	9.32	9.24	9.56	9.95	9.33	9.39	9.54	8.85	8.93	8.92	8.92
2048	9.40	9.37	9.29	9.59	9.95	9.39	9.44	9.66	8.91	9.01	9.01	9.00
2049	8.96	8.95	8.88	9.13	9.43	8.96	9.01	9.17	8.57	8.64	8.64	8.64
2050	9.60	9.57	9.49	9.79	10.14	9.59	9.64	9.86	9.11	9.20	9.20	9.20
2051	9.74	9.71	9.63	9.90	10.22	9.72	9.77	9.96	9.29	9.37	9.37	9.37
2052	8.98	8.95	8.90	9.10	9.34	8.96	9.00	9.11	8.63	8.69	8.69	8.68
2053	8.79	8.77	8.72	8.91	9.12	8.78	8.81	8.91	8.49	8.53	8.53	8.53
2054	8.77	8.77	8.72	8.89	9.09	8.77	8.81	8.89	8.50	8.54	8.54	8.54
2055	9.36	9.36	9.30	9.50	9.74	9.37	9.40	9.52	9.03	9.08	9.08	9.08
2056	8.41	8.42	8.39	8.51	8.66	8.42	8.45	8.49	8.23	8.25	8.25	8.25
2057	8.96	9.08	9.05	9.19	9.35	9.09	9.12	9.17	8.86	8.89	8.89	8.89
2058	8.90	8.75	8.71	8.85	9.01	8.75	8.78	8.83	8.53	8.56	8.56	8.56
2059	8.75	8.73	8.70	8.82	8.96	8.73	8.76	8.80	8.54	8.56	8.56	8.56
2060	9.45	9.43	9.39	9.53	9.70	9.44	9.46	9.53	9.20	9.24	9.24	9.23
2061	9.75	9.76	9.72	9.86	10.04	9.76	9.79	9.86	9.51	9.54	9.54	9.54
2062	8.65	8.64	8.62	8.72	8.83	8.65	8.67	8.70	8.50	8.53	8.51	8.51
2063	8.64	8.60	8.58	8.67	8.77	8.60	8.62	8.65	8.51	8.55	8.47	8.47
2064	8.56	8.68	8.66	8.74	8.84	8.68	8.70	8.73	8.60	8.64	8.55	8.55
2065	9.11	8.99	8.97	9.06	9.15	9.00	9.01	9.04	8.90	8.93	8.87	8.87
2066	8.74	8.73	8.71	8.78	8.87	8.73	8.74	8.77	8.64	8.67	8.61	8.61
2067	8.53	8.17	8.16	8.22	8.30	8.18	8.19	8.21	8.11	8.14	8.08	8.07
Total Loads	1718.29	1704.64	1671.62	1812.84	1967.09	1713.81	1736.28	1765.13	1561.85	1605.17	1602.95	1597.75

401647

Table RE2
Tri+ PCB Load Over Northumberland Dam

Year	Two Step Upstream Boundary Assumption (0.16 kg/day>0.0256 kg/day)											
	r13s2 (3/10/Hot Spots 36 & 37)	r14 (REM-3/10/S + Channel)	r14sn0 (REM-3/10/S + channel, assumes residual of 0 ppm)	r14sn2 (REM-3/10/S + channel, assumes max residual of 2 ppm)	r14sn5 (REM-3/10/S + channel, assumes max residual of 5 ppm)	r15a (CAP-3/10/Select Areas, assumes 10% deffective cap)	r15sn15 (CAP-3/10/S + channel, assumes 15% deffective cap)	r15sn25 (CAP-3/10/S + channel, assumes 25% deffective cap)	r16 (REM-0/0/3 + channel)	r17 (CAP-0/10/36-37)	r18 (CAP-0/10/mna)	r19 (CAP-0/mna/mna)
1998	274.41	274.41	274.41	274.41	274.41	274.41	274.41	274.41	274.41	274.41	274.41	274.41
1999	126.60	126.60	126.60	126.60	126.60	126.60	126.60	126.60	126.60	126.60	126.60	126.60
2000	151.91	151.91	151.91	151.91	151.91	151.91	151.91	151.91	151.91	151.91	151.91	151.91
2001	180.36	180.36	180.36	180.36	180.36	180.36	180.36	180.36	180.36	180.36	180.36	180.36
2002	122.72	122.72	122.72	122.72	122.72	122.72	122.72	122.72	122.72	122.72	122.72	122.72
2003	122.88	122.88	122.88	122.88	122.88	122.88	122.88	122.88	122.88	122.88	122.88	122.88
2004	96.47	96.24	95.99	97.10	98.41	96.29	96.50	96.69	96.04	96.62	96.62	96.44
2005	57.14	57.51	56.47	60.95	66.28	57.78	58.56	59.29	55.48	58.46	58.46	57.77
2006	51.40	57.01	54.93	63.87	74.07	57.64	59.10	60.46	50.06	57.77	57.70	56.29
2007	35.90	51.14	48.34	61.34	75.38	52.43	54.31	56.63	46.65	56.29	55.68	54.14
2008	23.64	22.75	20.87	29.60	38.66	23.78	25.04	26.47	20.53	22.45	21.84	23.63
2009	23.28	22.44	20.59	29.33	38.60	23.54	24.80	26.34	18.86	17.57	17.54	24.28
2010	32.87	31.78	28.93	43.04	58.87	33.90	35.95	38.80	19.27	24.44	24.39	40.92
2011	28.15	27.24	24.89	36.58	49.79	29.07	30.78	33.28	16.91	21.34	21.30	35.51
2012	25.60	24.72	22.70	32.42	43.25	26.12	27.56	29.70	15.77	19.22	19.18	29.18
2013	25.79	24.92	22.91	32.52	43.32	26.34	27.79	30.01	15.78	19.32	19.29	29.89
2014	21.21	20.50	19.01	25.88	33.44	21.39	22.44	23.88	13.75	16.01	15.98	21.79
2015	20.18	19.51	18.15	24.43	31.35	20.33	21.30	22.62	13.26	15.34	15.32	20.71
2016	15.96	15.46	14.49	18.88	23.65	16.01	16.69	17.53	11.08	12.47	12.46	15.76
2017	15.04	14.59	13.74	17.56	21.69	15.05	15.65	16.36	10.75	11.94	11.92	14.59
2018	17.52	17.03	15.95	21.13	27.04	17.86	18.67	19.94	11.89	13.95	13.93	20.17
2019	14.04	13.67	12.92	16.36	20.16	14.12	14.66	15.36	10.14	11.31	11.30	14.17
2020	15.54	15.15	14.33	18.12	22.36	15.63	16.23	17.01	11.13	12.41	12.39	15.49
2021	14.63	14.29	13.54	17.00	20.89	14.74	15.29	16.03	10.64	11.84	11.82	14.84
2022	12.50	12.23	11.68	14.16	16.92	12.51	12.91	13.39	9.57	10.35	10.34	12.01
2023	11.84	11.60	11.12	13.28	15.67	11.84	12.19	12.60	9.27	9.93	9.92	11.26
2024	15.03	14.71	14.00	17.34	21.19	15.17	15.71	16.50	11.14	12.34	12.33	15.60
2025	12.50	12.26	11.75	14.06	16.68	12.54	12.91	13.40	9.73	10.48	10.47	12.30
2026	12.69	12.46	11.95	14.26	16.91	12.75	13.12	13.65	9.92	10.70	10.69	12.68
2027	11.16	10.97	10.59	12.30	14.22	11.16	11.44	11.81	9.06	9.59	9.58	10.72
2028	11.94	11.73	11.32	13.19	15.33	11.95	12.26	12.71	9.62	10.22	10.21	11.61
2029	11.74	11.55	11.17	12.90	14.88	11.76	12.04	12.45	9.58	10.13	10.13	11.44
2030	11.51	11.34	10.99	12.54	14.32	11.51	11.77	12.13	9.55	10.02	10.02	11.10
2031	12.47	12.28	11.87	13.76	15.97	12.53	12.84	13.40	10.13	10.81	10.80	12.63
2032	11.30	11.15	10.83	12.27	13.94	11.32	11.56	11.95	9.48	9.96	9.96	11.11
2033	10.63	10.50	10.24	11.45	12.85	10.64	10.84	11.15	9.09	9.47	9.47	10.35
2034	11.14	11.01	10.74	11.92	13.29	11.13	11.33	11.61	9.58	9.94	9.93	10.69
2035	11.02	10.89	10.63	11.79	13.15	11.01	11.21	11.50	9.48	9.83	9.83	10.59
2036	11.06	10.94	10.69	11.83	13.16	11.07	11.26	11.62	9.57	9.95	9.95	10.78
2037	10.79	10.69	10.45	11.48	12.70	10.80	10.97	11.44	9.43	9.81	9.80	10.53
2038	9.81	9.72	9.55	10.31	11.19	9.79	9.92	10.19	8.77	9.01	9.01	9.41
2039	11.39	11.28	11.05	12.06	13.26	11.40	11.57	12.10	10.02	10.41	10.41	11.16
2040	9.63	9.56	9.41	10.06	10.82	9.62	9.73	10.01	8.74	8.96	8.96	9.35
2041	9.63	9.57	9.43	10.01	10.68	9.62	9.72	9.90	8.81	8.98	8.98	9.25
2042	8.37	8.32	8.22	8.64	9.12	8.36	8.43	8.54	7.79	7.90	7.90	8.08
2043	11.09	11.01	10.84	11.59	12.49	11.09	11.22	11.59	10.04	10.32	10.31	10.86
2044	10.58	10.51	10.35	11.00	11.78	10.57	10.68	11.03	9.66	9.90	9.90	10.36
2045	9.90	9.84	9.71	10.27	10.93	9.90	9.99	10.30	9.11	9.32	9.32	9.70
2046	9.43	9.38	9.29	9.70	10.20	9.42	9.49	9.64	8.82	8.94	8.94	9.16
2047	9.22	9.17	9.08	9.47	9.95	9.21	9.28	9.45	8.64	8.77	8.77	9.01
2048	9.25	9.21	9.12	9.48	9.92	9.25	9.31	9.55	8.70	8.84	8.84	9.07
2049	8.73	8.70	8.62	8.92	9.28	8.73	8.78	8.95	8.27	8.38	8.38	8.57
2050	9.71	9.68	9.58	9.96	10.41	9.72	9.78	10.03	9.14	9.29	9.28	9.56
2051	9.72	9.69	9.61	9.94	10.34	9.73	9.78	9.99	9.21	9.34	9.34	9.56
2052	8.72	8.70	8.63	8.88	9.18	8.72	8.76	8.89	8.34	8.43	8.43	8.58
2053	8.52	8.50	8.44	8.66	8.93	8.52	8.56	8.67	8.18	8.26	8.26	8.40
2054	8.53	8.51	8.46	8.66	8.91	8.53	8.56	8.67	8.21	8.28	8.28	8.41
2055	9.47	9.45	9.38	9.65	9.96	9.48	9.52	9.66	9.07	9.16	9.16	9.36
2056	7.86	7.85	7.81	7.95	8.12	7.86	7.88	7.93	7.65	7.68	7.68	7.75
2057	8.84	8.82	8.78	8.95	9.15	8.84	8.87	8.93	8.58	8.63	8.63	8.73
2058	8.38	8.36	8.33	8.48	8.67	8.38	8.41	8.46	8.13	8.17	8.17	8.25
2059	8.44	8.43	8.39	8.54	8.71	8.44	8.47	8.52	8.21	8.26	8.26	8.35
2060	9.44	9.42	9.38	9.55	9.77	9.44	9.47	9.55	9.15	9.21	9.21	9.34
2061	10.00	9.98	9.94	10.13	10.36	10.00	10.04	10.12	9.69	9.76	9.76	9.91
2062	8.31	8.30	8.27	8.38	8.52	8.31	8.33	8.37	8.14	8.18	8.16	8.23
2063	8.26	8.24	8.22	8.32	8.45	8.25	8.27	8.31	8.14	8.18	8.11	8.18
2064	8.43	8.42	8.40	8.50	8.62	8.43	8.45	8.49	8.33	8.38	8.30	8.37
2065	8.60	8.59	8.57	8.67	8.78	8.60	8.62	8.65	8.48	8.52	8.47	8.52
2066	8.44	8.43	8.40	8.49	8.60	8.43	8.45	8.48	8.33	8.36	8.31	8.36
2067	7.95	7.94	7.92	8.00	8.09	7.94	7.96	7.99	7.86	7.89	7.83	7.88
Total Loads	1977.22	1984.72	1948.84	2114.70	2300.46	2005.20	2030.87	2067.59	1841.24	1904.88	1902.79	2019.55

Table RE2
Tri+ PCB Load Over Northumberland Dam

Year	Constant Upstream Boundary Assumption (0.16 kg/day)							
	P3NAcw (No Action)	r01cw (0/0/3)	r02cw (0/10/mna)	r03cw (0/mna/mna)	r04cw (3/10/10)	r05cw (3/mna/mna)	r06cw (0/10/10)	r07cw (10/mna/mna)
1998	274.41	274.41	274.41	274.41	274.41	274.41	274.41	274.41
1999	126.60	126.60	126.60	126.60	126.60	126.60	126.60	126.60
2000	151.83	151.91	151.91	151.91	151.91	151.91	151.91	151.91
2001	180.14	180.36	180.36	180.36	180.36	180.36	180.36	180.36
2002	122.98	122.72	122.72	122.72	122.72	122.72	122.72	122.72
2003	122.41	122.88	122.88	122.88	122.88	122.88	122.88	122.88
2004	99.18	96.05	96.49	96.05	96.67	96.91	96.31	97.15
2005	104.70	93.12	95.18	93.12	95.97	97.11	94.46	98.06
2006	117.06	89.88	95.41	89.88	95.89	98.75	93.92	103.02
2007	123.60	85.46	92.96	86.90	85.48	97.81	91.30	108.74
2008	81.71	56.71	56.93	58.96	60.35	66.92	56.39	73.79
2009	83.37	55.69	52.90	60.50	60.84	68.29	52.87	75.07
2010	117.75	61.46	64.41	82.96	76.68	94.82	64.36	104.98
2011	105.32	57.75	60.23	76.11	70.26	85.82	60.19	94.19
2012	97.04	57.67	59.52	70.64	68.51	79.45	59.48	87.04
2013	99.41	59.01	60.89	72.65	69.99	81.56	60.85	89.19
2014	84.44	56.40	57.54	63.96	64.54	70.88	57.51	76.80
2015	82.00	56.22	57.26	63.21	63.73	69.61	57.24	75.08
2016	67.34	50.07	50.77	54.39	55.36	58.97	50.75	62.89
2017	65.55	50.54	51.12	54.05	55.18	58.09	51.11	61.55
2018	76.82	53.54	54.61	61.46	59.61	66.39	54.60	70.61
2019	63.03	48.91	49.48	52.64	53.09	56.23	49.47	59.29
2020	69.66	53.94	54.54	57.96	58.68	62.07	54.53	65.52
2021	67.07	52.54	53.09	56.44	56.81	60.13	53.08	63.22
2022	59.54	49.58	49.92	51.76	52.71	54.55	49.91	56.86
2023	57.70	49.08	49.36	50.84	51.82	53.30	49.35	55.36
2024	71.54	56.70	57.25	60.85	60.84	64.42	57.24	67.38
2025	61.48	51.77	52.10	54.10	54.72	56.71	52.09	58.88
2026	63.03	53.07	53.41	55.59	56.02	58.19	53.40	60.33
2027	57.11	49.90	50.11	51.37	52.14	53.39	50.11	55.05
2028	60.97	52.87	53.11	54.65	55.34	56.87	53.11	58.69
2029	60.71	53.24	53.46	54.90	55.53	56.96	53.46	58.65
2030	60.41	53.68	53.86	55.05	55.77	56.95	53.86	58.49
2031	65.11	56.19	56.47	58.47	58.68	60.66	56.47	62.44
2032	60.38	53.82	54.01	55.27	55.75	57.00	54.00	58.41
2033	57.61	52.21	52.36	53.32	53.85	54.81	52.36	56.02
2034	60.54	55.40	55.53	56.36	57.05	57.88	55.53	59.09
2035	60.02	54.82	54.95	55.78	56.45	57.29	54.94	58.48
2036	60.93	55.50	55.64	56.54	57.08	57.99	55.63	59.14
2037	60.42	54.97	55.09	55.88	56.42	57.21	55.08	58.29
2038	55.55	51.87	51.94	52.38	52.97	53.42	51.94	54.25
2039	64.40	58.73	58.85	59.67	60.18	61.00	58.84	62.09
2040	55.44	52.13	52.19	52.61	53.07	53.50	52.19	54.21
2041	55.60	52.86	52.90	5[illegible].20	53.73	54.03	52.90	54.67
2042	48.92	47.07	47.10	47.29	47.69	47.89	47.10	48.35
2043	63.96	59.83	59.91	60.51	60.95	61.55	59.91	62.37
2044	61.51	57.83	57.89	58.39	58.81	59.30	57.89	60.02
2045	57.97	54.77	54.82	55.24	55.61	56.03	54.82	56.65
2046	55.50	53.45	53.49	53.72	54.11	54.35	53.49	54.82
2047	54.58	52.37	52.41	52.67	52.99	53.25	52.41	53.70
2048	55.60	52.43	52.46	52.71	53.00	53.25	52.46	53.69
2049	52.68	50.13	50.15	50.35	50.60	50.80	50.15	51.16
2050	58.50	55.04	55.08	55.37	55.63	55.93	55.08	56.39
2051	58.78	55.76	55.80	56.03	56.29	56.53	55.80	56.93
2052	52.79	50.87	50.89	51.05	51.26	51.43	50.89	51.73
2053	51.72	49.99	50.01	50.16	50.34	50.50	50.01	50.76
2054	51.88	50.24	50.26	50.41	50.58	50.72	50.26	50.97
2055	57.40	55.30	55.32	55.54	55.72	55.94	55.32	56.25
2056	47.94	47.15	47.16	47.23	47.38	47.45	47.16	47.62
2057	53.88	52.80	52.82	52.92	53.08	53.19	52.82	53.39
2058	51.09	50.08	50.09	50.16	50.34	50.42	50.09	50.61
2059	51.60	50.63	50.64	50.74	50.87	50.97	50.64	51.14
2060	57.65	56.30	56.31	56.45	56.59	56.74	56.31	56.95
2061	61.01	59.59	59.61	59.77	59.92	60.08	59.61	60.31
2062	50.95	50.23	50.23	50.30	50.42	50.50	50.23	50.63
2063	50.67	50.00	50.00	50.07	50.18	50.25	50.00	50.38
2064	51.79	51.15	51.16	51.23	51.33	51.40	51.16	51.53
2065	52.90	52.31	52.31	52.37	52.48	52.54	52.31	52.65
2066	51.88	51.33	51.34	51.39	51.49	51.55	51.34	51.66
2067	49.04	48.41	48.41	48.46	48.55	48.60	48.41	48.70
Total Loads	5204.08	4547.24	4580.41	4699.88	4712.85	4865.98	4575.37	5001.23

Table RE3
Tri+ PCB Load Over Federal Dam

Year	Two Step Upstream Boundary Assumption (0.16 kg/day>0.0256 kg/day)												
	P3NAs2 (No Action)	r01s2 (0/0/3)	r02s2 (0/10/mna)	r03s2 (0/mna/mna)	r04s2 (3/10/10)	r05s2 (3/mna/mna)	r06s2 (0/10/10)	r07s2 (10/mna/mna)	r08s2 (0/0/3)	r09s2 (3/10/10)	r10s2 (10/mna/mna)	r11s2 (3 plus channel/10/ Hot Spots 36 & 37)	r12s2 (0/10/Hot Spots 36 & 37)
1998	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29
1999	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67
2000	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50
2001	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73
2002	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85
2003	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51
2004	95.66	94.56	94.75	94.56	94.83	94.93	94.67	95.04	94.61	94.78	95.04	94.78	94.72
2005	92.33	86.27	87.33	86.27	87.75	88.37	86.95	88.87	86.48	87.60	88.87	87.61	87.46
2006	105.04	88.73	92.05	88.73	92.50	94.19	91.14	96.28	89.01	92.32	96.28	92.48	92.13
2007	103.76	78.57	83.84	79.41	77.33	86.49	82.71	93.24	78.65	77.06	93.24	80.99	84.36
2008	50.58	37.62	38.13	38.54	38.79	42.69	37.59	46.16	37.64	38.61	46.16	37.54	38.43
2009	46.87	32.01	30.74	34.15	33.56	38.40	30.16	42.03	32.02	33.39	42.03	31.73	30.69
2010	93.72	49.28	52.04	64.96	59.38	74.65	50.99	82.84	49.36	59.07	82.84	55.29	51.36
2011	71.76	33.65	36.35	48.24	42.61	55.95	35.71	62.52	33.70	42.36	62.52	39.28	35.96
2012	65.69	31.88	34.14	42.89	40.37	50.41	33.56	56.83	31.93	40.13	56.83	37.08	33.78
2013	67.45	31.79	34.09	43.78	40.97	51.64	33.66	58.34	31.87	40.74	58.34	37.36	33.75
2014	49.22	24.41	25.85	31.30	31.28	37.35	25.59	42.52	24.47	31.11	42.52	28.44	25.64
2015	45.07	21.85	23.14	28.28	28.34	33.99	22.93	38.85	21.91	28.18	38.85	25.67	22.99
2016	26.72	13.93	14.65	17.29	17.63	20.57	14.53	23.37	13.96	17.53	23.37	16.07	14.55
2017	24.65	13.10	13.73	15.93	16.55	19.01	13.62	21.64	13.12	16.45	21.64	15.07	13.64
2018	33.48	14.18	15.25	20.91	19.02	24.94	15.14	28.39	14.23	18.94	28.39	17.17	15.22
2019	22.19	11.16	11.75	14.22	14.31	16.98	11.66	19.32	11.19	14.23	19.32	13.01	11.70
2020	28.54	13.69	14.41	17.59	18.02	21.42	14.31	24.66	13.74	17.93	24.66	16.25	14.38
2021	26.06	12.43	13.08	16.22	16.30	19.61	13.00	22.48	12.47	16.23	22.48	14.74	13.07
2022	18.27	9.65	10.05	11.72	12.26	14.06	9.99	16.03	9.67	12.20	16.03	11.17	10.03
2023	16.65	9.08	9.42	10.81	11.41	12.91	9.37	14.69	9.10	11.36	14.69	10.44	9.40
2024	29.43	13.95	14.65	18.25	18.26	22.03	14.56	25.21	14.01	18.20	25.21	16.59	14.67
2025	19.57	10.07	10.48	12.50	12.87	14.99	10.42	17.07	10.10	12.81	17.07	11.75	10.49
2026	19.36	9.86	10.27	12.37	12.62	14.81	10.22	16.86	9.90	12.57	16.86	11.54	10.29
2027	14.99	8.40	8.68	9.91	10.42	11.73	8.63	13.26	8.43	10.38	13.26	9.61	8.68
2028	17.76	9.66	9.99	11.55	12.10	13.75	9.94	15.58	9.70	12.06	15.58	11.14	10.00
2029	17.24	9.62	9.92	11.39	11.92	13.47	9.87	15.20	9.65	11.88	15.20	11.02	9.93
2030	15.92	9.26	9.52	10.76	11.32	12.62	9.47	14.17	9.29	11.28	14.17	10.51	9.54
2031	18.57	9.93	10.27	12.19	12.34	14.32	10.23	16.08	9.98	12.31	16.08	11.44	10.31
2032	15.28	8.81	9.06	10.35	10.69	12.04	9.02	13.43	8.85	10.66	13.43	9.98	9.08
2033	13.31	8.04	8.24	9.24	9.62	10.67	8.20	11.84	8.07	9.59	11.84	9.02	8.26
2034	15.36	9.71	9.92	10.89	11.49	12.52	9.87	13.84	9.75	11.46	13.84	10.81	9.93
2035	23.52	18.12	18.43	19.48	20.03	20.92	18.39	22.22	18.16	20.01	22.22	19.26	18.40
2036	33.27	27.44	27.78	28.75	29.21	30.27	27.74	31.48	27.48	29.19	31.48	28.62	27.80
2037	29.50	23.83	24.13	24.97	25.43	26.36	24.08	27.48	23.87	25.41	27.48	24.89	24.14
2038	20.71	17.08	17.27	17.75	18.21	18.75	17.24	19.55	17.11	18.20	19.55	17.82	17.28
2039	27.07	21.23	21.50	22.35	22.83	23.76	21.46	24.90	21.28	22.81	24.90	22.29	21.52
2040	16.38	13.14	13.29	13.73	14.08	14.57	13.26	15.24	13.17	14.07	15.24	13.76	13.30
2041	15.01	12.34	13.42	13.74	14.14	14.44	13.39	15.12	12.36	14.12	15.12	13.85	12.48
2042	10.43	8.79	10.31	10.51	10.77	11.01	10.28	11.40	8.81	10.76	11.40	10.58	8.88
2043	19.45	15.19	17.22	17.83	18.26	18.94	17.18	19.80	15.23	18.24	19.80	17.84	15.38
2044	19.84	15.32	15.27	15.78	16.17	16.75	15.23	17.50	15.36	16.16	17.50	15.71	15.48
2045	15.60	12.54	12.10	12.50	12.79	13.24	12.07	13.82	12.57	12.78	13.82	12.35	12.66
2046	14.17	12.01	11.57	11.83	12.16	12.47	11.54	12.95	12.03	12.15	12.95	11.78	12.10
2047	11.96	9.93	9.63	9.89	10.13	10.43	9.60	10.85	9.95	10.13	10.85	9.83	10.01
2048	12.25	9.49	9.25	9.49	9.72	10.00	9.22	10.41	9.54	9.76	10.41	9.48	9.60
2049	10.37	8.25	8.08	8.27	8.45	8.67	8.05	8.99	8.29	8.48	8.99	8.26	8.34
2050	12.84	9.76	9.60	9.89	10.10	10.42	9.57	10.86	9.83	10.15	10.86	9.89	9.89
2051	13.43	10.49	10.35	10.60	10.83	11.13	10.31	11.55	10.56	10.88	11.55	10.62	10.62
2052	9.22	7.49	7.42	7.58	7.73	7.92	7.39	8.20	7.53	7.76	8.20	7.60	7.57
2053	8.51	7.01	6.96	7.11	7.24	7.41	6.94	7.64	7.04	7.26	7.64	7.12	7.08
2054	8.60	7.17	7.14	7.28	7.40	7.57	7.12	7.80	7.20	7.42	7.80	7.30	7.23
2055	10.69	8.70	8.69	8.89	9.04	9.28	8.66	9.59	8.74	9.07	9.59	8.91	8.79
2056	6.69	5.98	5.97	6.04	6.14	6.23	5.95	6.38	5.99	6.14	6.38	6.06	6.01
2057	9.01	7.92	7.93	8.04	8.16	8.31	7.90	8.51	7.95	8.18	8.51	8.07	7.98
2058	8.15	7.23	7.25	7.33	7.46	7.58	7.22	7.77	7.25	7.47	7.77	7.37	7.28
2059	8.13	7.21	7.23	7.33	7.43	7.55	7.20	7.72	7.23	7.44	7.72	7.35	7.26
2060	10.63	9.28	9.32	9.46	9.58	9.77	9.28	10.00	9.31	9.60	10.00	9.49	9.35
2061	11.41	10.00	10.05	10.21	10.34	10.54	10.01	10.79	10.03	10.35	10.79	10.24	10.08
2062	7.46	6.78	6.81	6.88	6.96	7.06	6.78	7.19	6.80	6.96	7.19	6.90	6.82
2063	7.27	6.67	6.69	6.76	6.83	6.92	6.66	7.04	6.71	6.83	7.04	6.78	6.73
2064	7.32	6.74	6.76	6.83	6.89	6.99	6.74	7.10	6.79	6.90	7.10	6.84	6.81
2065	7.56	7.06	7.09	7.14	7.21	7.30	7.06	7.41	7.09	7.21	7.41	7.16	7.11
2066	7.59	7.10	7.13	7.19	7.26	7.34	7.11	7.45	7.14	7.26	7.45	7.21	7.16
2067	6.74	6.32	6.34	6.39	6.44	6.51	6.32	6.60	6.35	6.44	6.60	6.40	6.37
Total Loads	2919.86	2377.28	2412.28	2511.56	2510.80	2646.46	2403.21	2756.47	2380.16	2507.59	2756.47	2461.78	2410.52

Table RE3
Tri+ PCB Load Over Federal Dam

Year	Two Step Upstream Boundary Assumption (0.16 kg/day>0.0256 kg/day)											
	r13s2 (3/10/Hot Spots 36 & 37)	r14 (REM-3/10/S + Channel)	r14sn0 (REM-3/10/S + channel, assumes residual of 0 ppm)	r14sn2 (REM-3/10/S + channel, assumes max residual of 2 ppm)	r14sn5 (REM-3/10/S + channel, assumes max residual of 5 ppm)	r15a (CAP-3/10/Select Areas, assumes 10% deffective cap)	r15sn15 (CAP-3/10/S + channel, assumes 15% deffective cap)	r15sn25 (CAP-3/10/S + channel, assumes 25% deffective cap)	r16 (REM-0/0/3 + channel)	r17 (CAP-0/10/36-37)	r18 (CAP-0/10/mna)	r19 (CAP-0/mna/mna)
1998	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330 29	330.29
1999	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67
2000	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50
2001	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73
2002	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85
2003	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51
2004	94.74	94.64	94.53	95.01	95.58	94.59	94.75	94.76	94.55	94.80	94.80	94.73
2005	86.99	87.13	86.58	88.94	91.75	87.26	87.68	88.07	86.10	87.63	87.63	87.26
2006	89.17	92.37	91.10	96.56	102.88	92.75	93.65	94.50	88.17	92.86	92.83	91.96
2007	68.04	81.37	79.49	88.16	97.71	82.22	83.48	85.08	78.54	85.30	84.97	83.91
2008	36.99	38.63	37.21	42.52	47.38	39.15	40.08	40.84	37.60	39.05	38.76	39.47
2009	32.14	32.88	31.04	37.46	42.83	33.51	34.83	35.72	32.04	31.46	31.59	35.03
2010	57.27	58.16	54.58	68.63	81.86	59.90	62.54	64.90	49.68	53.26	54.33	66.82
2011	41.30	41.65	39.01	50.03	60.98	43.17	45.15	47.22	33.93	37.66	38.31	49.69
2012	39.22	39.37	36.99	46.78	56.41	40.60	42.37	44.25	32.15	35.25	35.84	44.26
2013	39.94	39.61	37.29	47.13	57.19	40.93	42.61	44.59	31.86	35.31	35.89	45.16
2014	30.56	30.15	28.49	35.46	42.56	31.00	32.16	33.46	24.42	26.70	27.08	32.32
2015	27.76	27.32	25.82	32.19	38.79	28.11	29.16	30.37	21.88	23.99	24.29	29.22
2016	17.28	17.01	16.15	19.77	23.47	17.45	18.05	18.69	13.93	15.10	15.28	17.82
2017	16.24	15.97	15.19	18.48	21.86	16.35	16.90	17.47	13.10	14.14	14.29	16.41
2018	18.77	18.42	17.40	22.07	27.18	19.15	19.90	20.99	14.24	16.09	16.24	21.61
2019	14.10	13.86	13.19	16.12	19.23	14.24	14.72	15.28	11.18	12.20	12.30	14.66
2020	17.80	17.46	16.58	20.46	24.62	17.94	18.57	19.33	13.74	15.06	15.16	18.19
2021	16.12	15.83	15.05	18.52	22.31	16.28	16.84	17.55	12.48	13.70	13.79	16.75
2022	12.12	11.91	11.39	13.68	16.15	12.18	12.56	12.99	9.67	10.43	10.49	12.08
2023	11.29	11.10	10.64	12.67	14.85	11.33	11.67	12.04	9.10	9.75	9.80	11.12
2024	18.12	17.80	16.97	20.74	24.95	18.30	18 91	19.75	14.03	15.38	15.46	18.86
2025	12.77	12.55	12.02	14.40	17.05	12.85	13.23	13.72	10.11	10.92	10.97	12.88
2026	12.53	12.32	11.81	14.14	16.75	12.62	13.00	13.50	9.91	10.72	10.76	12.74
2027	10.34	10.18	9.81	11.48	13.33	10.38	10.65	11.00	8.43	8.98	9.02	10.19
2028	12.03	11.84	11.39	13.39	15.61	12.08	12.40	12.84	9.71	10.37	10.41	11.89
2029	11.86	11.68	11.26	13.13	15.22	11.90	12.20	12.62	9.66	10.28	10.31	11.71
2030	11.26	11.10	10.73	12.37	14.22	11.29	11.56	11.92	9.30	9.83	9.87	11.04
2031	12.29	12.11	11.69	13.63	15.87	12.37	12.69	13.23	10.00	10.70	10.73	12.54
2032	10.65	10.51	10.18	11.67	13.39	10.69	10.94	11.33	8.86	9.38	9.40	10.63
2033	9.58	9.46	9.19	10.43	11.85	9.61	9.81	10.12	8.08	8.50	8.52	9.47
2034	11.44	11.31	11.01	12.37	13.92	11.46	11.69	12.00	9.75	10.19	10.22	11.14
2035	20.00	19.59	19.28	20.66	22.15	19.75	19.97	20.27	17.57	18.64	18.71	19.72
2036	29.18	28.81	28.47	29.97	31.53	28.99	29.22	29.59	26.31	28.06	28.09	29.01
2037	25.40	25.09	24.78	26.12	27.51	25.25	25.46	25.90	22.91	24.41	24.44	25.24
2038	18.18	17.98	17.77	18.68	19.63	18.08	18.22	18.47	16.48	17.45	17.47	17.92
2039	22.80	22.55	22.25	23.53	24.89	22.70	22.90	23.40	20.56	21.80	21.83	22.64
2040	14.05	13.92	13.74	14.48	15.27	14.00	14.12	14.38	12.78	13.45	13.47	13.89
2041	14.11	14.00	13.85	14.50	15.20	14.07	14.17	14.35	12.04	12.60	13.57	13.87
2042	10.75	10.68	10.58	11.00	11.45	10.72	10.79	10.89	8.61	8.95	10.40	10.58
2043	18.23	18.10	17.89	18.79	19.80	18.20	18.34	18.70	14.94	15.58	17.47	18.04
2044	16.04	15.82	15.61	16.50	17.49	15.92	16.06	16.40	15.15	15.66	15.49	15.97
2045	12.61	12.34	12.15	12.94	13.80	12.43	12.55	12.83	12.24	12.79	12.27	12.65
2046	11.99	11.76	11.59	12.26	12.98	11.83	11.93	12.09	11.74	12.19	11 69	11.94
2047	10.01	9.84	9.71	10.25	10.85	9.90	9.98	10.15	9.75	10.09	9.74	9.99
2048	9.66	9.52	9.39	9.88	10.43	9.57	9.65	9.86	9.38	9.69	9.40	9.63
2049	8.40	8.30	8.20	8.58	9.01	8.34	8 40	8.55	8.17	8.41	8.20	8.38
2050	10.08	9.96	9.84	10.32	10.86	10.02	10.10	10.32	9.71	9.99	9.78	10.04
2051	10.80	10.69	10.57	11.04	11.57	10.74	10.82	11 03	10.44	10.71	10.51	10.75
2052	7.71	7.65	7.58	7.87	8.21	7.68	7.73	7.85	7.46	7.62	7.51	7.67
2053	7.22	7.17	7.11	7.36	7.65	7 20	7.24	7 35	6.99	7.12	7.05	7.19
2054	7.39	7.35	7.29	7.53	7.80	7.38	7.42	7.51	7.16	7.28	7.22	7.35
2055	9.04	8.99	8.92	9.22	9.58	9.03	9.08	9.21	8.70	8.85	8.80	9.00
2056	6.12	6.10	6.06	6.21	6.38	6.11	6.14	6.18	5.97	6.04	6.01	6.08
2057	8.15	8.12	8.07	8.28	8.52	8.14	8.18	8.25	7.92	8.02	8.00	8.10
2058	7.45	7 43	7.38	7.56	7.77	7.44	7.47	7.53	7.23	7.31	7.30	7.38
2059	7.42	7.40	7.36	7.52	7.72	7.41	7.44	7.50	7.21	7.29	7.28	7.38
2060	9.57	9.55	9.50	9.72	9.98	9.58	9.62	9.71	9.29	9.40	9.40	9.54
2061	10.33	10.31	10.25	10.49	10.76	10 33	10.38	10.47	10.02	10.12	10.14	10.29
2062	6.95	6.94	6.91	7.04	7.18	6.95	6.98	7.02	6.79	6.85	6.85	6.92
2063	6.82	6.81	6.78	6.90	7.03	6.82	6.84	6.88	6.70	6.76	6.73	6.79
2064	6.88	6.88	6.85	6.96	7.09	6.89	6.91	6.95	6.78	6.84	6.80	6.87
2065	7.20	7.20	7.17	7.28	7.40	7.21	7.23	7.26	7.08	7.14	7.12	7.17
2066	7.24	7.24	7 22	7.32	7.44	7.25	7.27	7.30	7.13	7.19	7.17	7.22
2067	6.43	6.43	6.41	6.49	6.59	6.44	6.45	6.48	6.35	6.40	6.37	6.42
Total Loads	2483.49	2494.78	2458 85	2610.22	2767.83	2512.58	2538.36	2569.31	2372.32	2434.24	2440.16	2541.71

Table RE3
Tri+ PCB Load Over Federal Dam

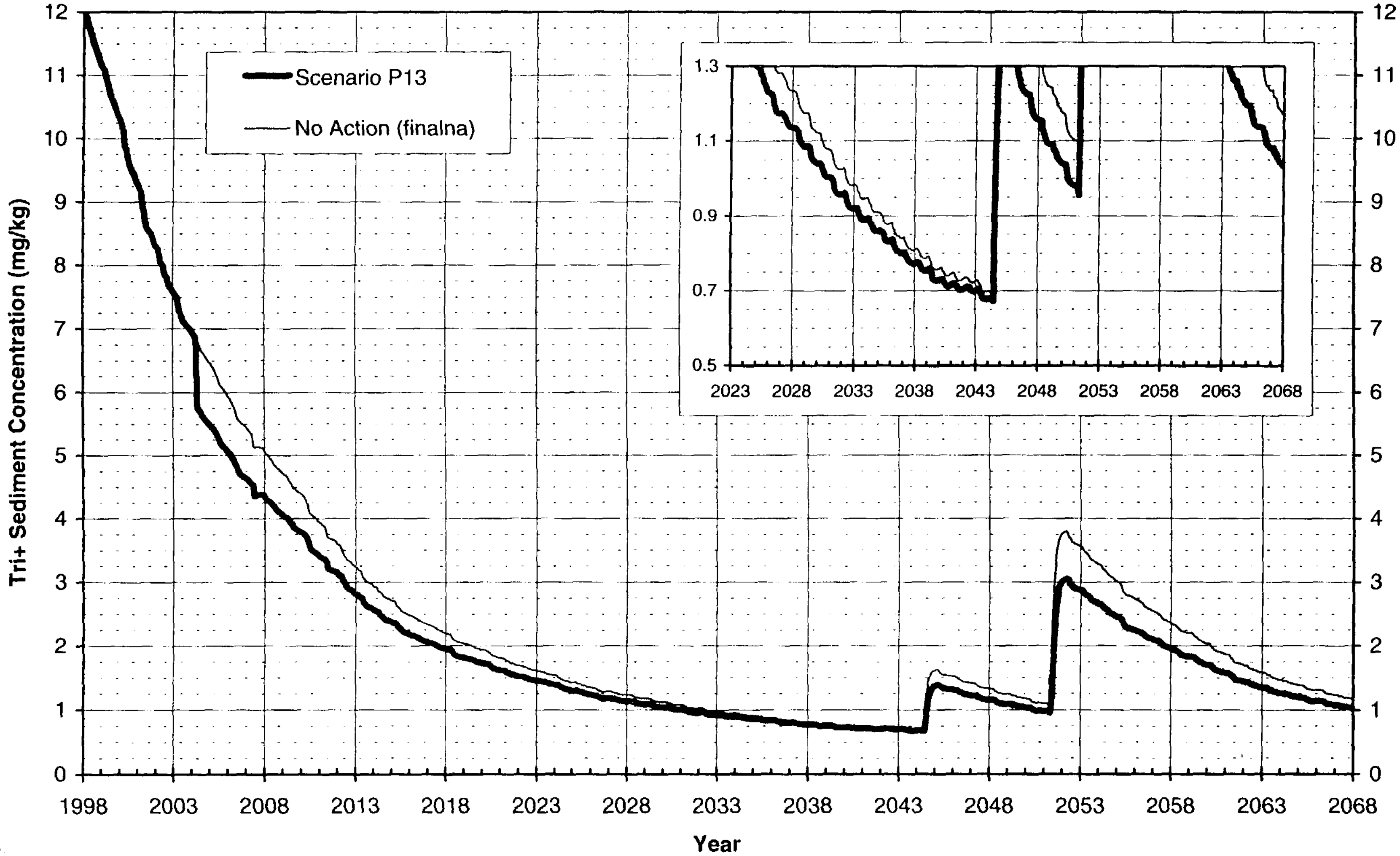
Year	Constant Upstream Boundary Assumption (0.16 kg/day)							
	P3NAcw (No Action)	r01cw (0/0/3)	r02cw (0/10/mna)	r03cw (0/mna/mna)	r04cw (3/10/10)	r05cw (3/mna/mna)	r06cw (0/10/10)	r07cw (10/mna/mna)
1998	330.29	330.29	330.29	330.29	330.29	330.29	330.29	330.29
1999	157.67	157.67	157.67	157.67	157.67	157.67	157.67	157.67
2000	205.50	205.50	205.50	205.50	205.50	205.50	205.50	205.50
2001	236.73	236.73	236.73	236.73	236.73	236.73	236.73	236.73
2002	137.85	137.85	137.85	137.85	137.85	137.85	137.85	137.85
2003	130.51	130.51	130.51	130.51	130.51	130.51	130.51	130.51
2004	95.66	94.56	94.67	94.56	94.83	94.93	94.67	95.04
2005	111.39	105.31	106.37	105.31	106.80	107.42	106.00	107.91
2006	129.01	112.65	115.97	112.65	116.41	118.12	115.06	120.22
2007	128.92	103.51	108.86	104.41	102.03	111.53	107.72	118.35
2008	71.28	58.10	58.65	59.15	59.21	63.33	58.02	66.83
2009	67.57	52.36	51.09	54.74	53.99	59.04	50.35	62.70
2010	131.00	84.99	88.37	102.03	96.04	111.81	87.04	120.08
2011	103.84	64.15	67.63	80.15	74.22	87.93	66.84	94.56
2012	101.03	65.94	68.86	78.06	75.33	85.66	68.15	92.14
2013	104.58	67.79	70.60	80.75	77.76	88.68	70.09	95.44
2014	83.79	58.27	60.03	65.74	65.64	71.86	59.74	77.06
2015	80.29	56.47	58.00	63.38	63.38	69.15	57.77	74.05
2016	52.56	39.43	40.29	43.06	43.36	46.37	40.16	49.19
2017	51.68	39.84	40.59	42.89	43.50	46.00	40.48	48.65
2018	64.02	44.28	45.50	51.36	49.41	55.43	45.38	58.91
2019	48.73	37.44	38.12	40.70	40.76	43.48	38.03	45.84
2020	63.30	48.14	48.96	52.28	52.68	56.14	48.87	59.40
2021	60.01	46.09	46.83	50.08	50.15	53.51	46.75	56.40
2022	47.03	38.23	38.69	40.43	40.96	42.79	38.63	44.77
2023	45.15	37.42	37.81	39.26	39.86	41.38	37.76	43.17
2024	72.84	57.07	57.85	61.58	61.57	65.40	57.76	68.59
2025	53.41	43.74	44.19	46.28	46.64	48.80	44.14	50.90
2026	53.64	43.97	44.41	46.59	46.83	49.06	44.37	51.11
2027	45.34	38.63	38.94	40.22	40.72	42.06	38.89	43.59
2028	53.61	45.38	45.73	47.35	47.90	49.57	45.68	51.41
2029	53.93	46.18	46.51	48.03	48.56	50.14	46.46	51.87
2030	52.09	45.32	45.61	46.89	47.45	48.77	45.56	50.32
2031	58.19	49.43	49.79	51.77	51.91	53.92	49.75	55.69
2032	51.49	44.93	45.20	46.54	46.87	48.24	45.16	49.64
2033	46.98	41.63	41.84	42.88	43.25	44.32	41.81	45.49
2034	56.74	51.00	51.22	52.23	52.83	53.87	51.18	55.20
2035	62.56	57.09	57.41	58.49	59.04	59.94	57.37	61.25
2036	74.58	68.68	69.04	70.04	70.50	71.57	69.00	72.79
2037	69.94	64.21	64.52	65.39	65.84	66.78	64.47	67.91
2038	54.47	50.81	51.01	51.50	51.96	52.50	50.98	53.30
2039	72.67	66.77	67.05	67.93	68.40	69.35	67.01	70.49
2040	49.56	46.29	46.44	46.89	47.24	47.74	46.41	48.41
2041	49.04	46.35	47.33	47.67	48.06	48.38	47.30	49.06
2042	37.54	35.88	37.25	37.45	37.72	37.96	37.23	38.35
2043	67.28	62.98	64.84	65.46	65.89	66.58	64.79	67.44
2044	64.24	59.76	59.73	60.26	60.64	61.23	59.69	61.98
2045	52.70	49.61	49.24	49.66	49.95	50.40	49.22	50.98
2046	52.07	49.88	49.50	49.77	50.10	50.42	49.47	50.90
2047	45.97	43.91	43.66	43.93	44.17	44.47	43.64	44.89
2048	46.61	43.82	43.63	43.88	44.10	44.39	43.60	44.80
2049	41.90	39.75	39.62	39.81	39.99	40.22	39.59	40.54
2050	51.65	48.55	48.43	48.72	48.93	49.26	48.40	49.69
2051	55.90	52.94	52.83	53.08	53.31	53.62	52.79	54.04
2052	41.10	39.35	39.29	39.46	39.61	39.81	39.27	40.08
2053	39.34	37.82	37.79	37.93	38.06	38.24	37.77	38.47
2054	40.70	39.26	39.25	39.39	39.51	39.68	39.22	39.91
2055	50.26	48.24	48.24	48.45	48.60	48.84	48.21	49.15
2056	34.20	33.47	33.48	33.54	33.64	33.74	33.45	33.88
2057	45.82	44.71	44.73	44.84	44.96	45.11	44.70	45.31
2058	41.92	40.98	41.00	41.09	41.22	41.34	40.97	41.52
2059	42.28	41.34	41.36	41.46	41.56	41.69	41.34	41.86
2060	54.58	53.22	53.26	53.41	53.52	53.71	53.22	53.94
2061	59.16	57.73	57.79	57.95	58.07	58.28	57.75	58.53
2062	40.22	39.53	39.56	39.63	39.71	39.81	39.53	39.94
2063	39.55	38.92	38.96	39.02	39.10	39.19	38.93	39.31
2064	40.12	39.52	39.56	39.63	39.68	39.78	39.53	39.90
2065	41.83	41.31	41.35	41.40	41.47	41.56	41.32	41.67
2066	42.20	41.69	41.73	41.79	41.85	41.94	41.71	42.05
2067	37.66	37.22	37.26	37.31	37.35	37.43	37.23	37.52

Total Loads

401652

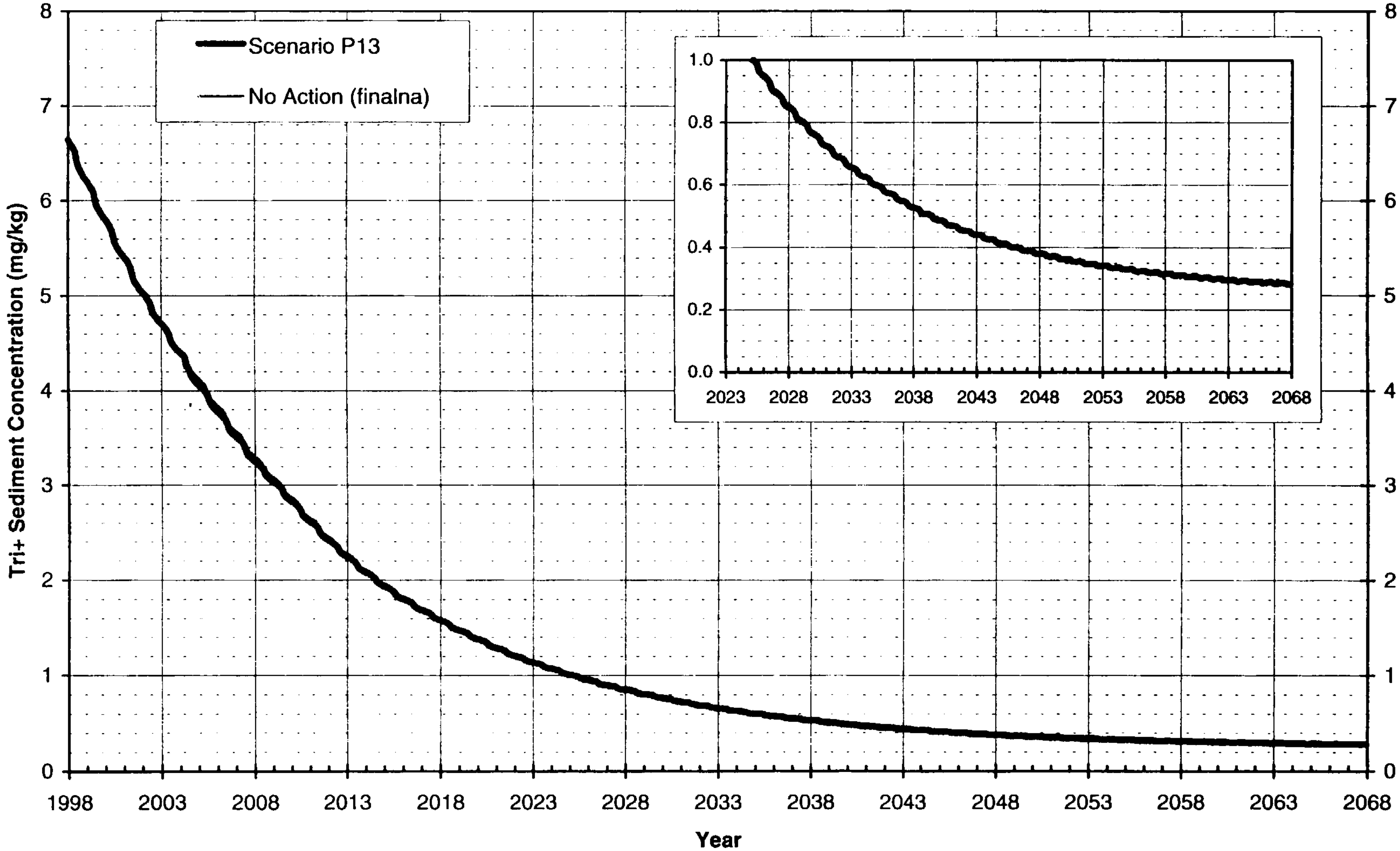
Figure PRE-1
Comparison Between Remediation Scenario P13 and No Action Forecast for TIP Cohesive Surficial Sediment.

Note: This scenario uses 1977 initial sediment



401653

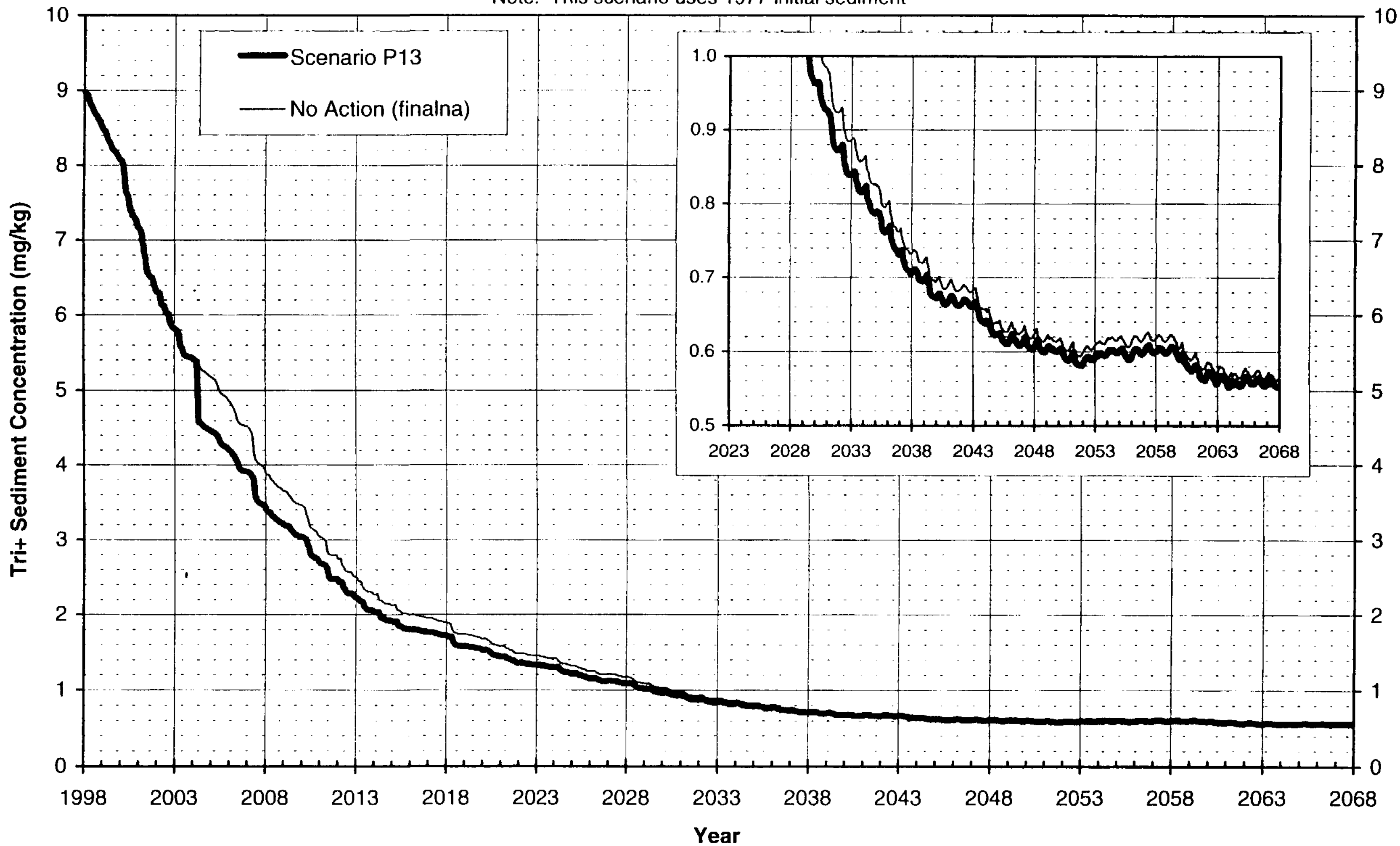
Figure PRE-2
Comparison Between Remediation Scenario P13 and No Action Forecast for
TIP Non-Cohesive Surficial Sediment.
Note: This scenario uses 1977 initial sediment



401654

FigsPre1toPre14 11/16/00

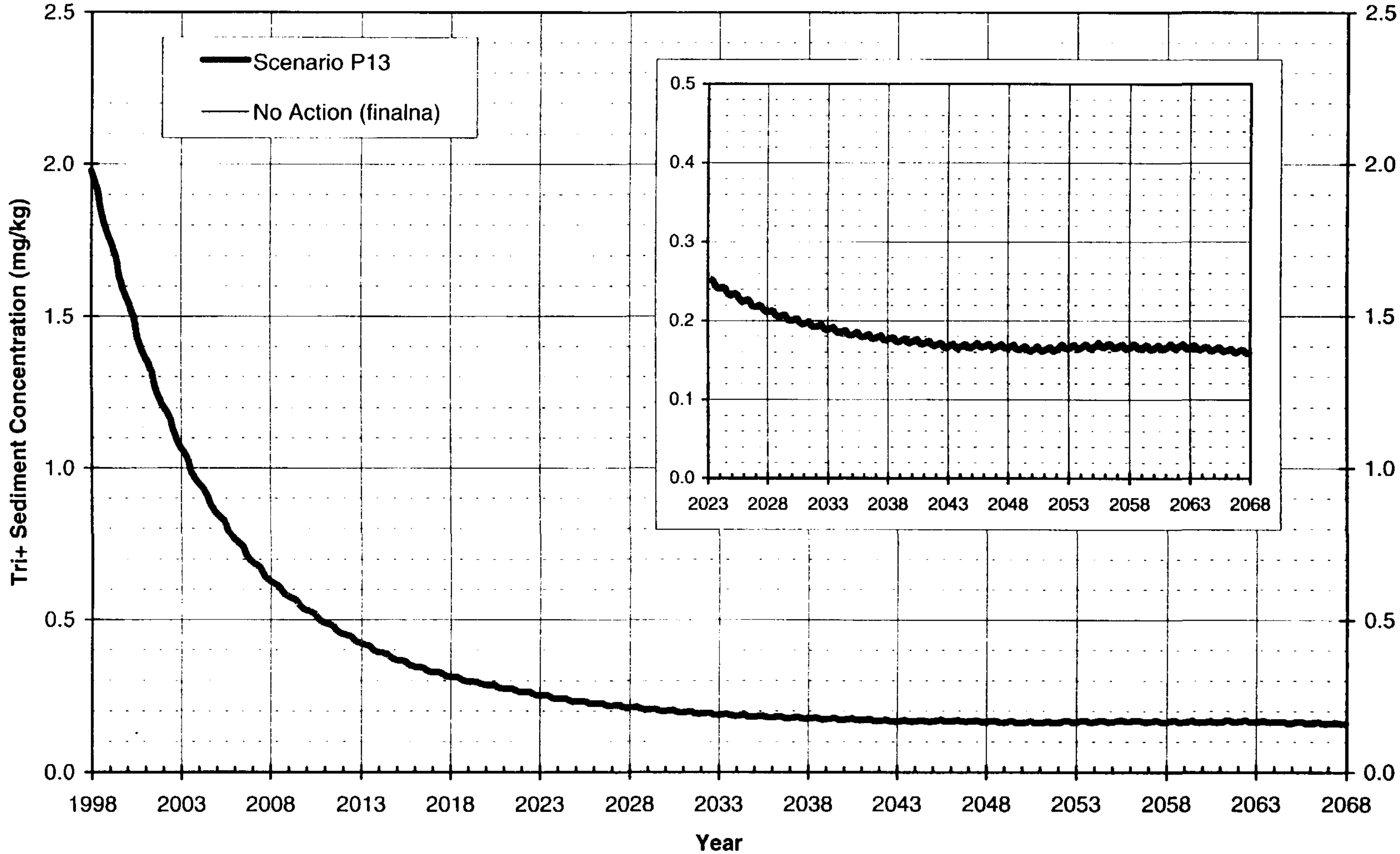
Figure PRE-3
Comparison Between Remediation Scenario P13 and No Action Forecast for Schuylerville Cohesive Surficial Sediment.
Note: This scenario uses 1977 initial sediment



401655

FigsPre1toPre14 11/16/00

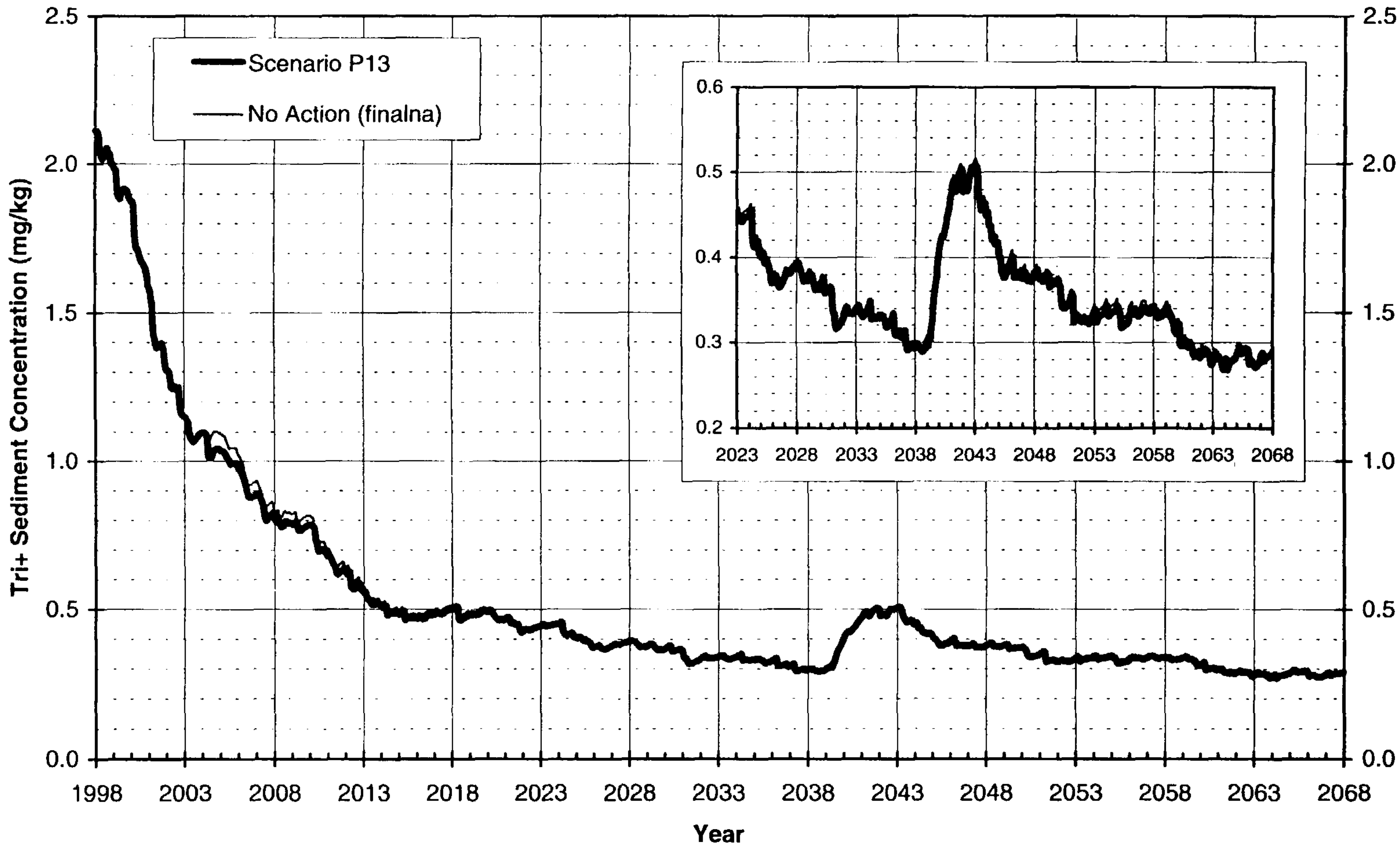
Figure PRE-4
Comparison Between Remediation Scenario P13 and No Action Forecast for Schuylerville Non-Cohesive Surficial Sediment.
Note: This scenario uses 1977 initial sediment



401656

FigsPre1toPre14 11/16/00

Figure PRE-5
Comparison Between Remediation Scenario P13 and No Action Forecast for Stillwater Cohesive Surficial Sediment.
Note: This scenario uses 1977 initial sediment

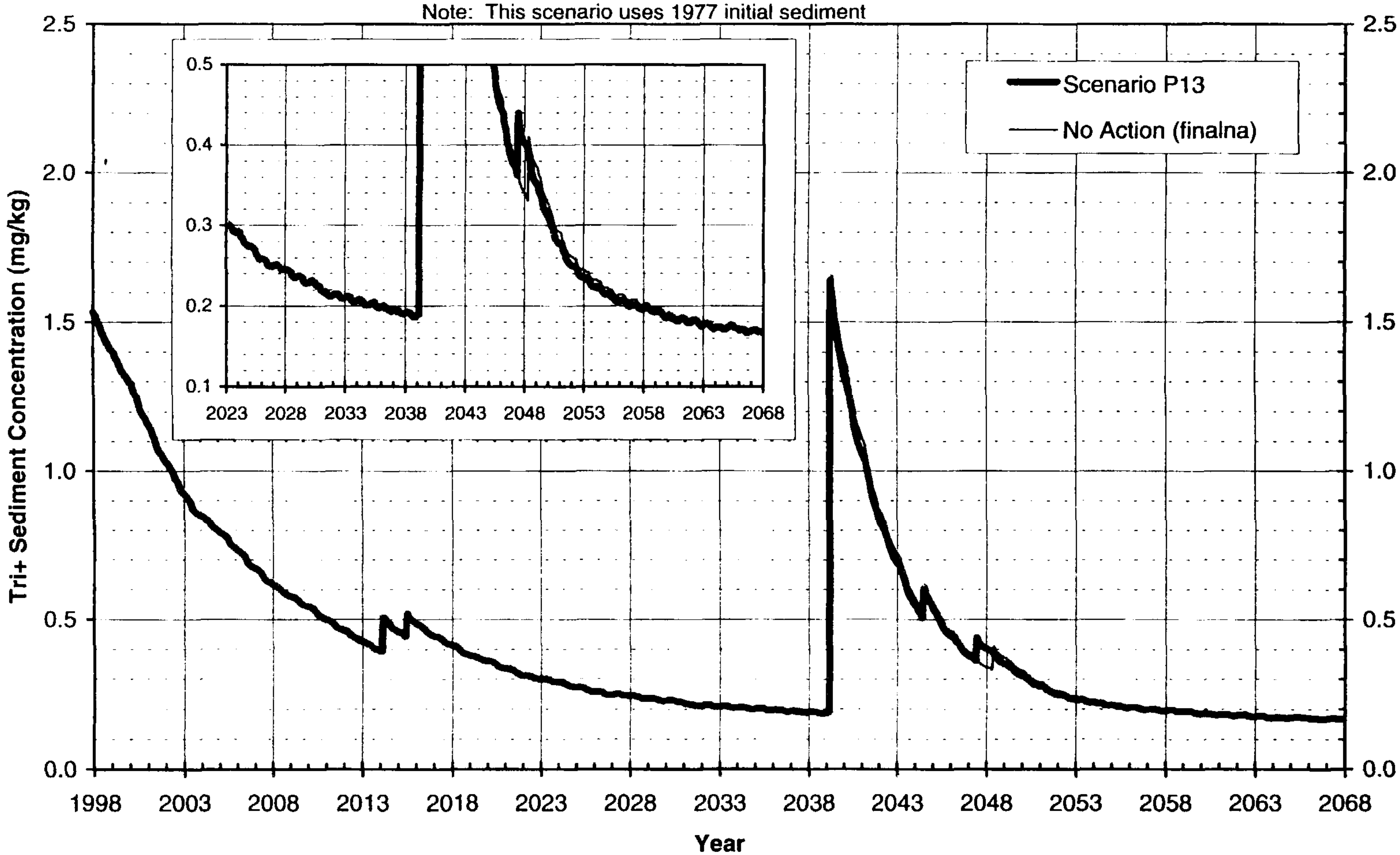


401657

FigsPre1toPre14 11/16/00

Figure PRE-6
Comparison Between Remediation Scenario P13 and No Action Forecast for Stillwater Non-Cohesive Surficial Sediment

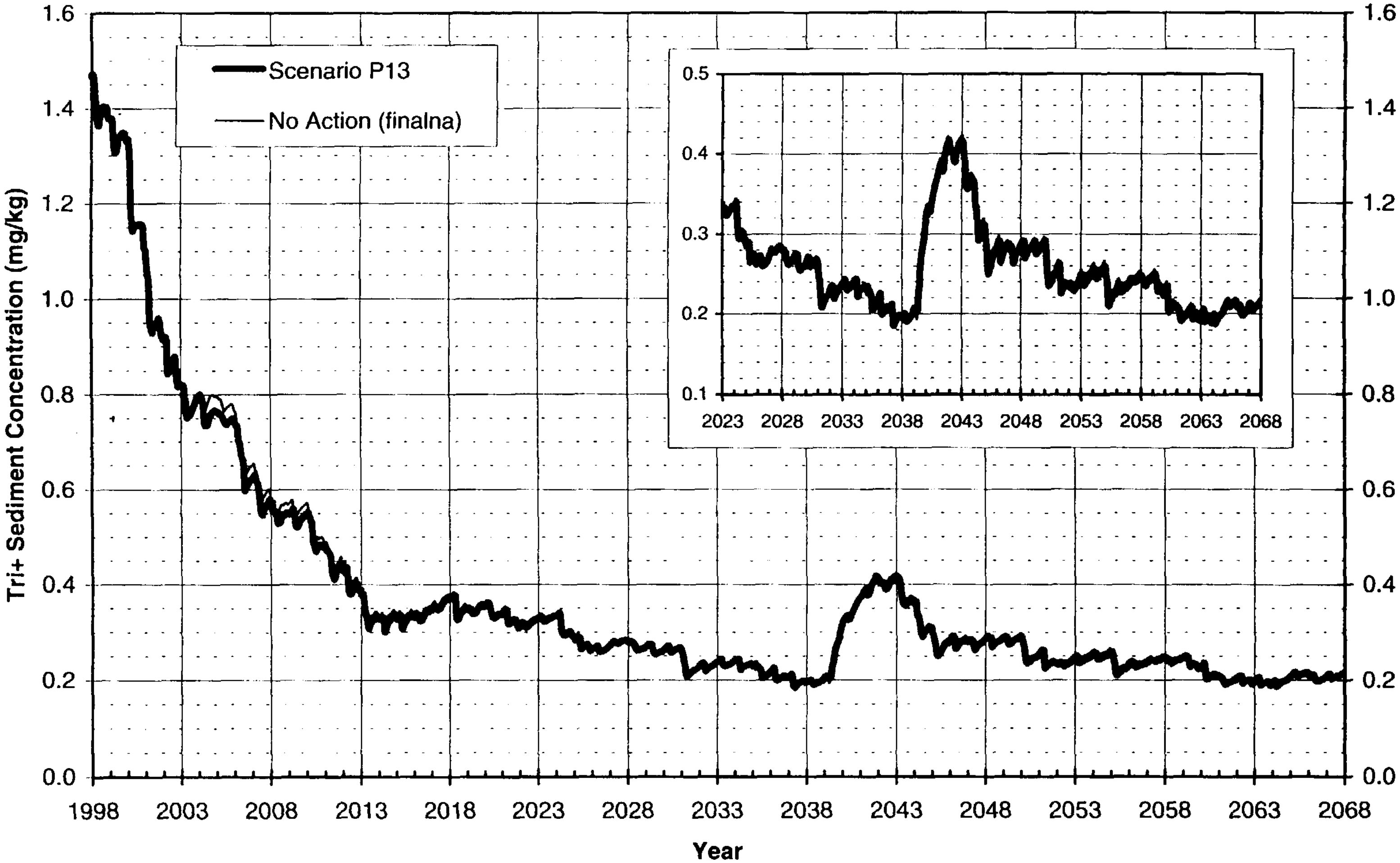
Note: This scenario uses 1977 initial sediment



401658

FigsPre1toPre14 11/16/00

Figure PRE-7
Comparison Between Remediation Scenario P13 and No Action Forecast for Waterford Cohesive Surficial Sediment
Note: This scenario uses 1977 initial sediment

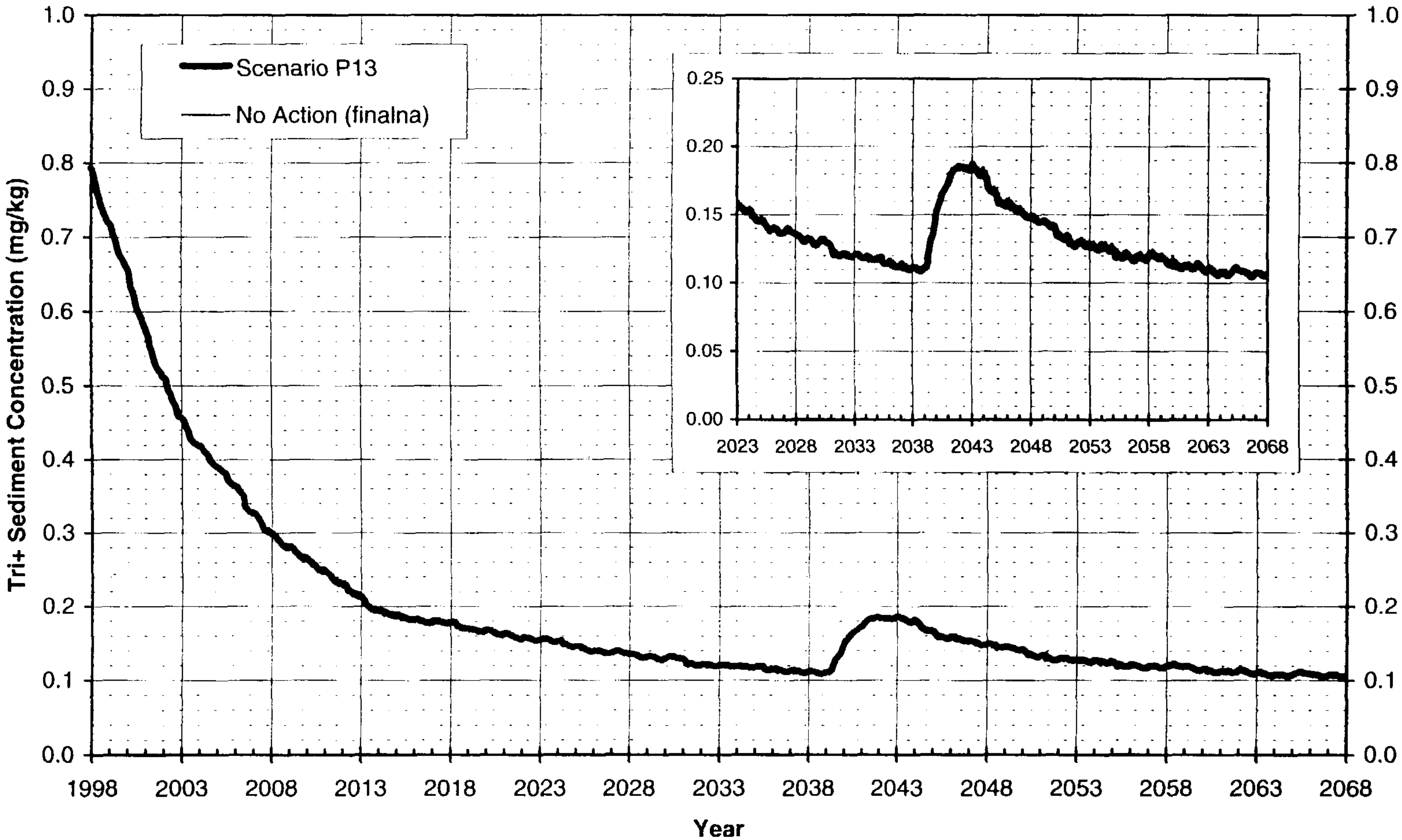


401659

FigsPre1toPre14 11/16/00

Figure PRE-8
Comparison Between Remediation Scenario P13 and No Action Forecast for Waterford Non-Cohesive Surficial Sediment

Note: This scenario uses 1977 initial sediment

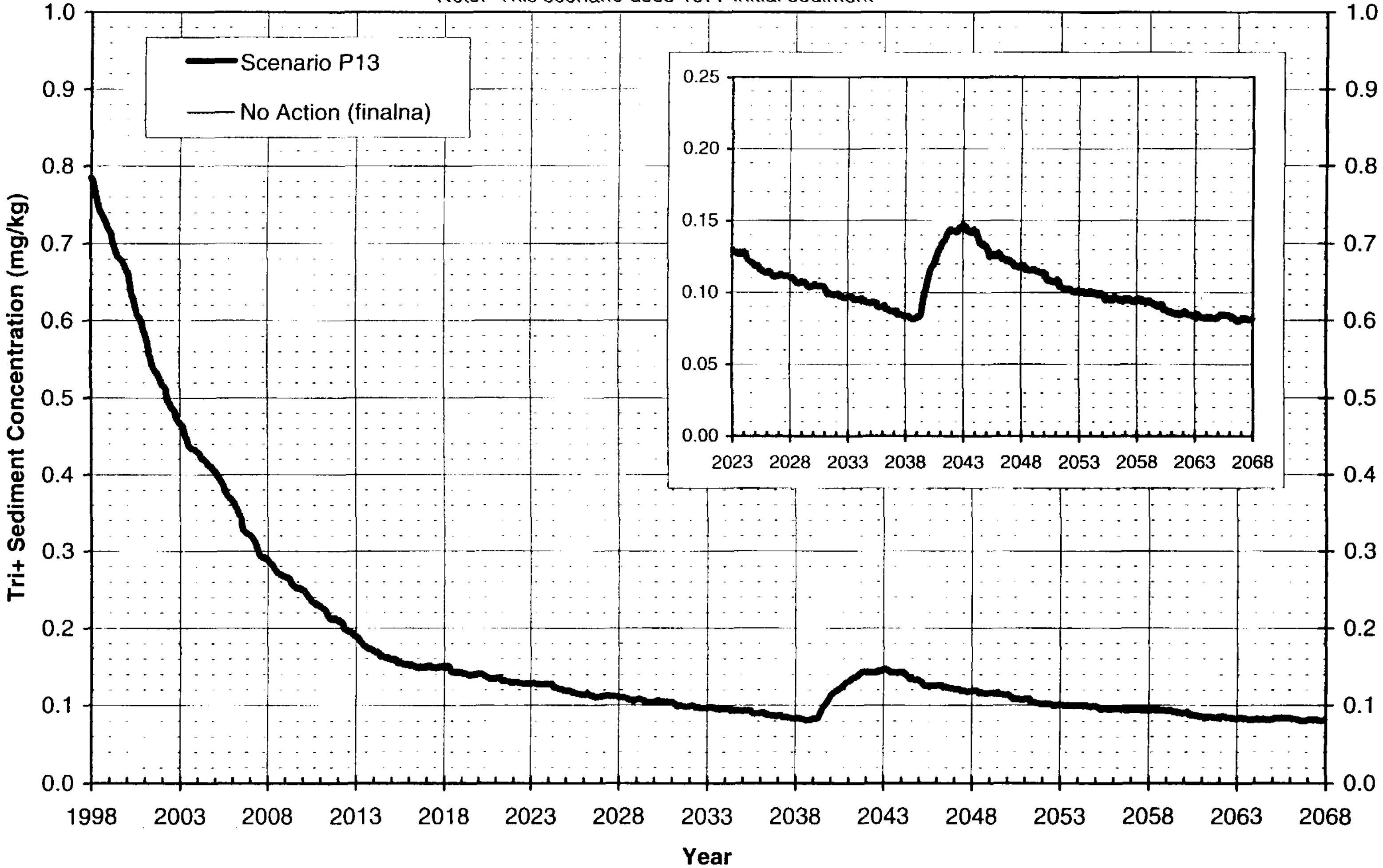


401660

FigsPre1toPre14 11/16/00

Figure PRE-9
Comparison Between Remediation Scenario P13 and No Action Forecast for Federal Dam Non-Cohesive Surficial Sediment

Note: This scenario uses 1977 initial sediment

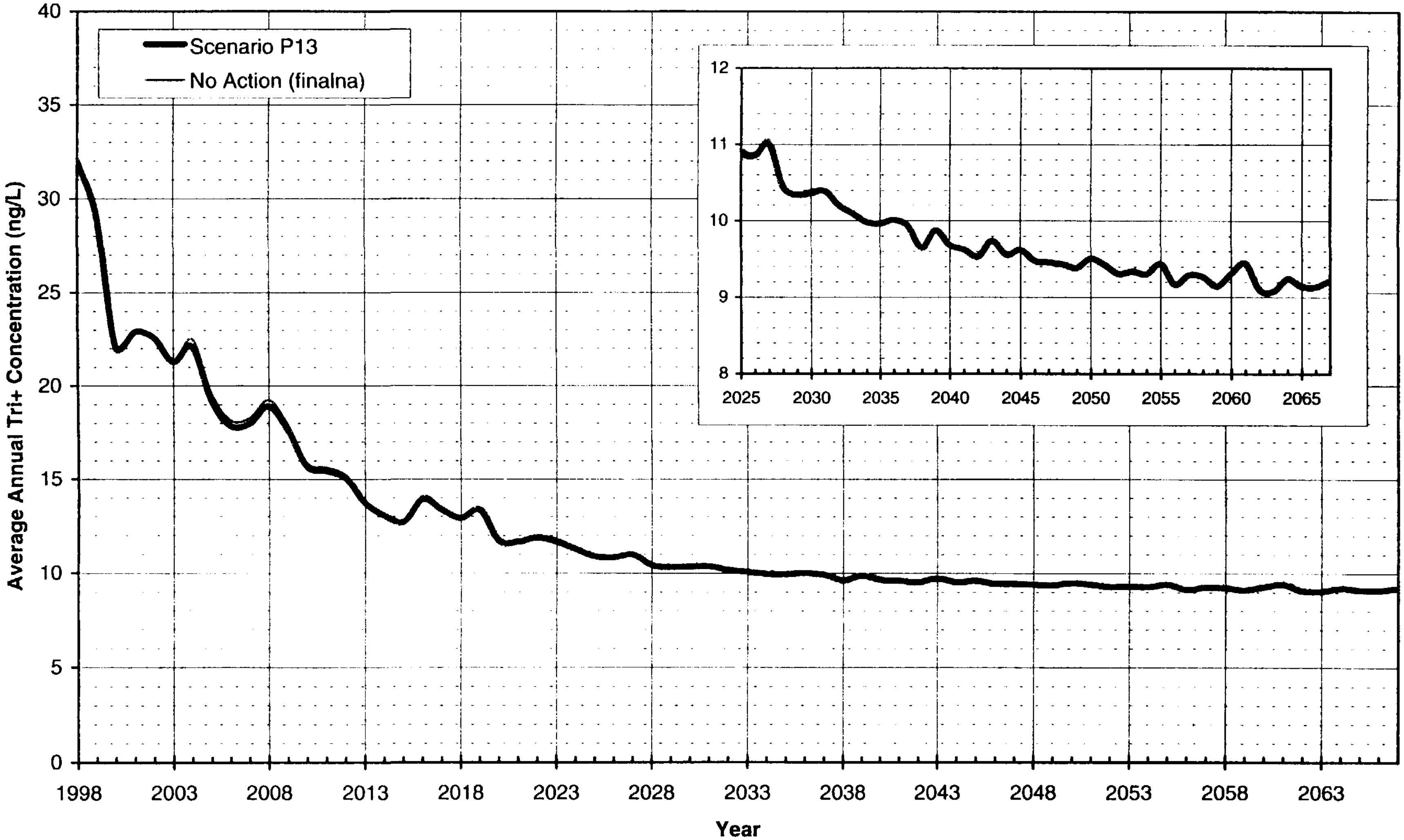


401661

FigsPre1toPre14 11/16/00

Figure PRE-10
Comparison Between Remediation Scenario P13 and No Action Forecast for Thompson Island Dam Average Annual Tri+ PCB Water Column Concentrations.

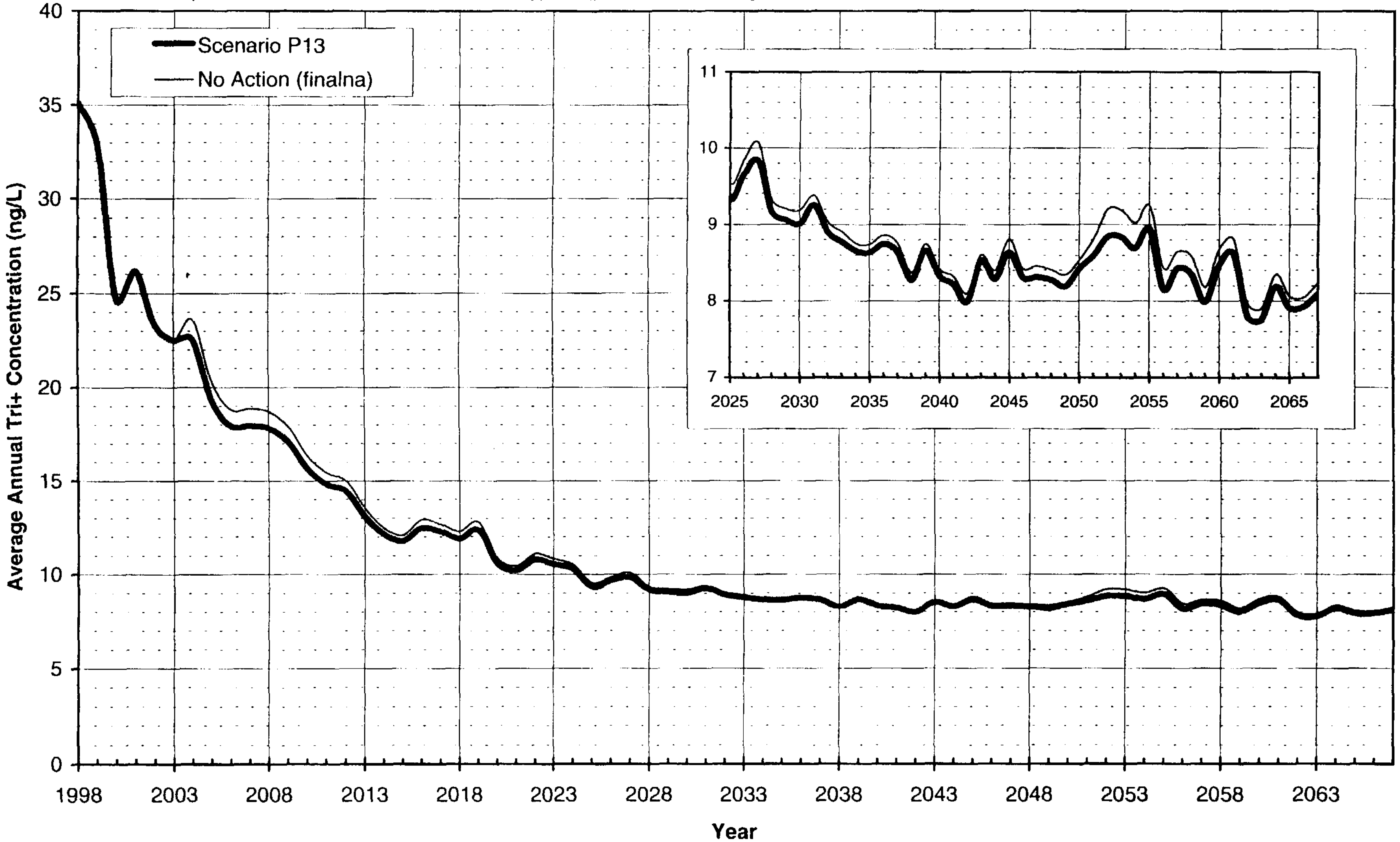
Note: This scenario uses 1977 initial sediment



401662

FigsPre1toPre14 11/16/00

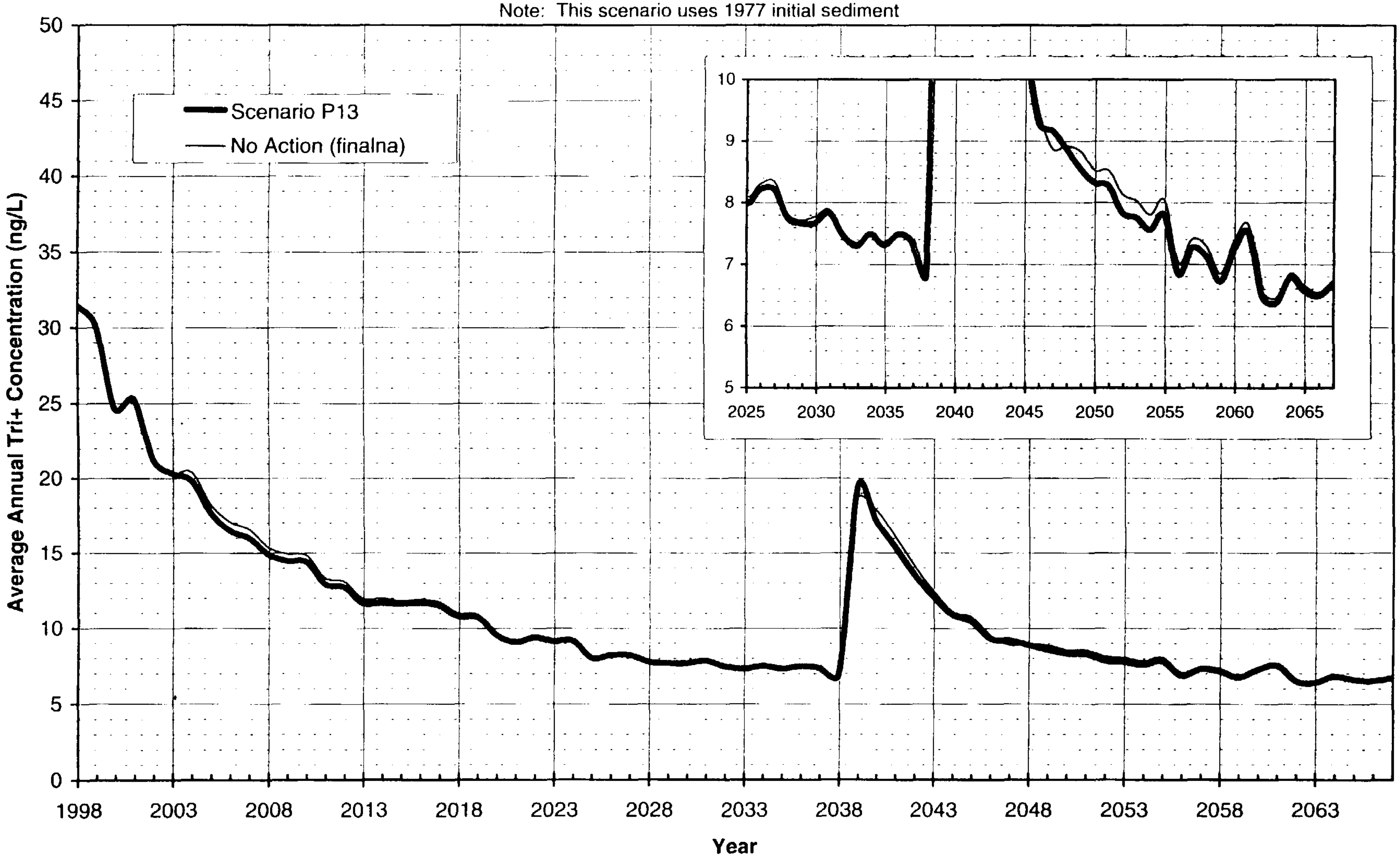
Figure PRE-11
Comparison Between Remediation Scenario P13 and No Action Forecast for Schuylerville Average Annual Tri+ PCB Water Column Concentrations.
Note: This scenario uses 1977 initial sediment



401663

FigsPre1toPre14 11/16/00

Figure PRE-12
Comparison Between Remediation Scenario P13 and No Action Forecast for Stillwater Average Annual Tri+ PCB Water Column Concentrations.

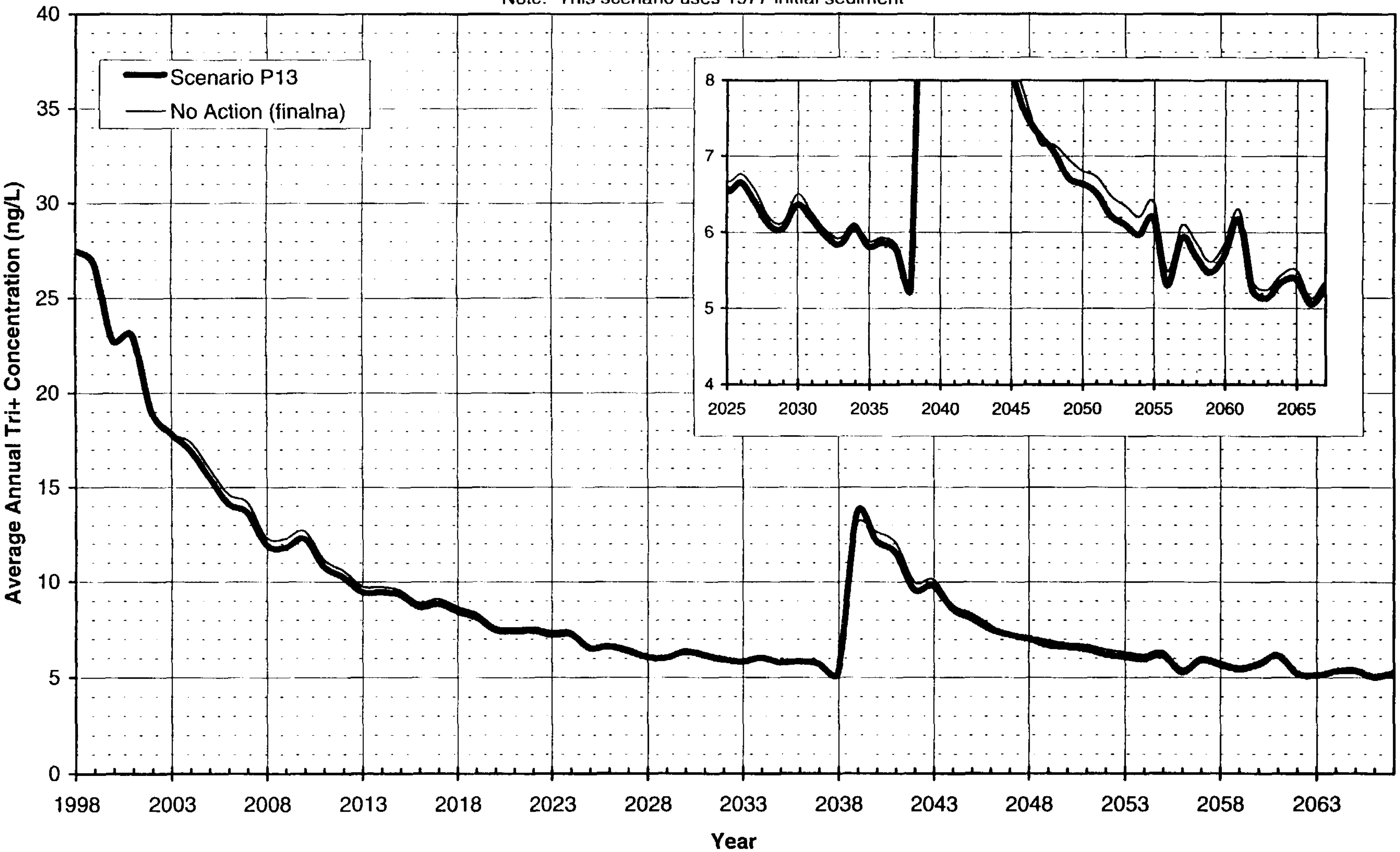


401664

FigsPre1toPre14 11/16/00

Figure PRE-13
Comparison Between Remediation Scenario P13 and No Action Forecast for Waterford Average Annual Tri+ PCB Water Column Concentrations.

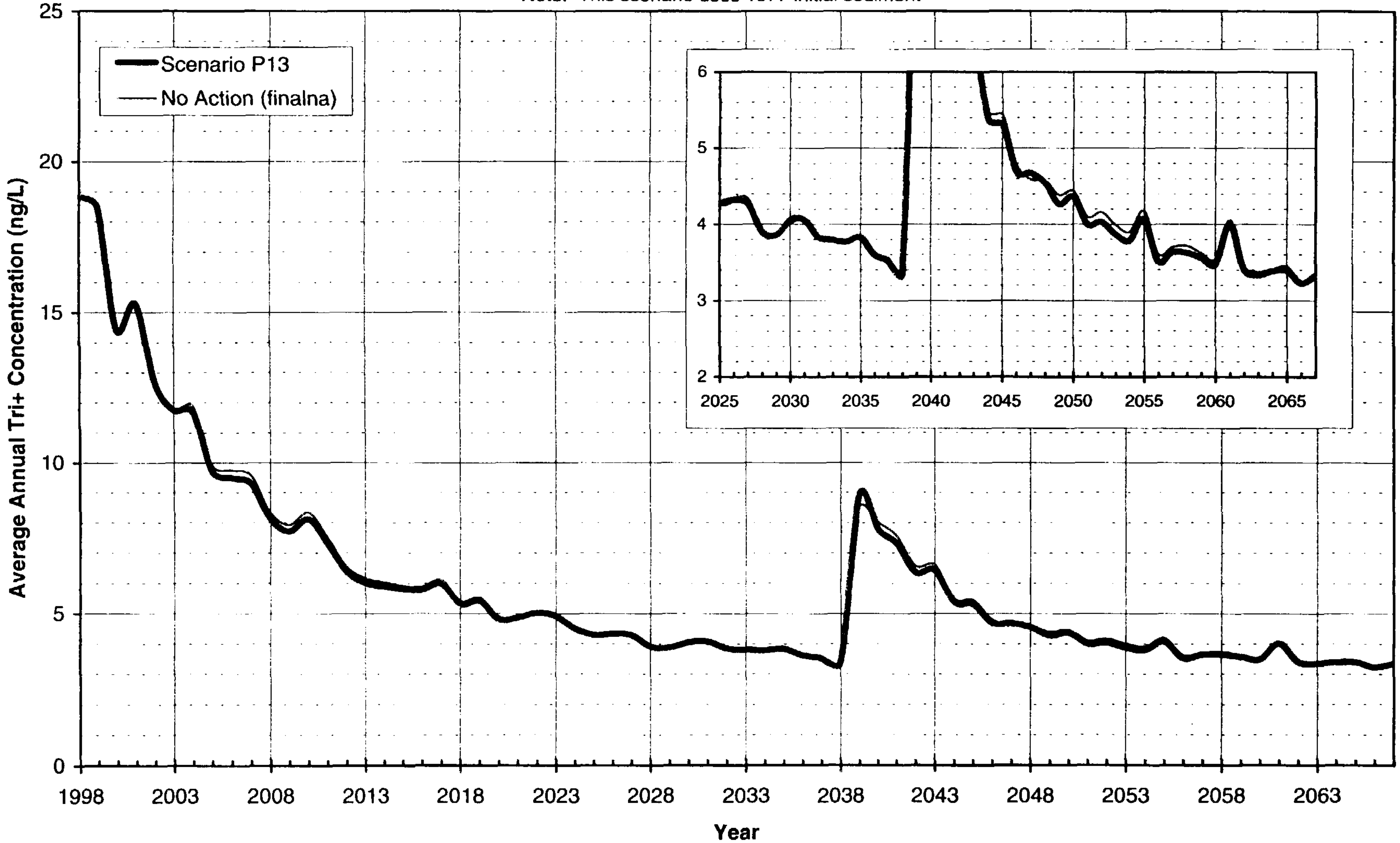
Note: This scenario uses 1977 initial sediment



401665

FigsPre1toPre14 11/16/00

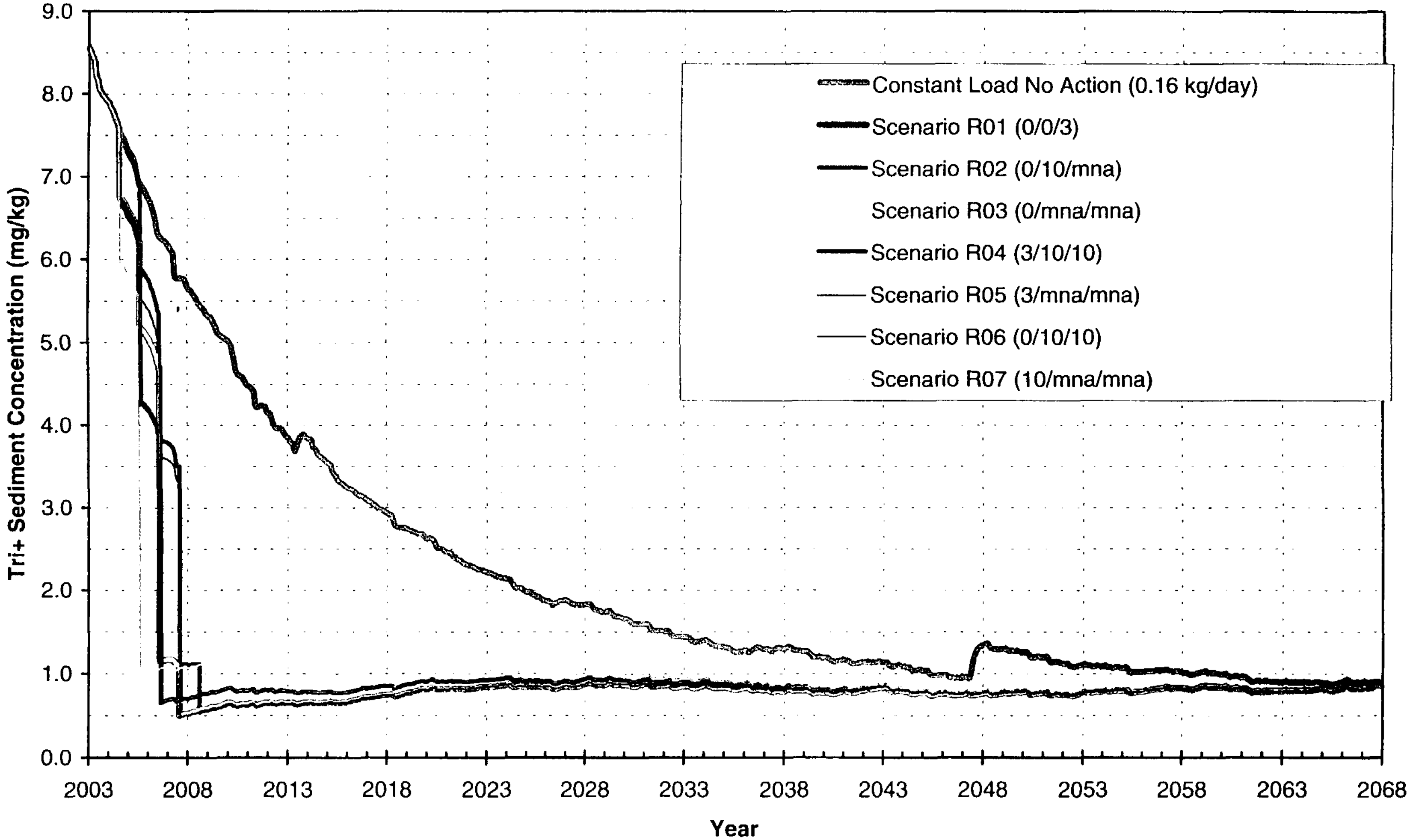
Figure PRE-14
Comparison Between Remediation Scenario P13 and No Action Forecast for Federal Dam Average Annual Tri+ PCB Water Column Concentrations.
Note: This scenario uses 1977 initial sediment



401666

FigsPre1toPre14 11/16/00

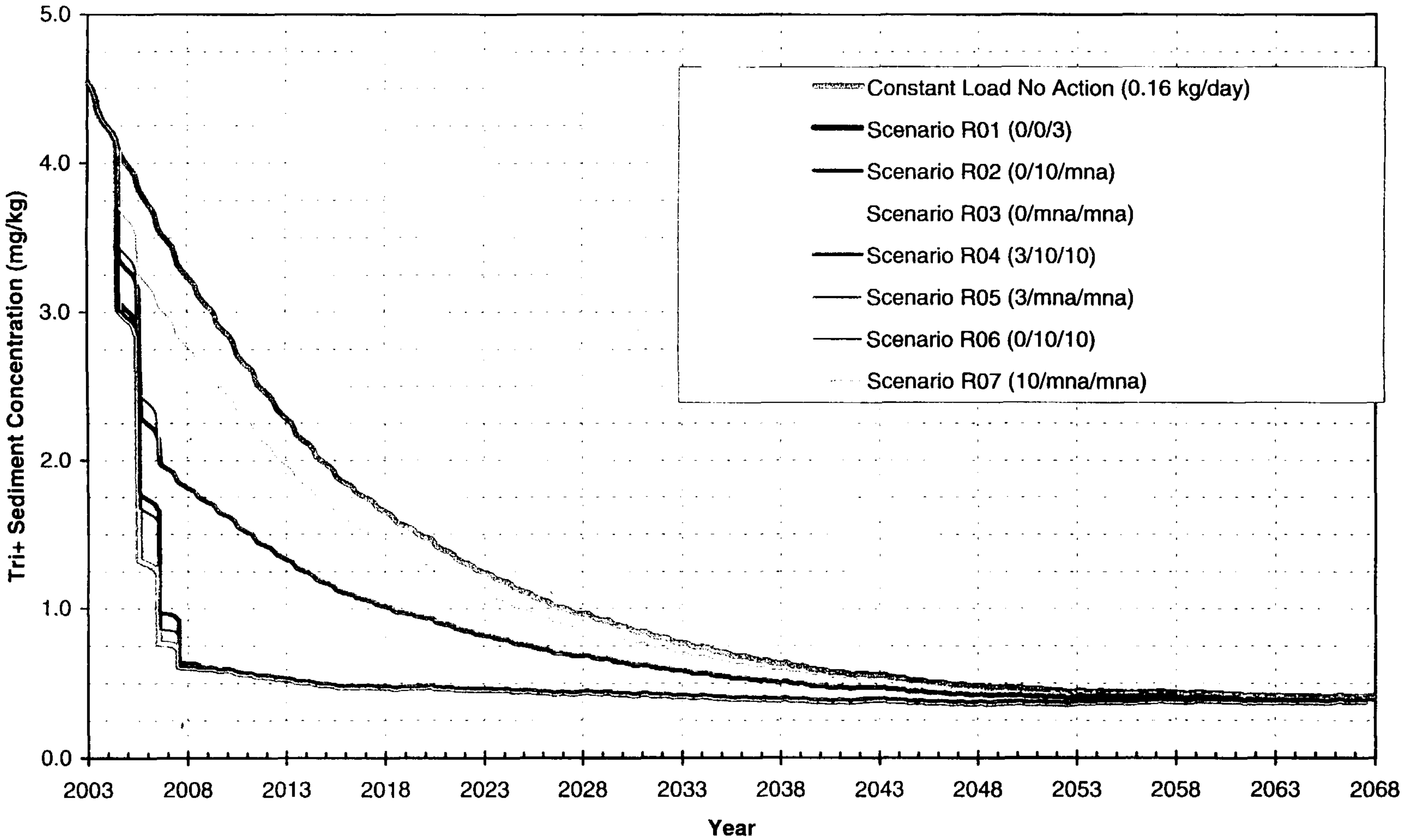
Figure RE1. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Constant Upstream Load Conditions



401667

rel_rel4 11/16/00

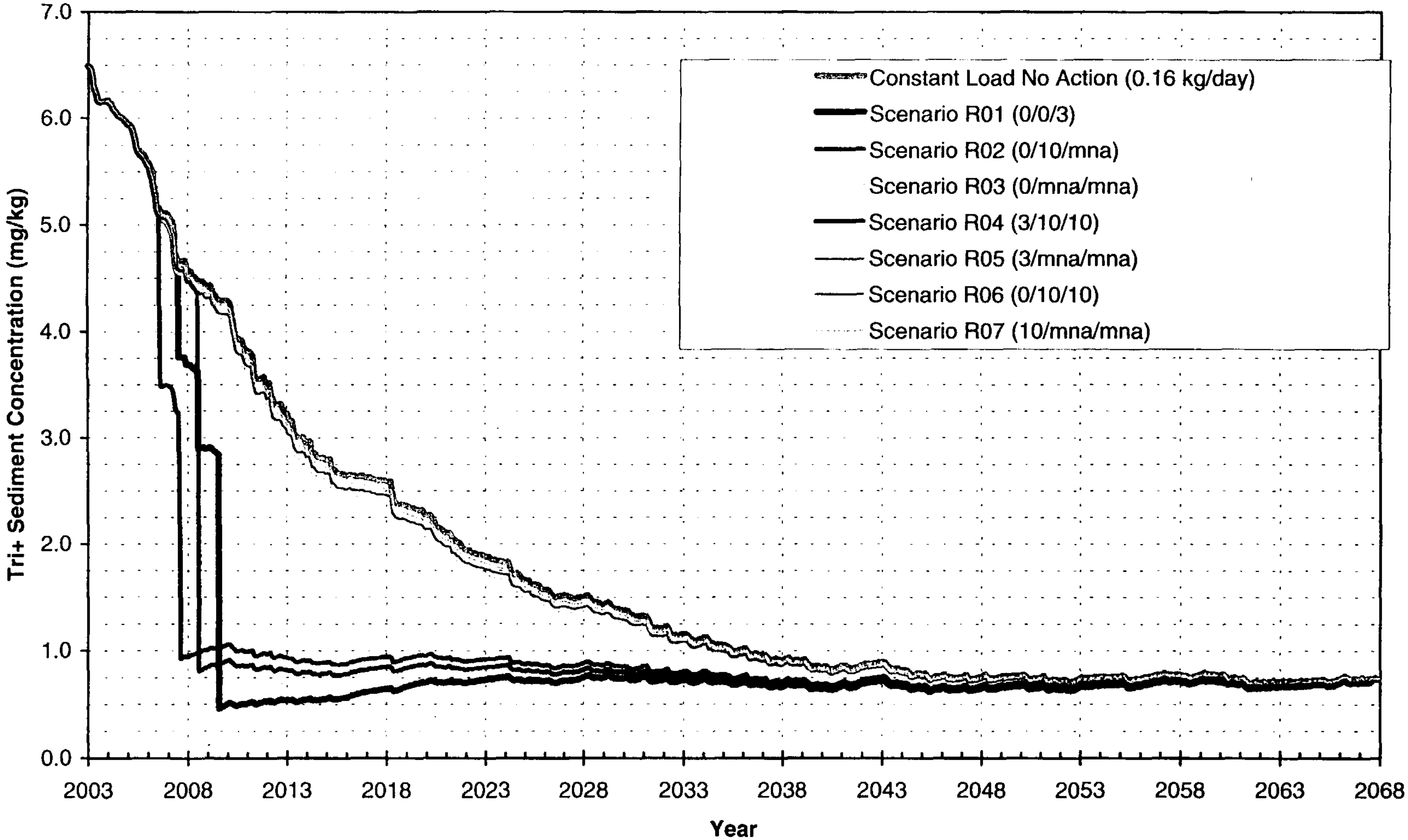
Figure RE2. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions



401668

rel_rel4 11/16/00

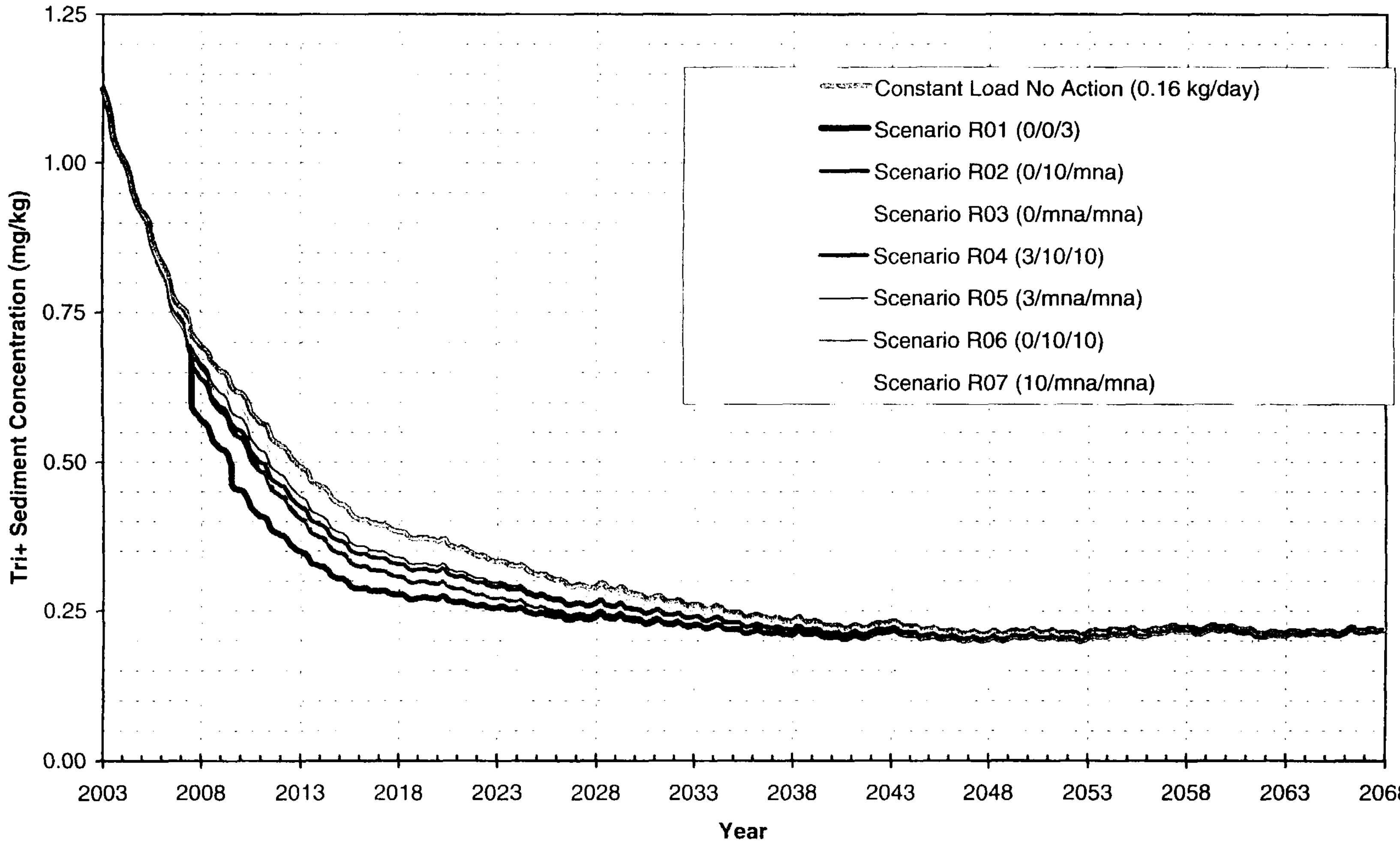
Figure RE3. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Constant Upstream Load Conditions



401669

rel_rel4 11/16/00

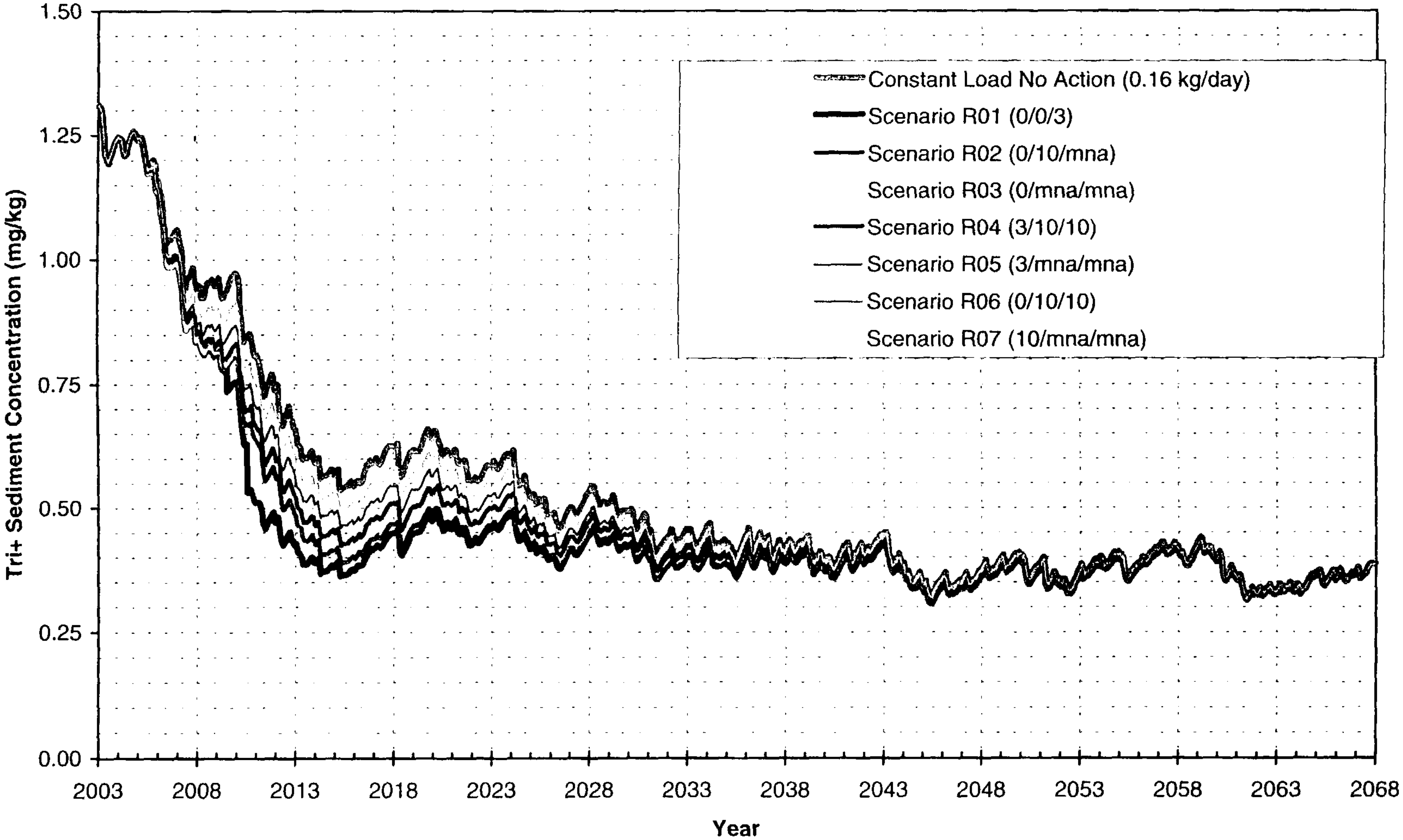
Figure RE4. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions



401670

rel_rel4 11/16/00

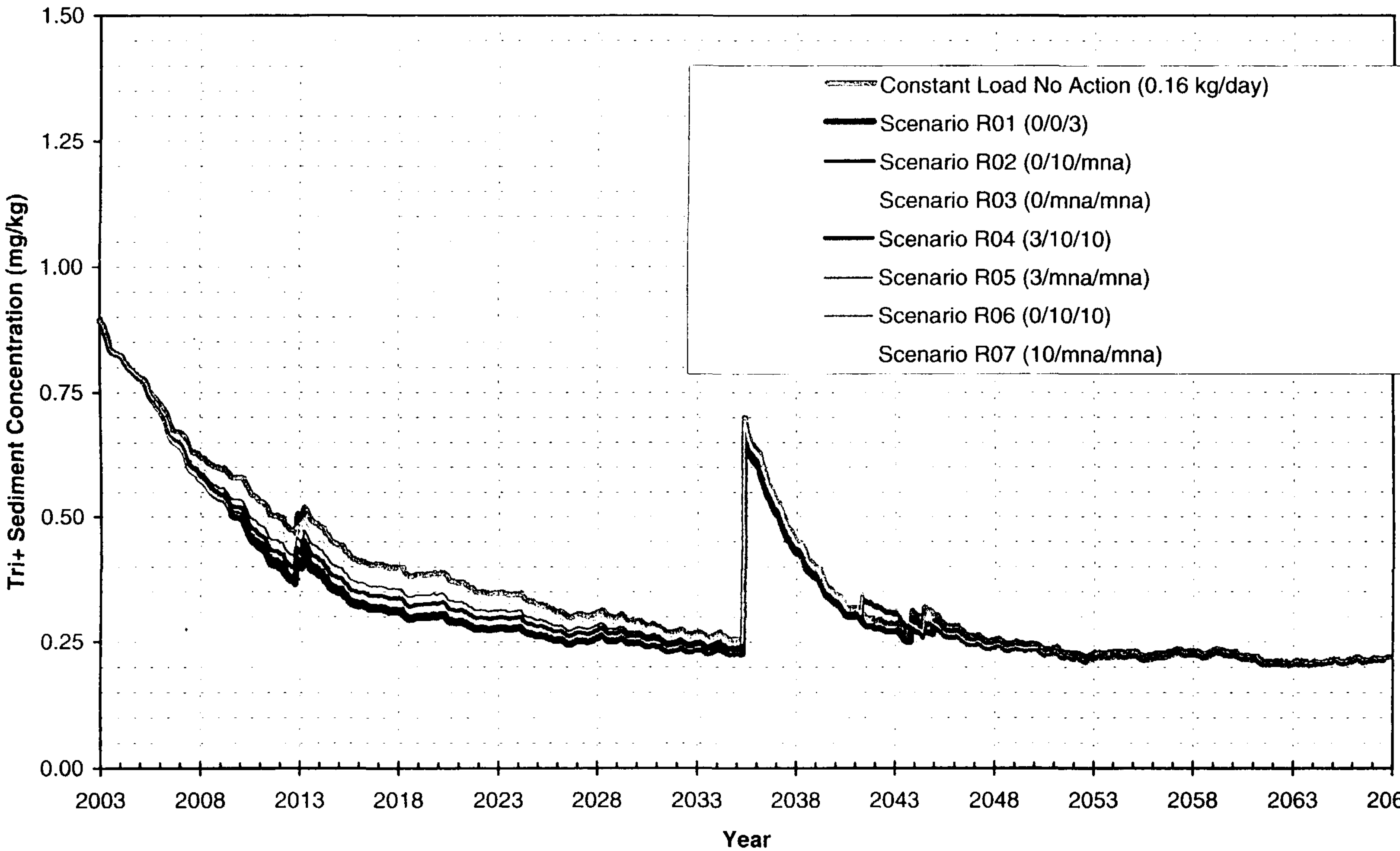
Figure RE5. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Constant Upstream Load Conditions



401671

rel_re14 11/16/00

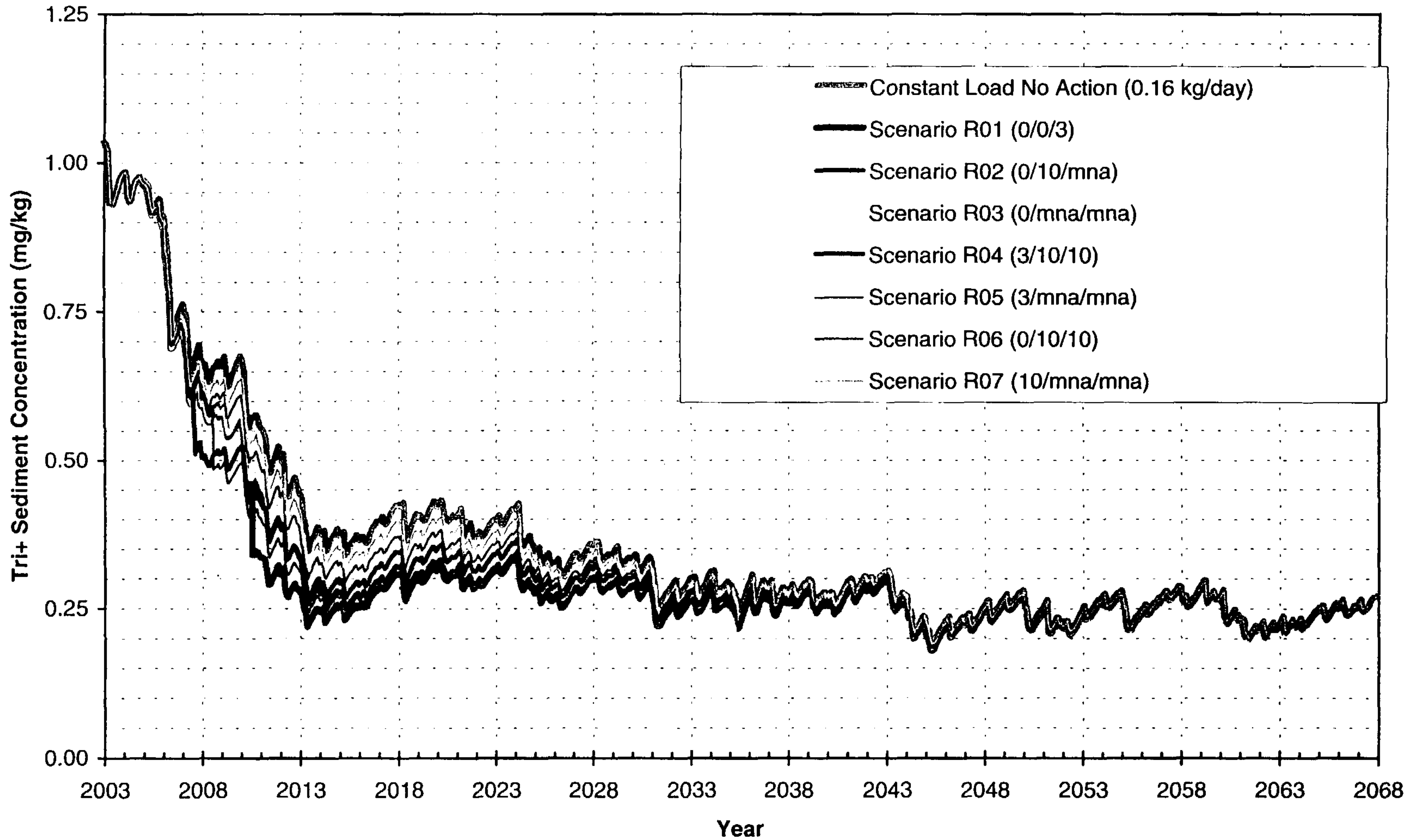
Figure RE6. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions



401672

rel_rel4 11/16/00

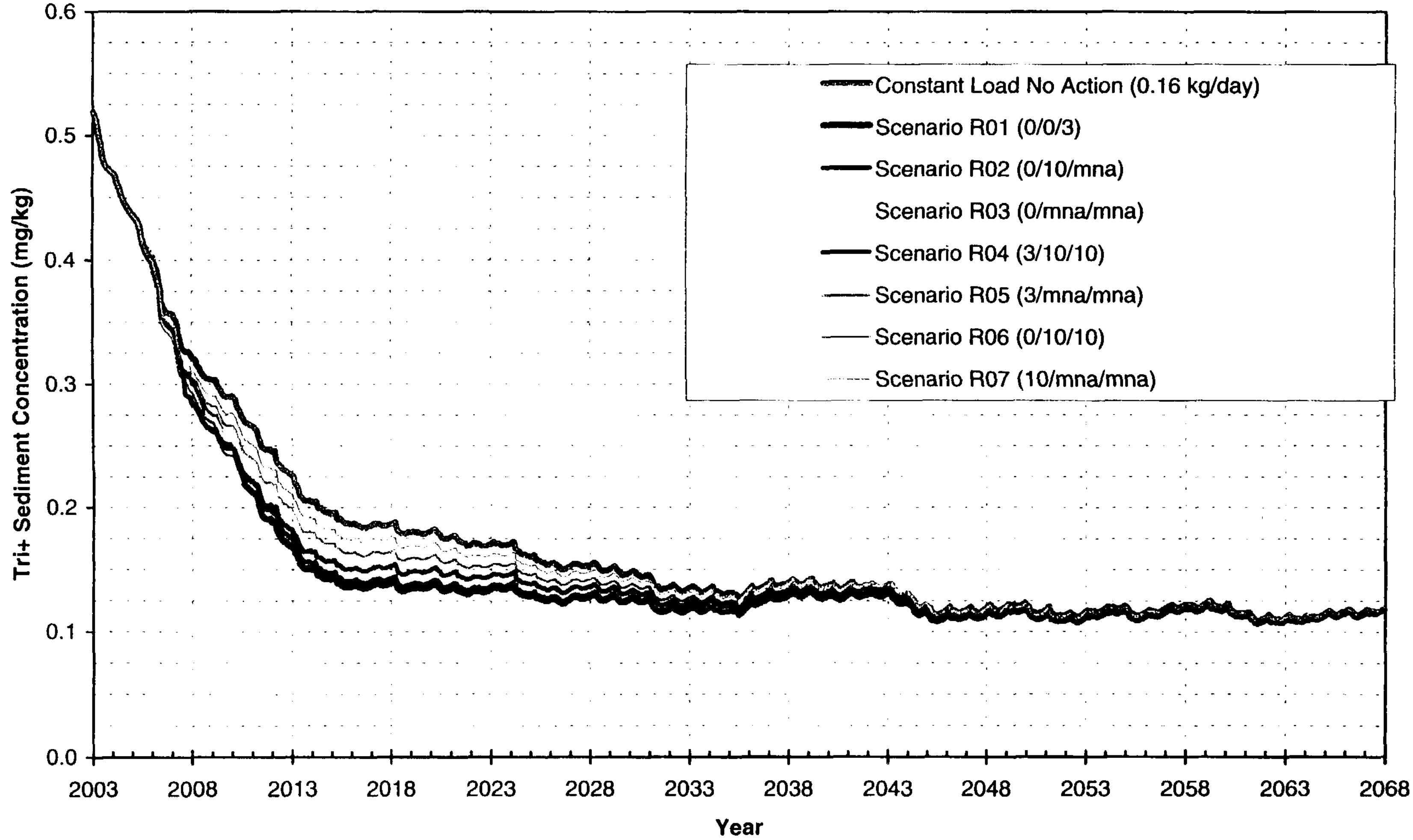
Figure RE7. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Constant Upstream Load Conditions



401673

rel_re14 11/16/00

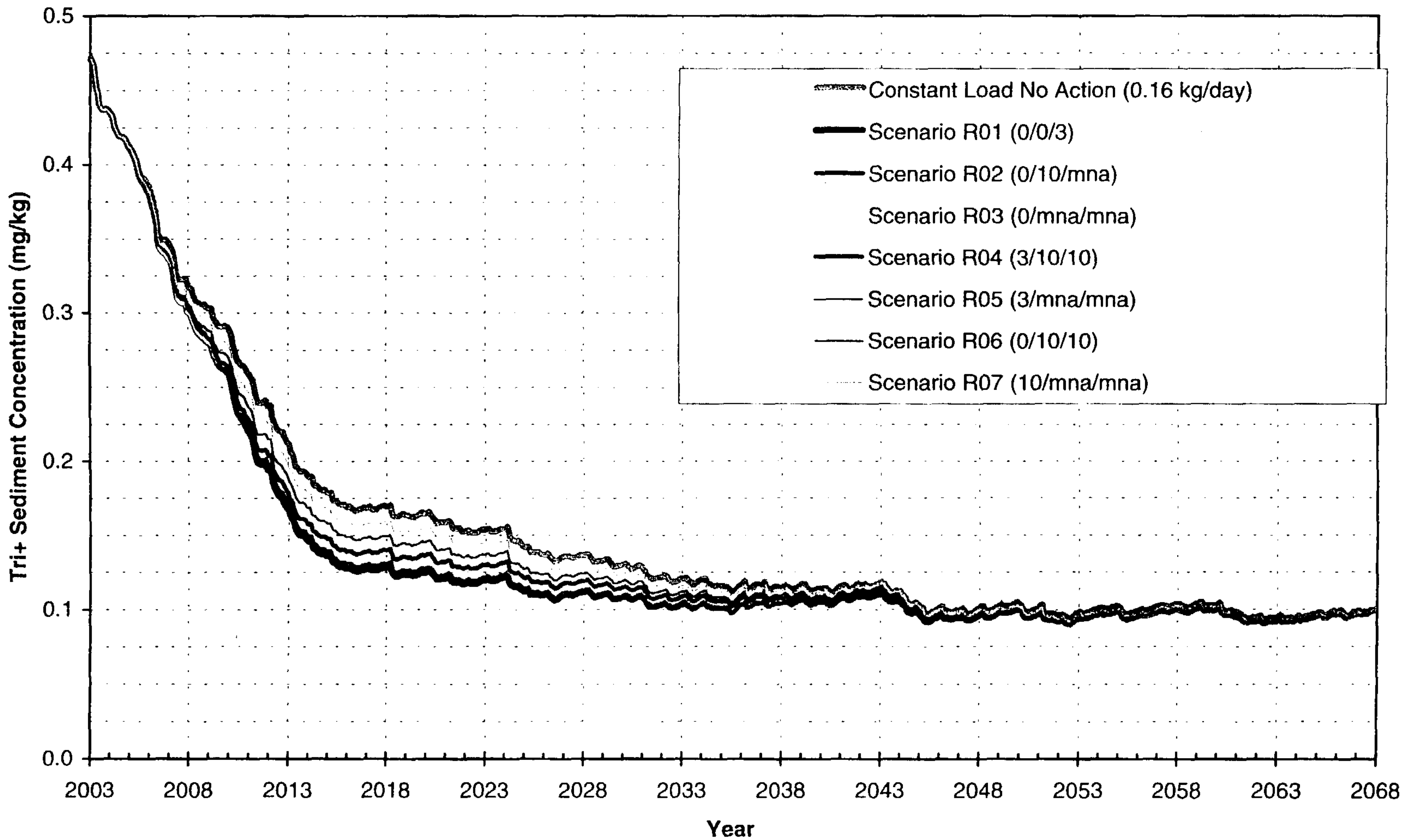
Figure RE8. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions



401674

rel_rel4 11/16/00

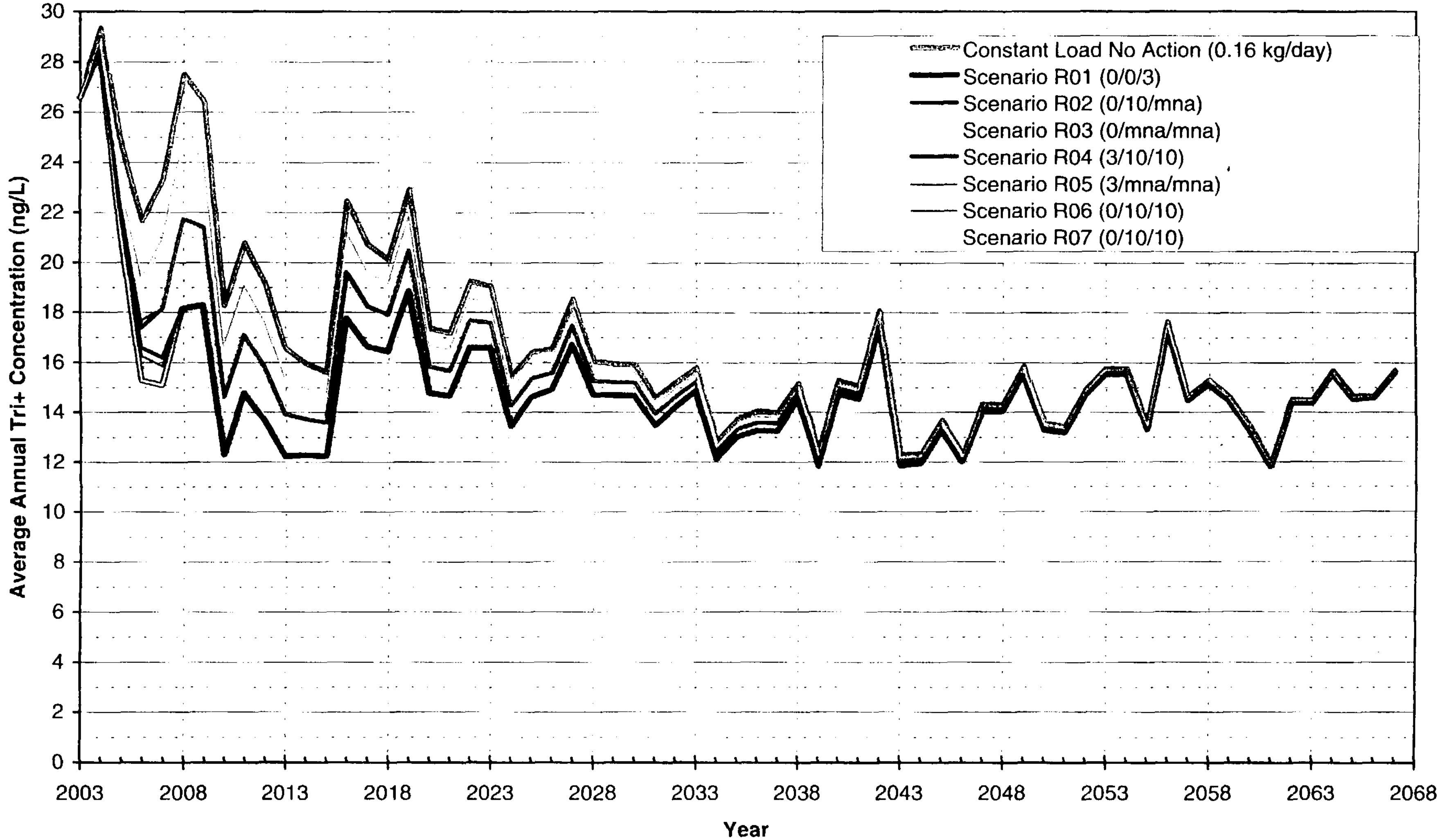
Figure RE9. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Constant Upstream Load Conditions



401675

rel_rel4 11/16/00

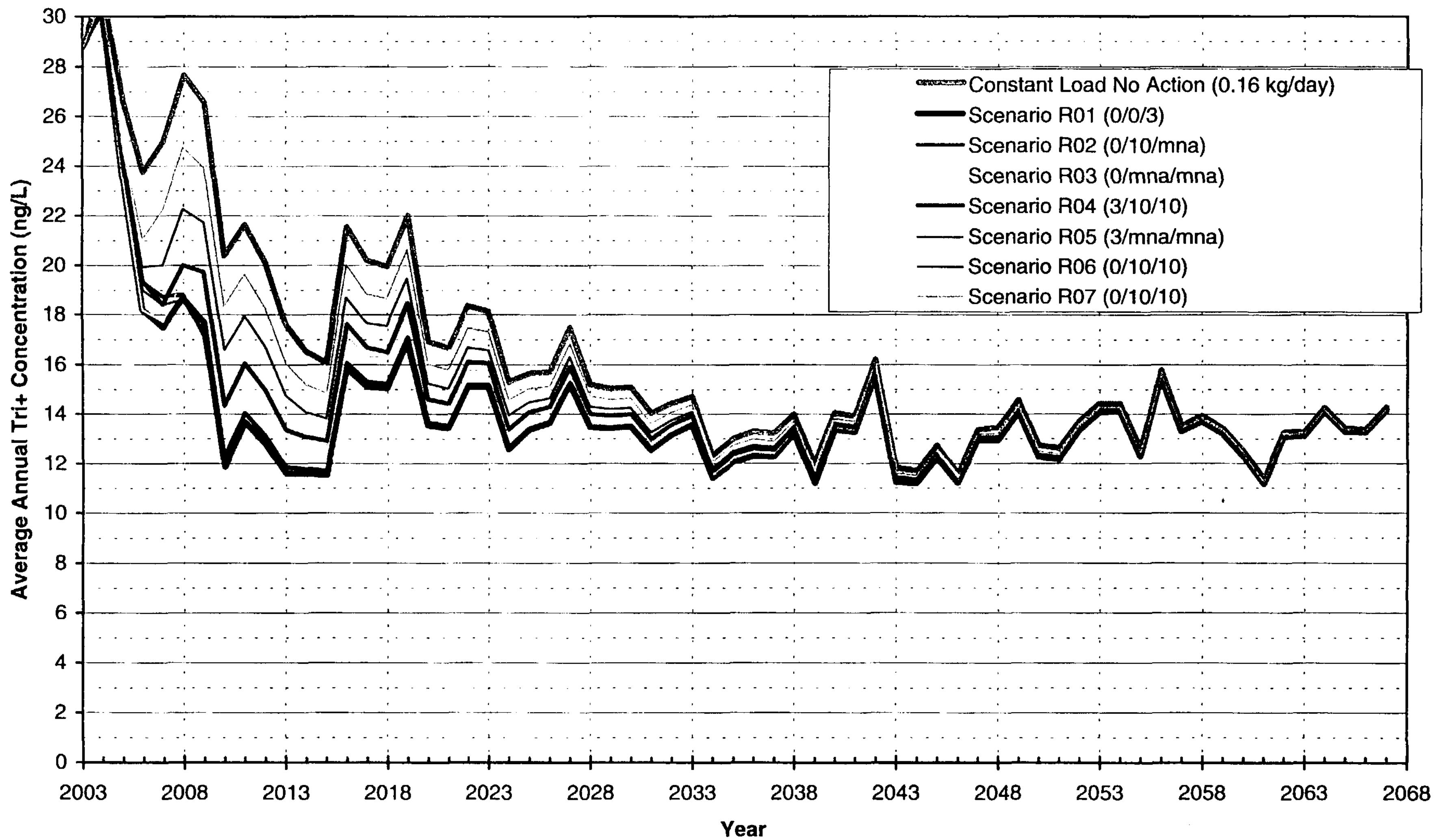
Figure RE10. Comparison Between Water Column Forecasts at Thompson Island Dam - Constant Upstream Load Conditions



rel_re14 11/16/00

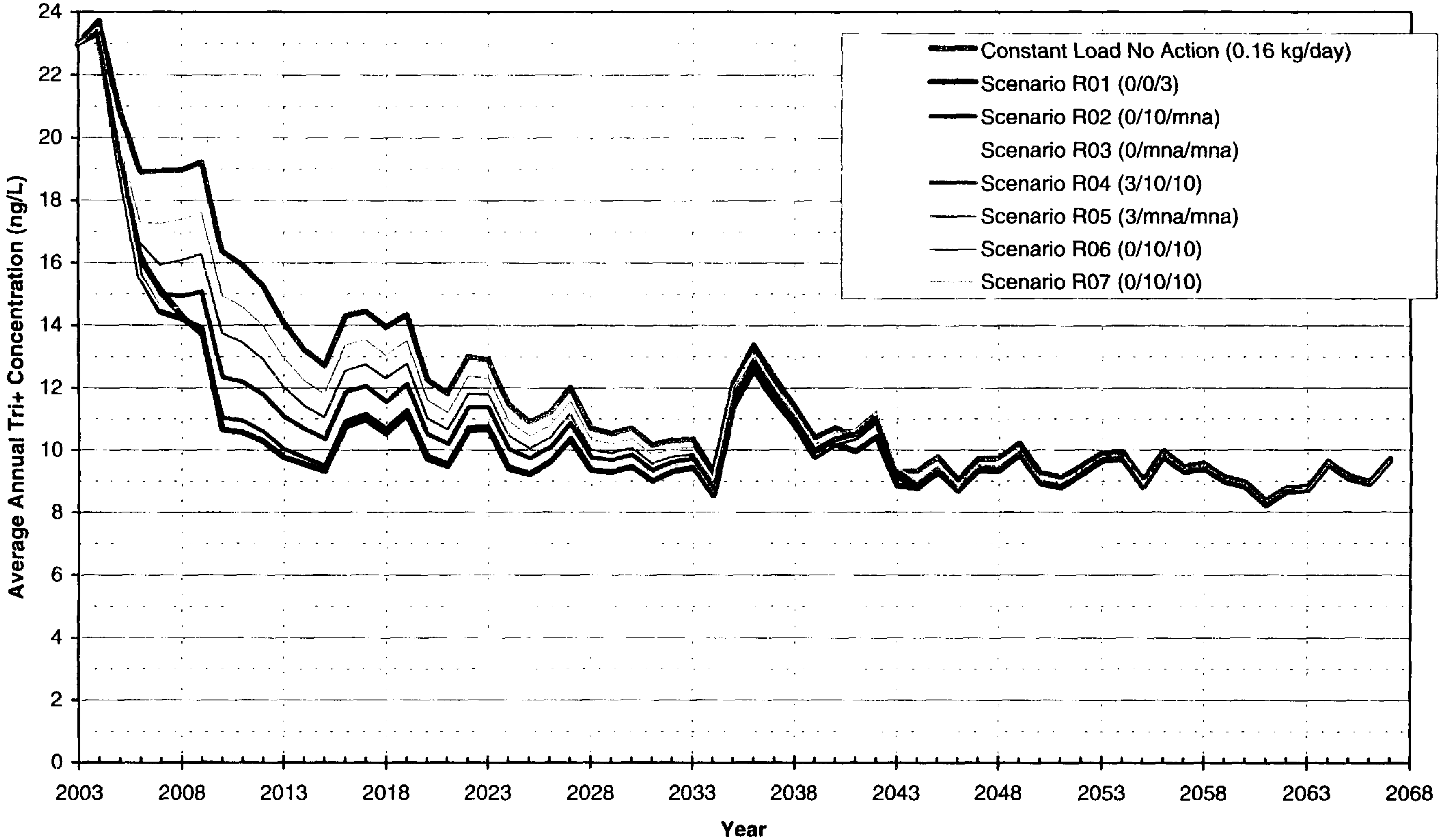
401676

Figure RE11. Comparison Between Water Column Forecasts at Northumberland Dam - Constant Upstream Load Conditions



401677

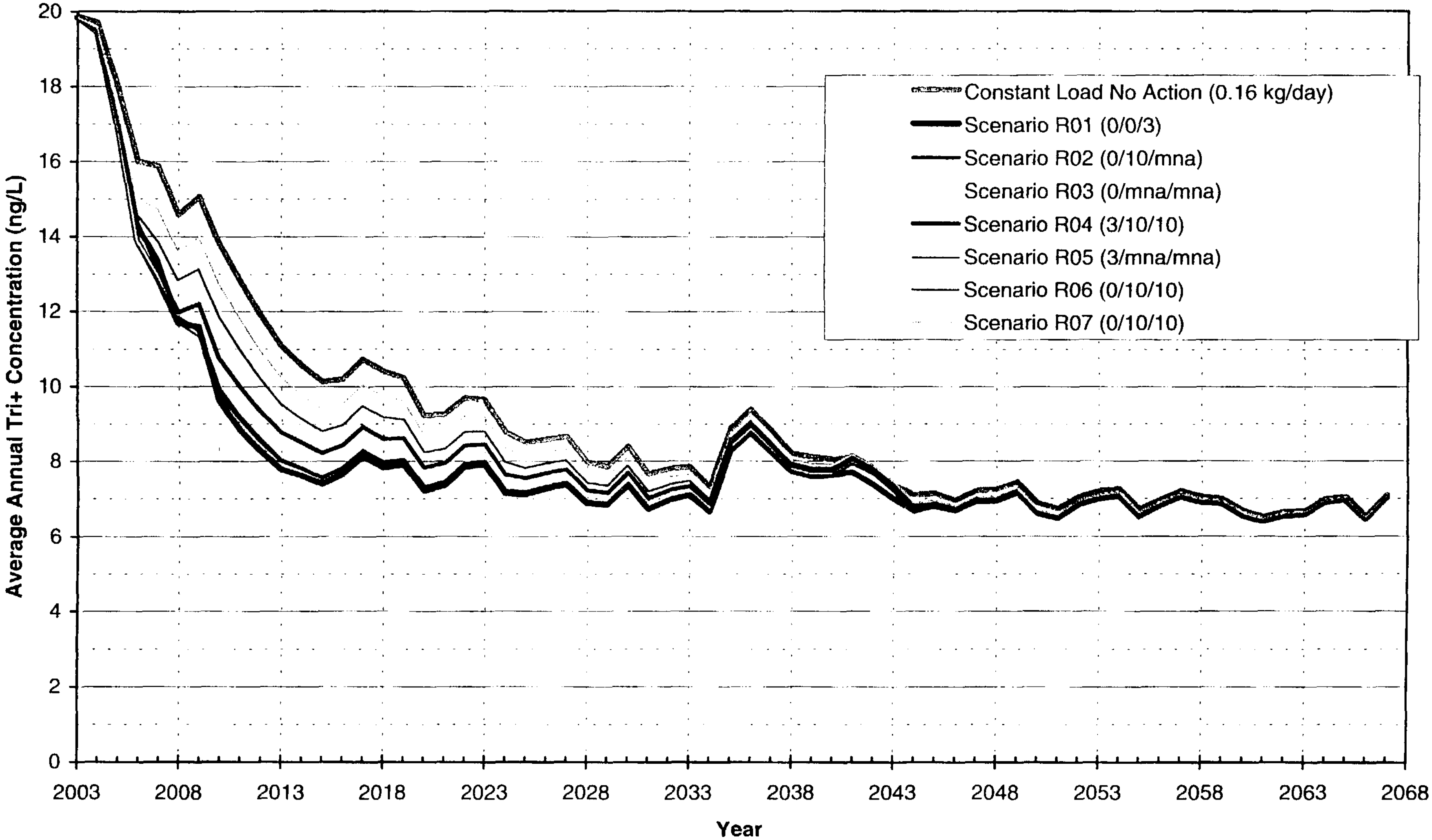
Figure RE12. Comparison Between Water Column Forecasts at Stillwater - Constant Upstream Load Conditions



401678

rel_re14 11/16/00

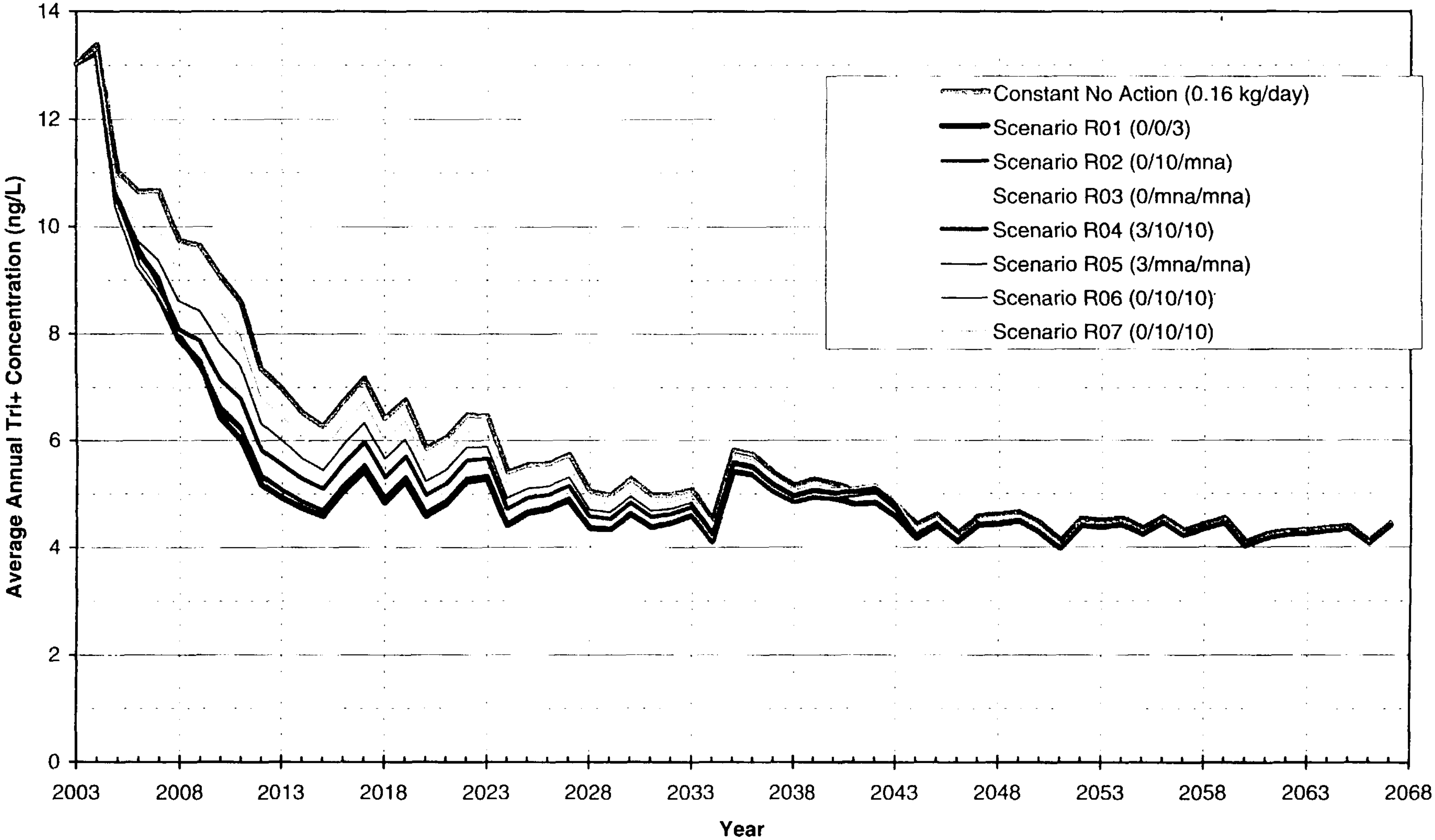
Figure RE13. Comparison Between Water Column Forecasts at Waterford - Constant Upstream Load Conditions



401679

rel_rel4 11/16/00

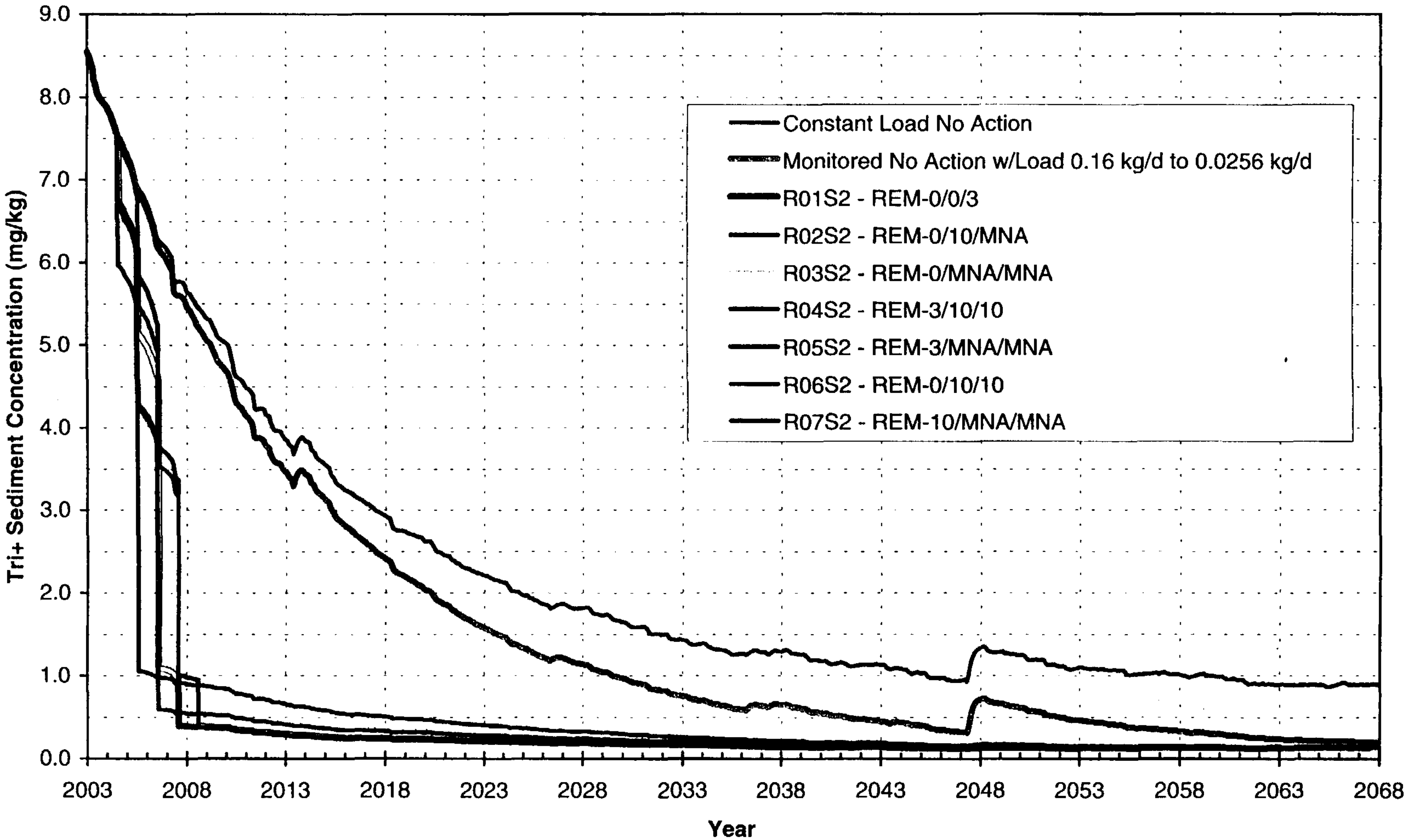
Figure RE14. Comparison Between Water Column Forecasts at Federal Dam - Constant Upstream Load Conditions



401680

rel_re14 11/16/00

Figure RE15. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401681

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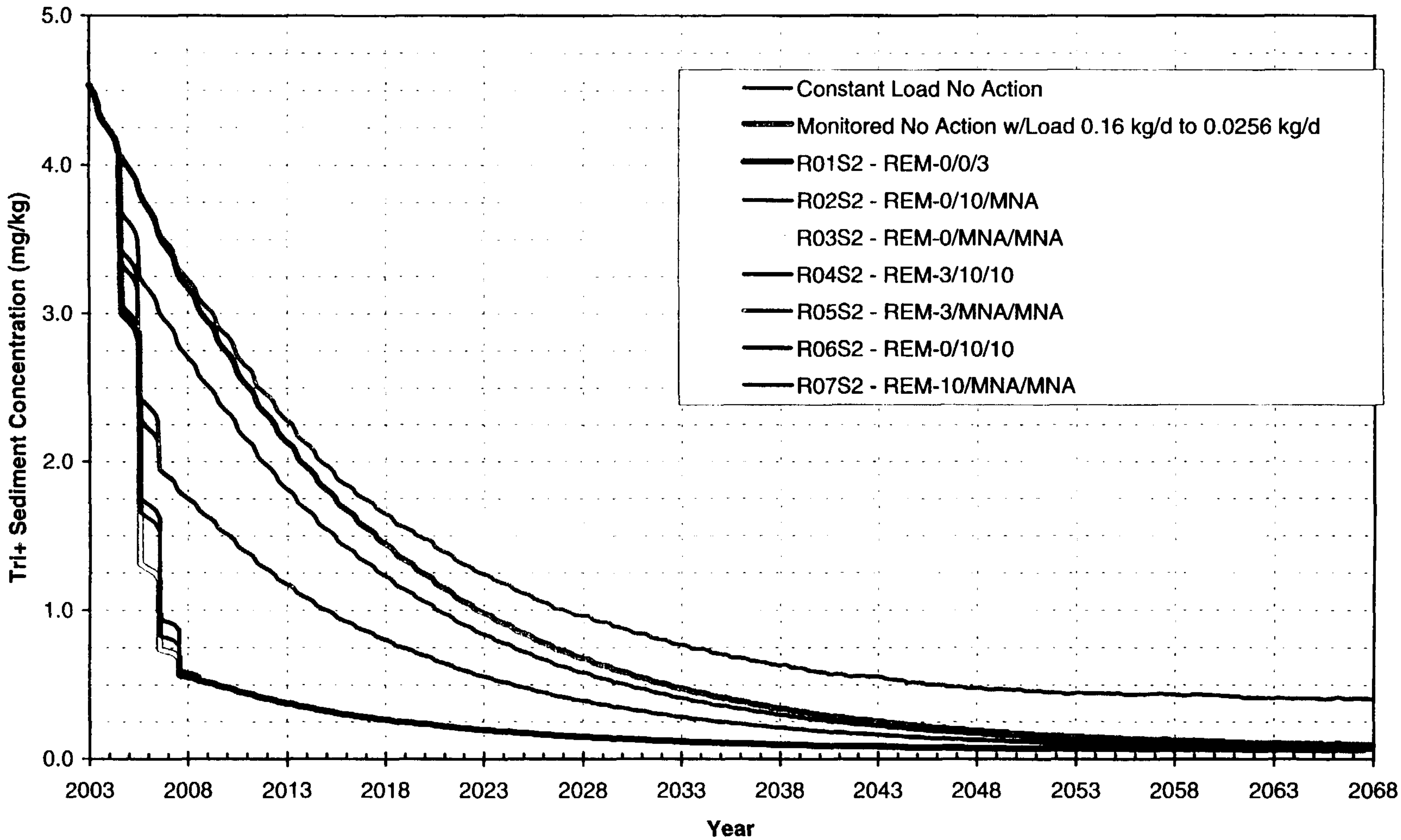
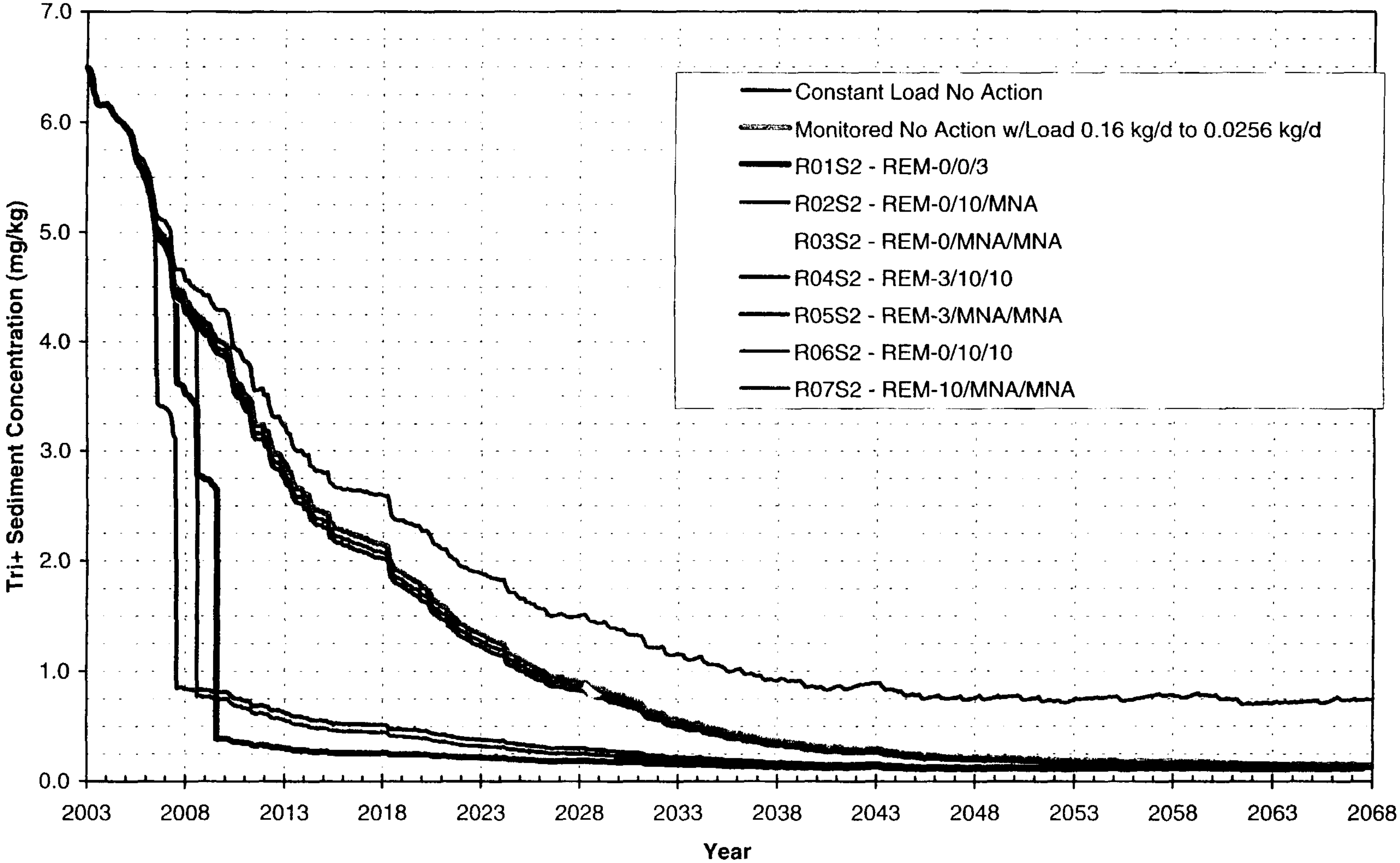
Figure RE16. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions



Fig_RE15_thru_RE28 11/16/00

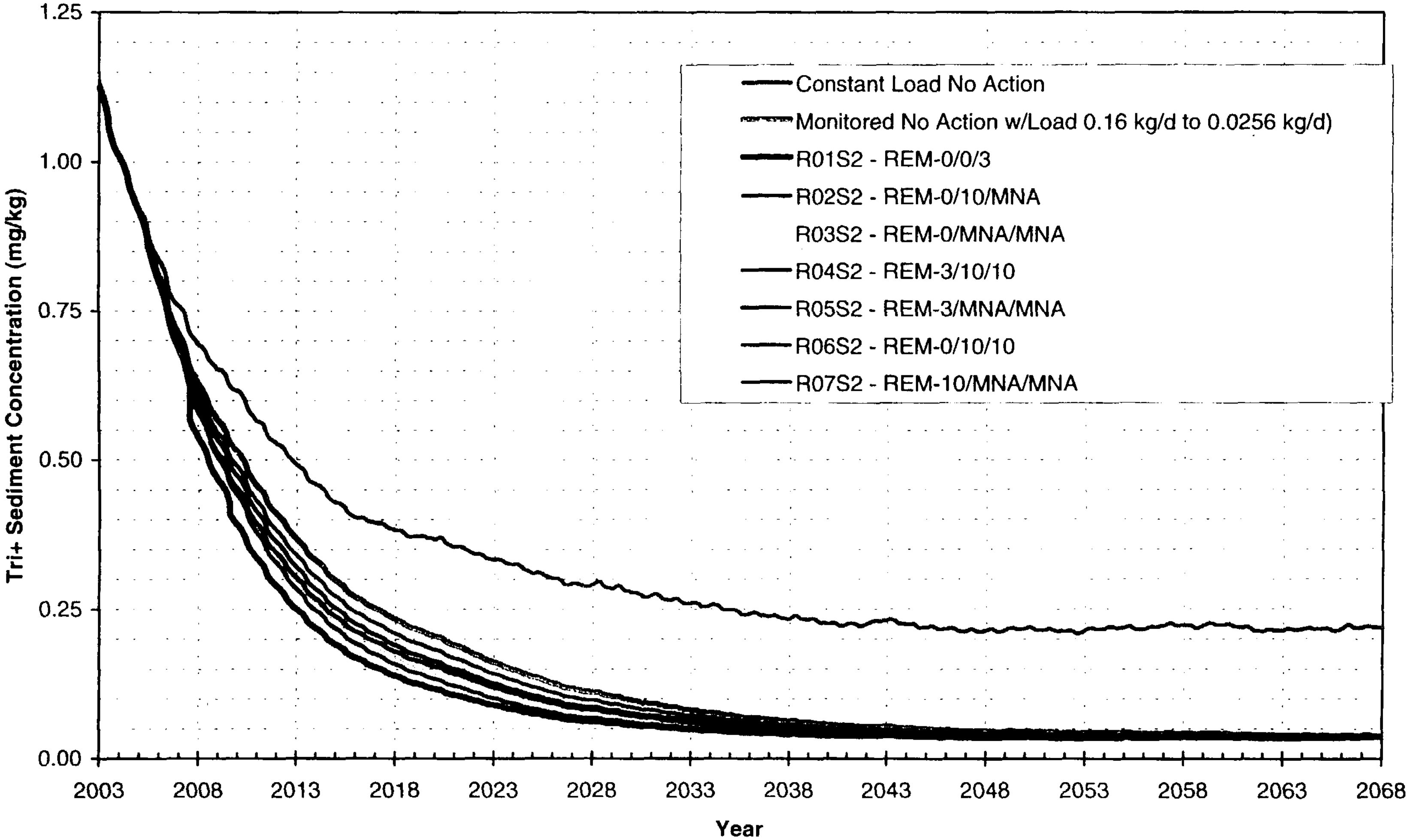
401682

Figure RE17. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401683

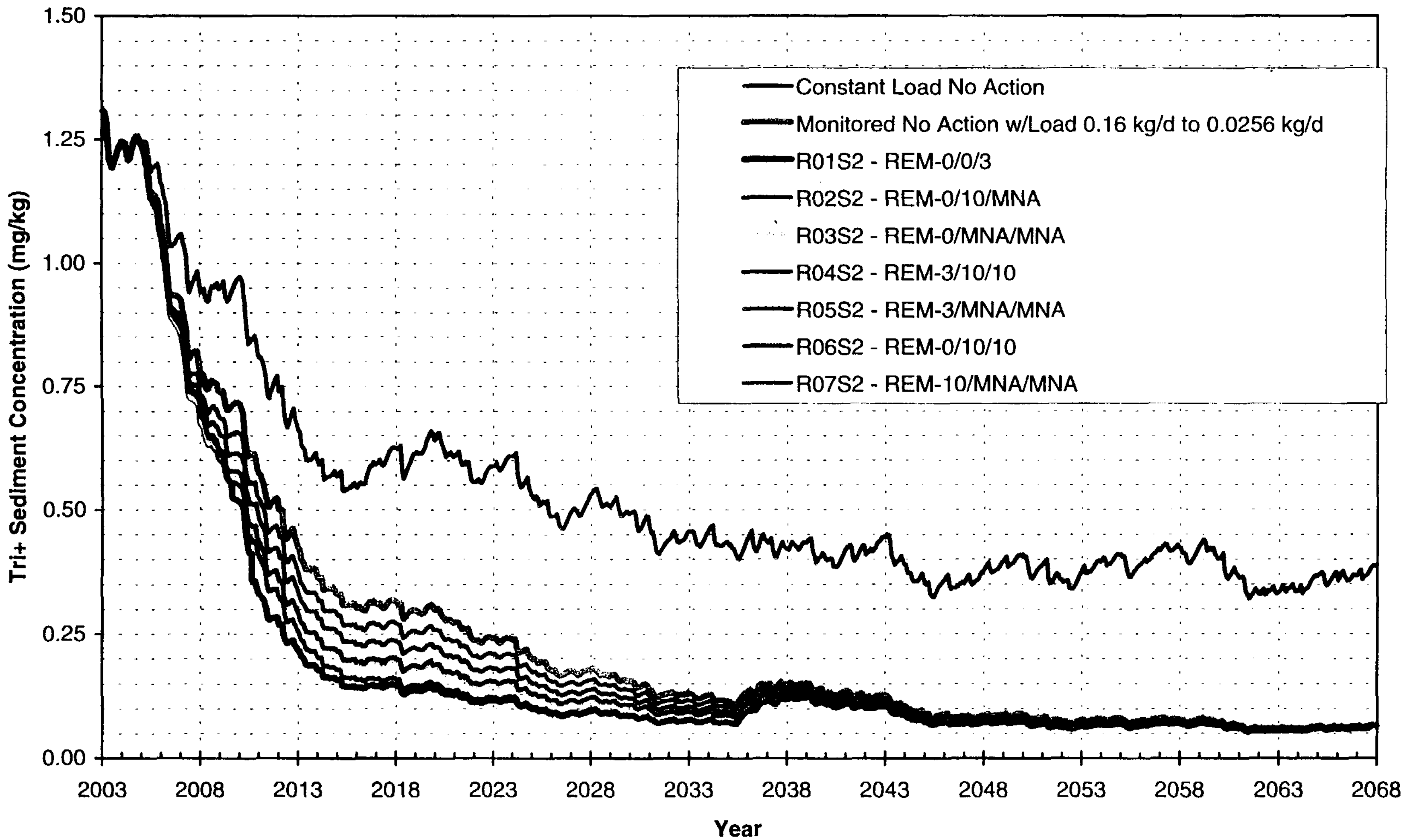
Figure RE18. Comparison Between Forescasts for Schuylerville Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401684

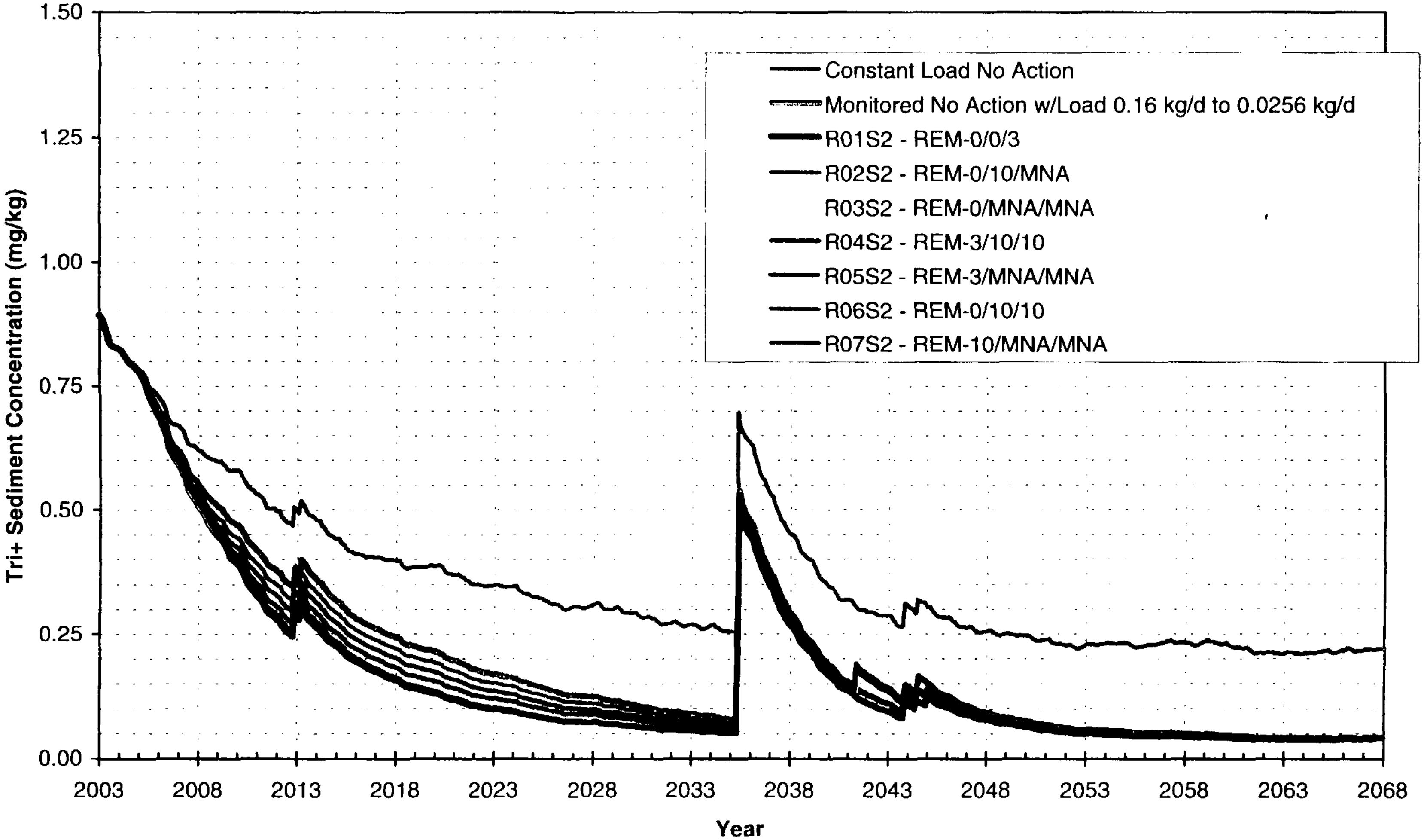
Fig_RE15_thru_RE28 11/16/00

Figure RE19. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401685

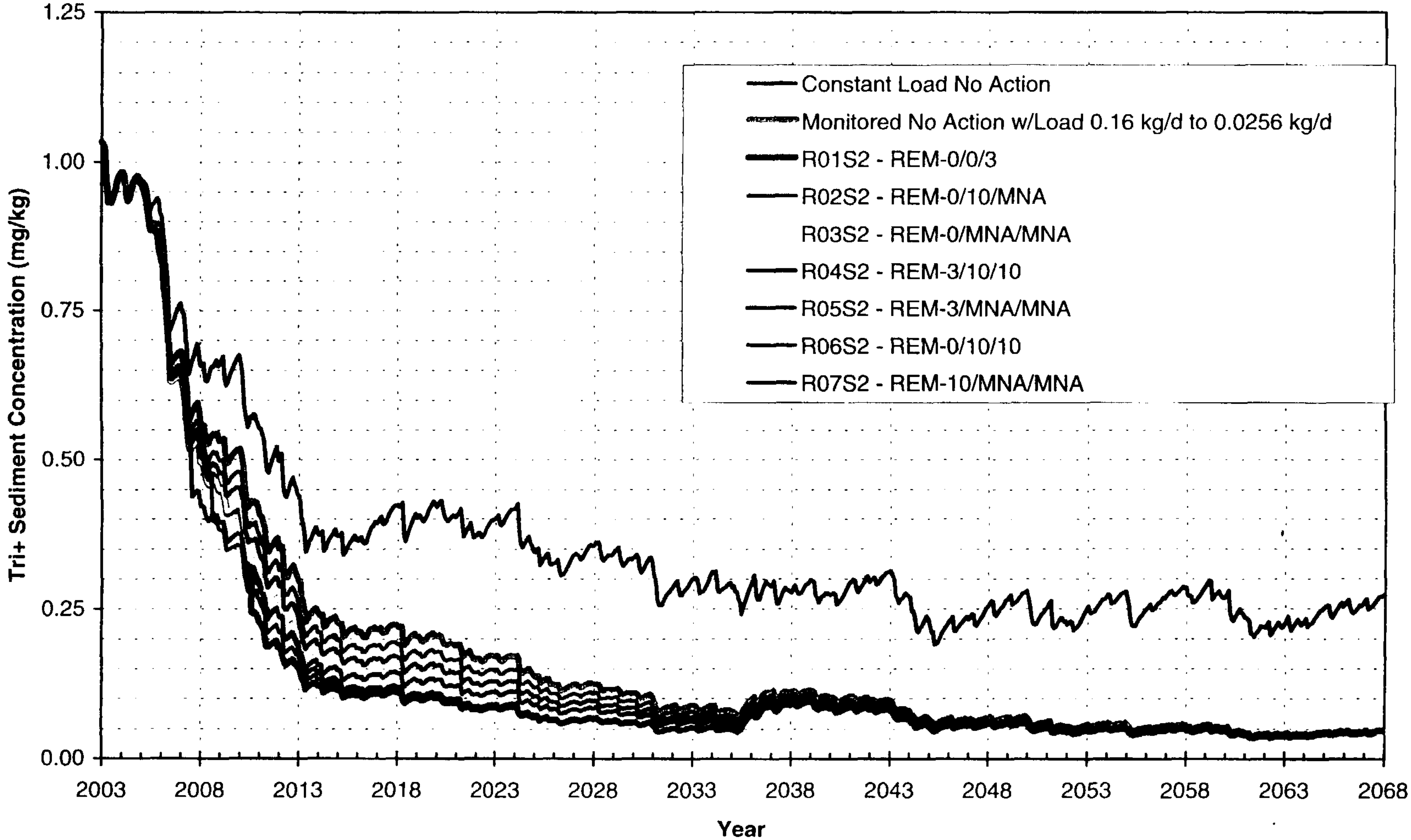
Figure RE20. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401686

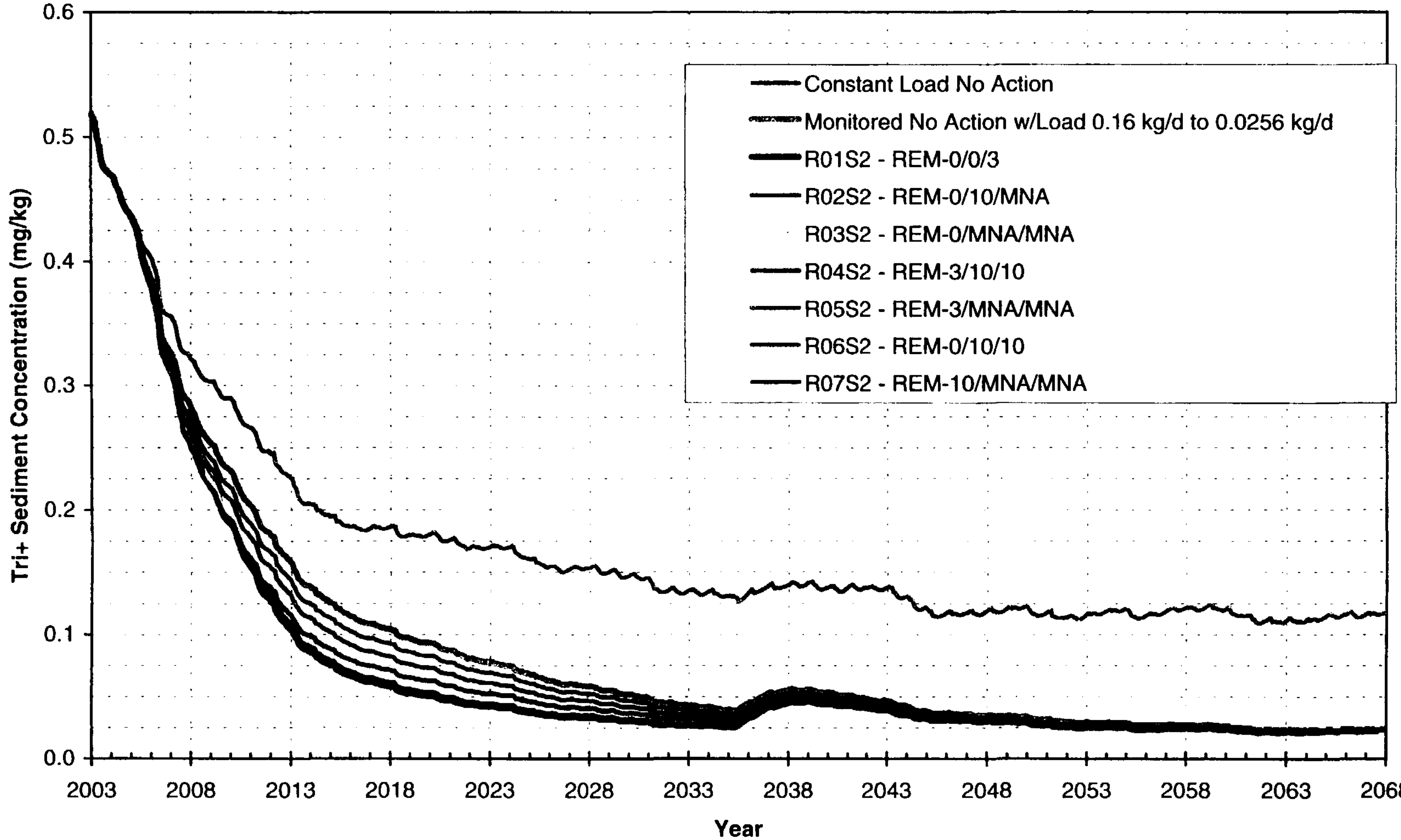
Fig_RE15_thru_RE28 11/16/00

Figure RE21. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401687

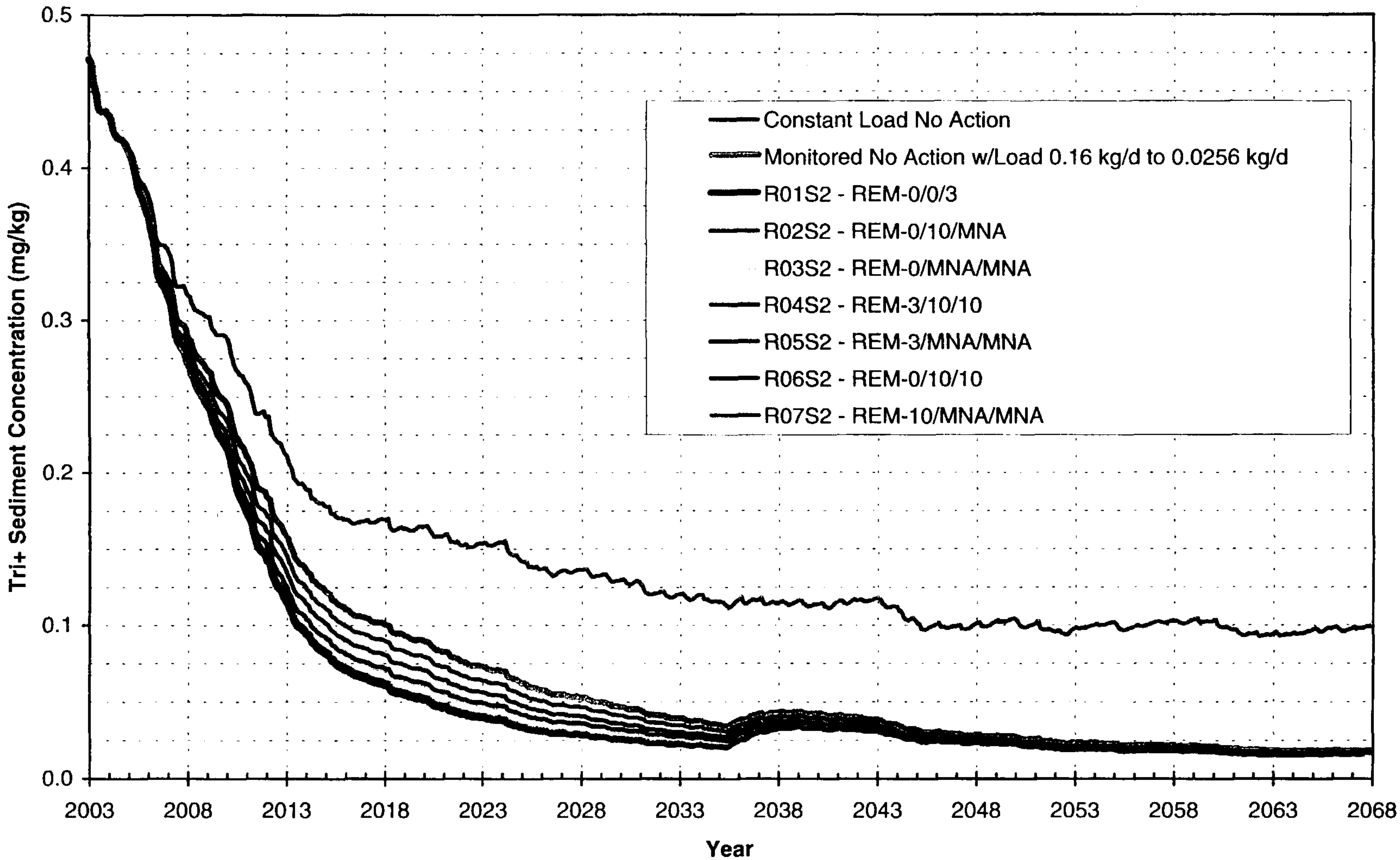
Figure RE22. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401688

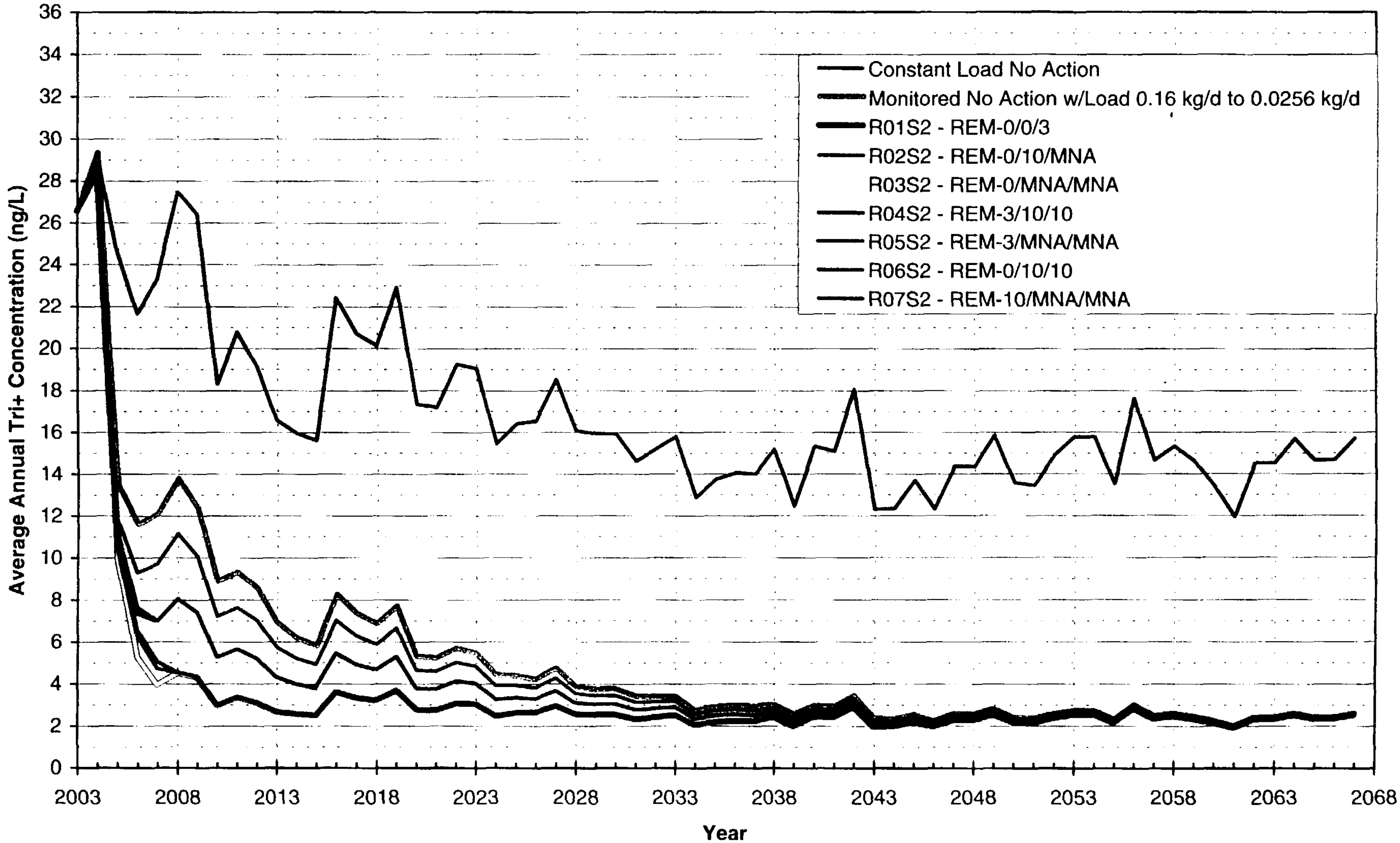
Fig. RE15_thru_RE28 11/16/00

Figure RE23. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Step Down Upstream Load Conditions



401689

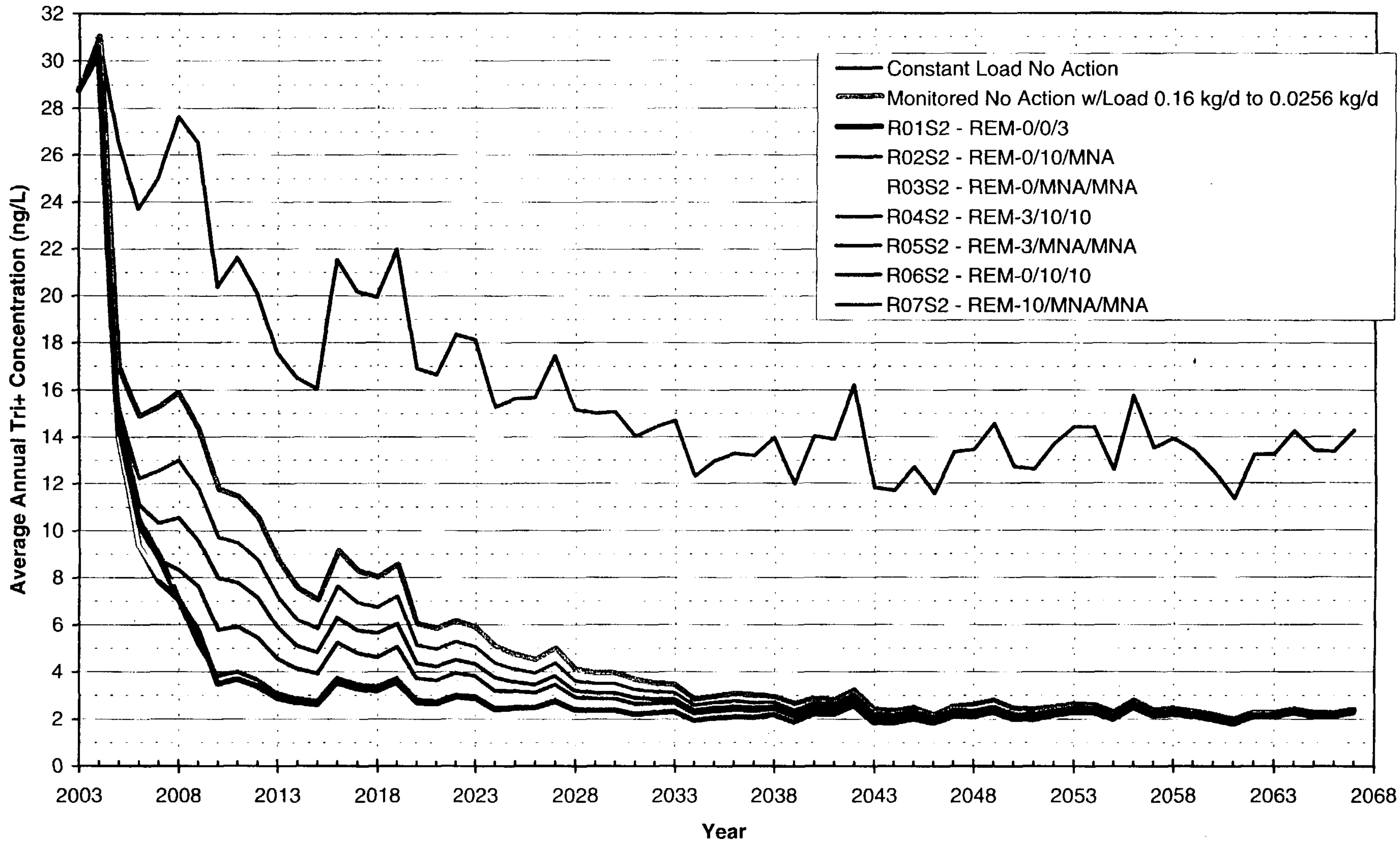
Figure RE24. Comparison Between Water Column Forecasts at Thompson Island Dam - Step Down Upstream Load Conditions



401690

Fig_RE15_thru_RE28 11/16/00

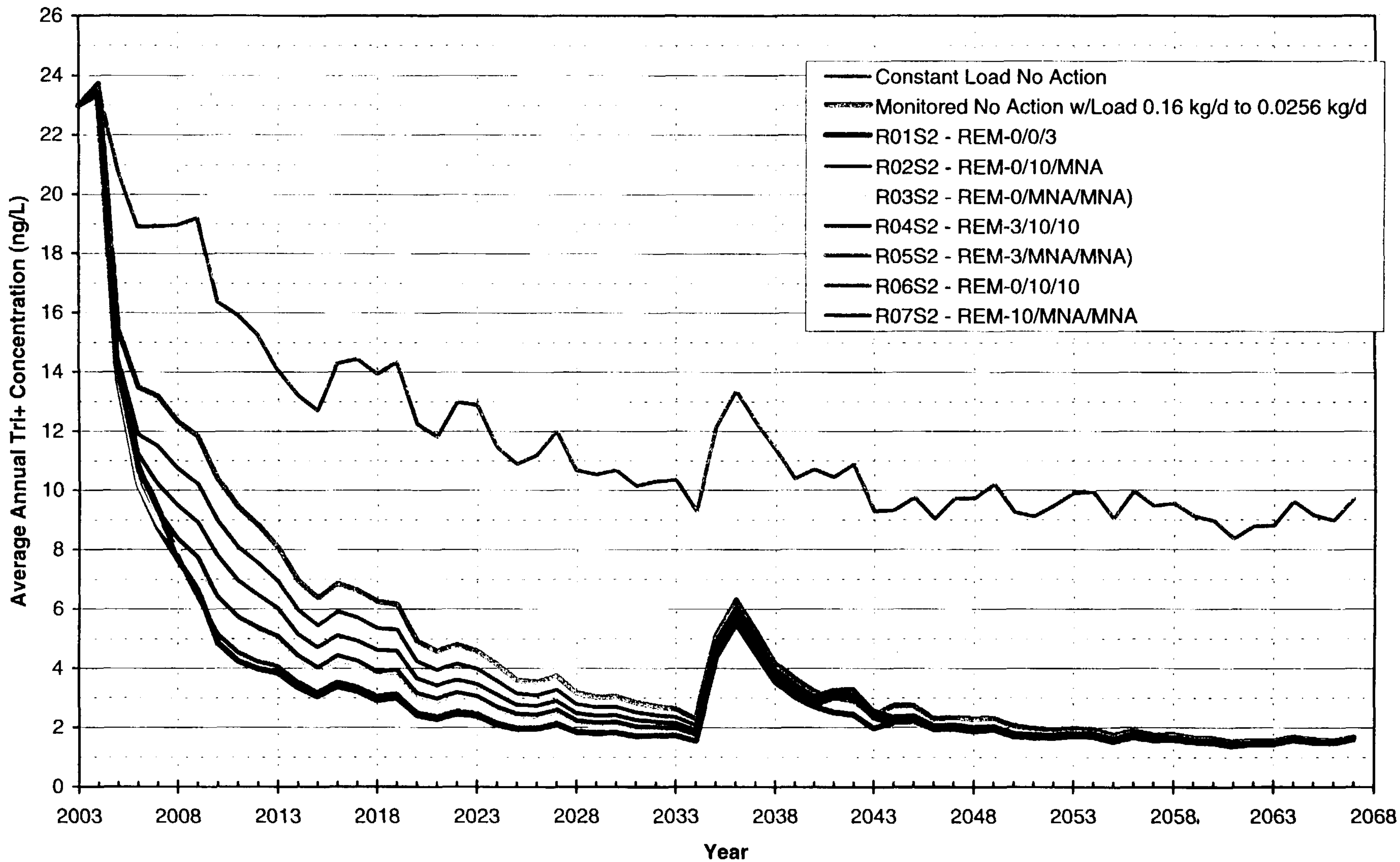
Figure RE25. Comparison Between Water Column Forecasts at Northumberland Dam - Step Down Upstream Load Conditions



401691

Fig_RE15_thru_RE28 11/16/00

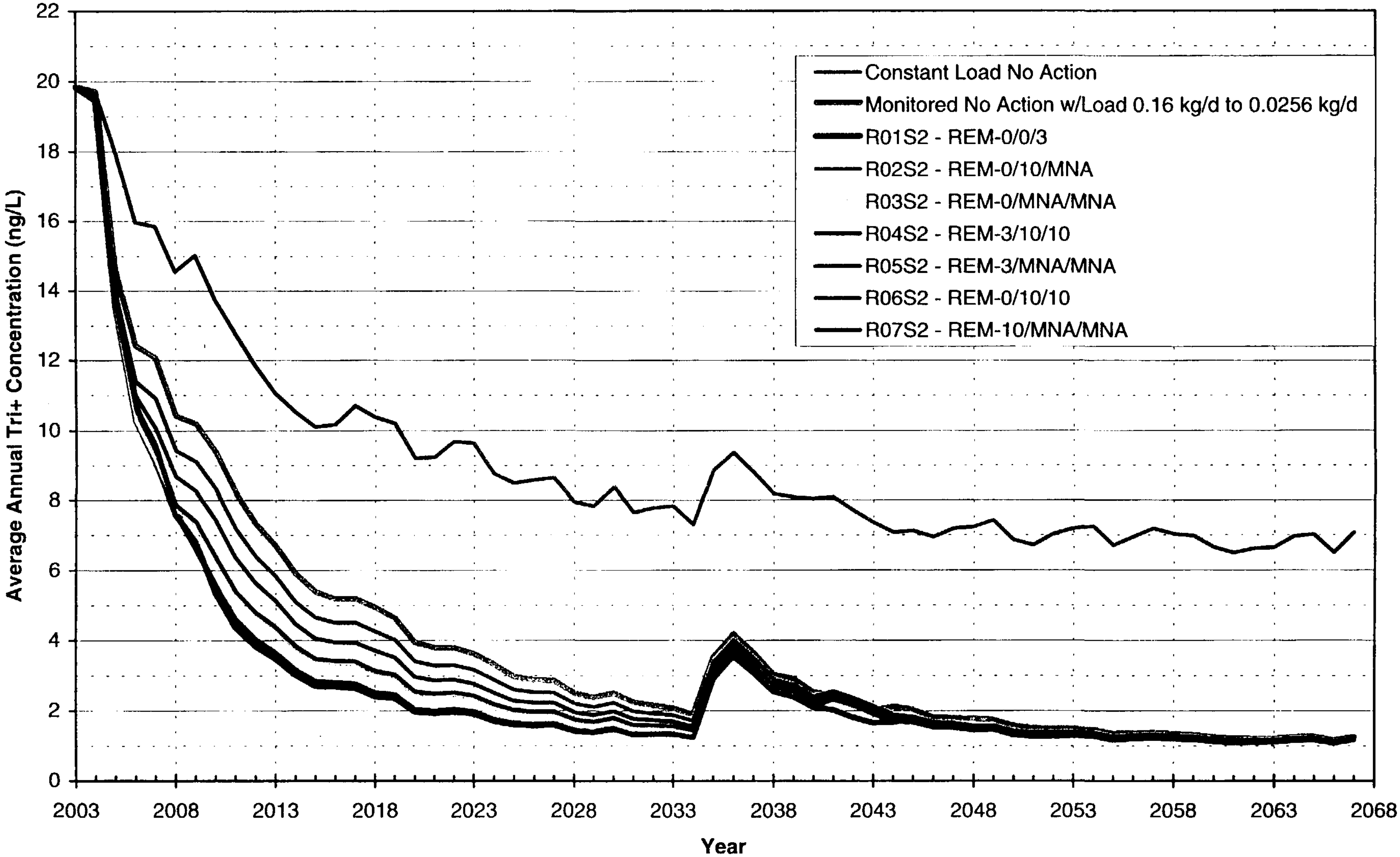
Figure RE26. Comparison Between Water Column Forecasts at Stillwater - Step Down Upstream Load Conditions



401692

Fig_RE15_thru_RE28 11/16/00

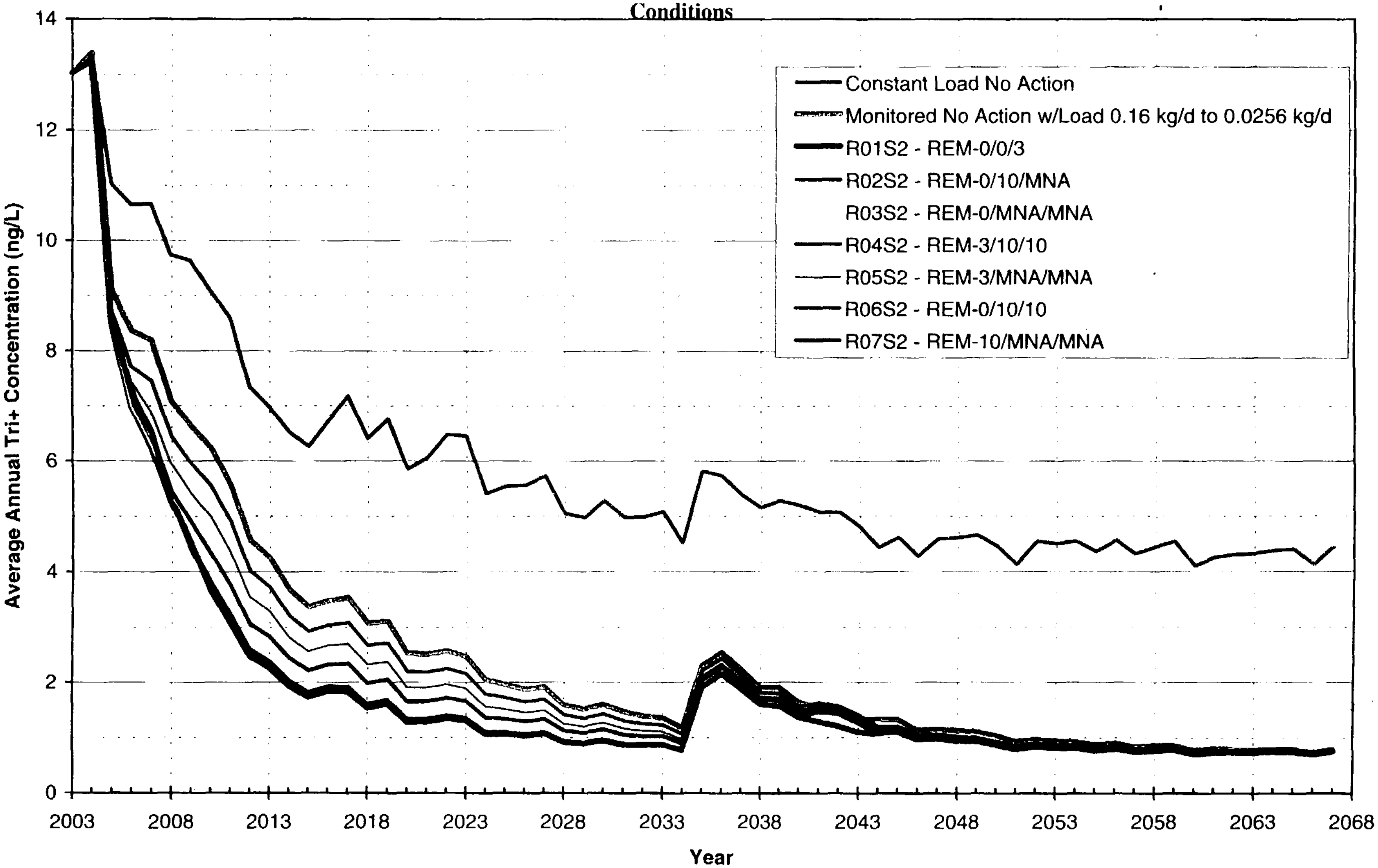
Figure RE27. Comparison Between Water Column Forecasts at Waterford - Step Down Upstream Load Conditions



401693

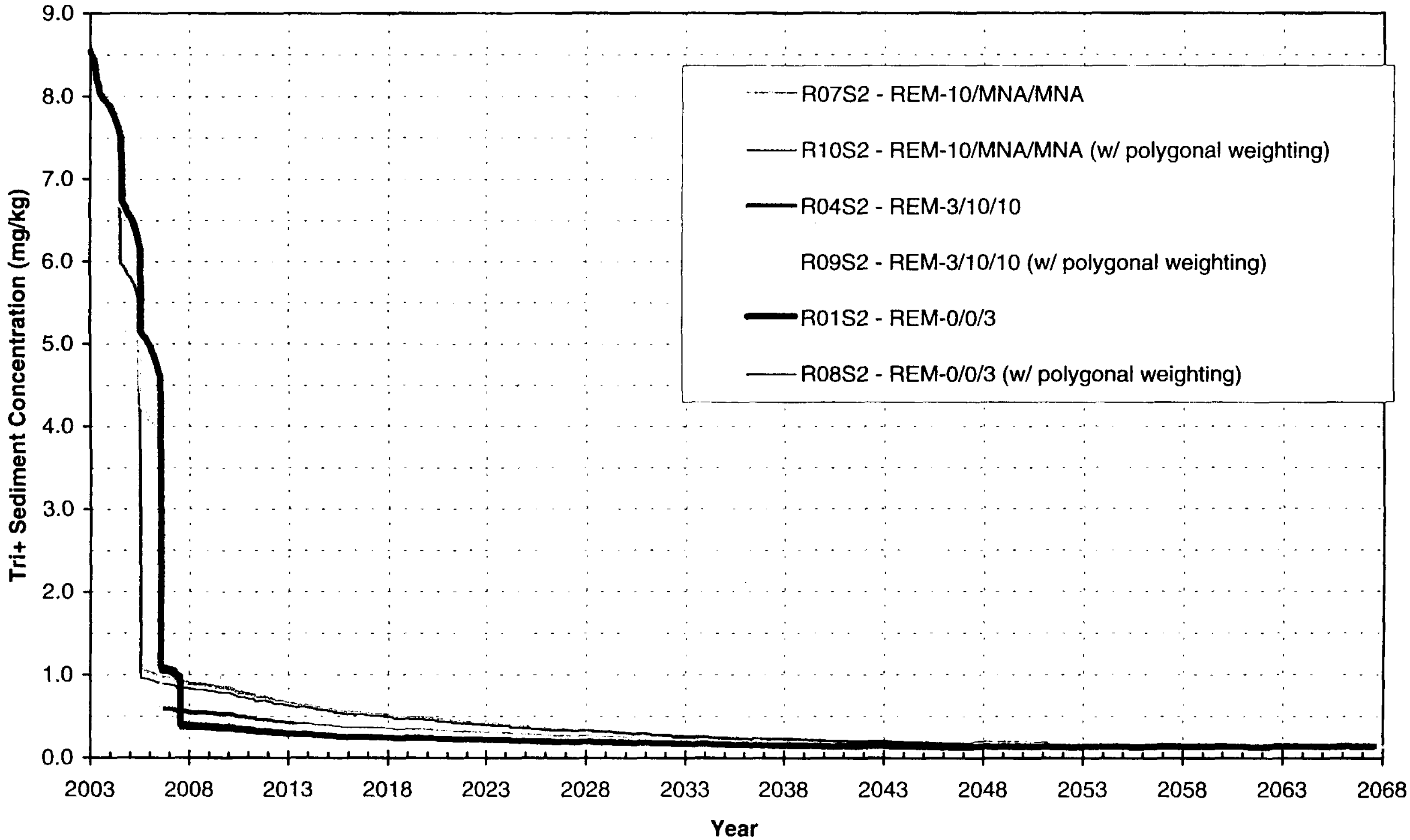
Fig_RE15_thru_RE28 11/16/00

Figure RE28. Comparison Between Water Column Forecasts at Federal Dam - Step Down Upstream Load Conditions



401694

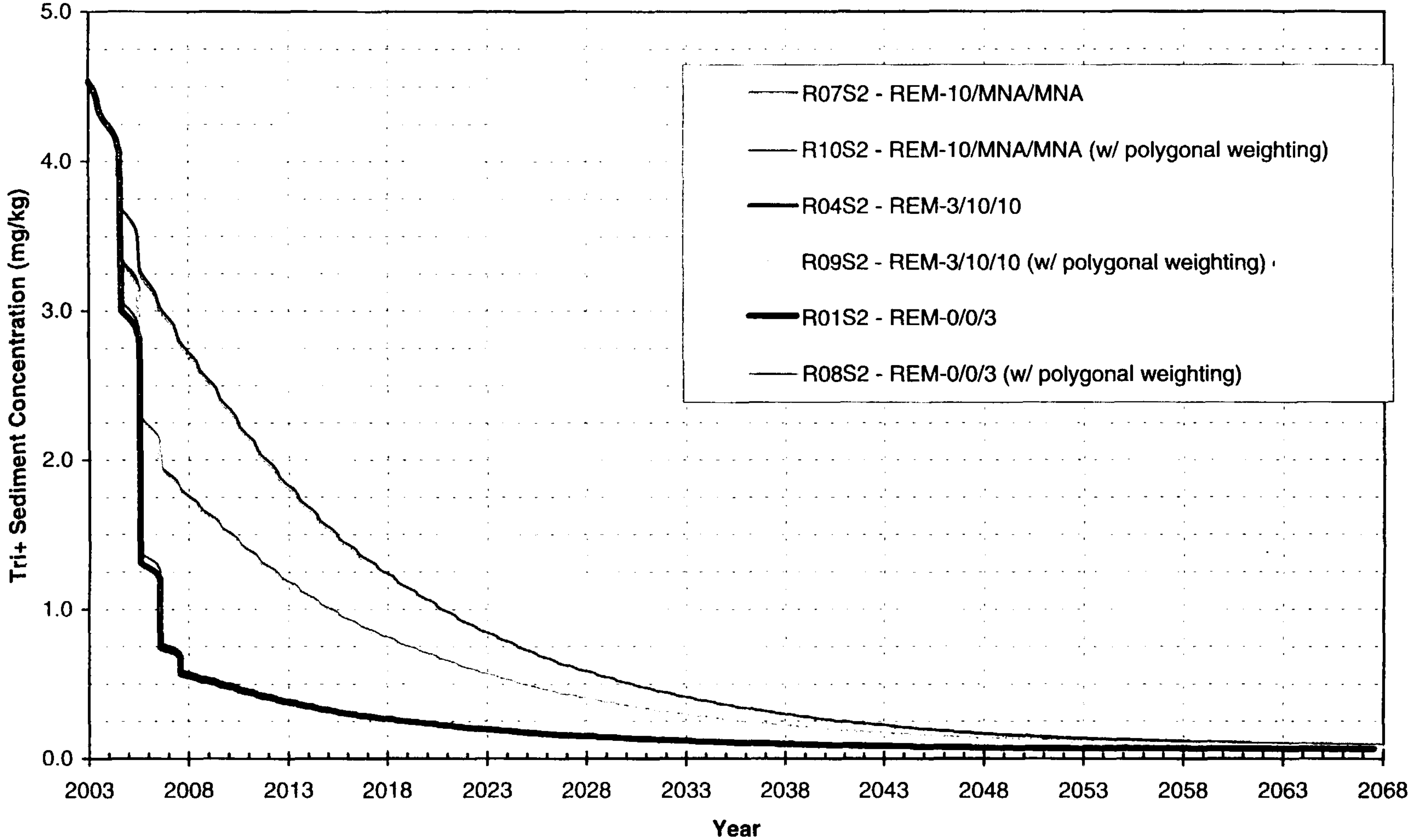
Figure RE29. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401695

Fig_RE29_thru_RE42 11/16/00

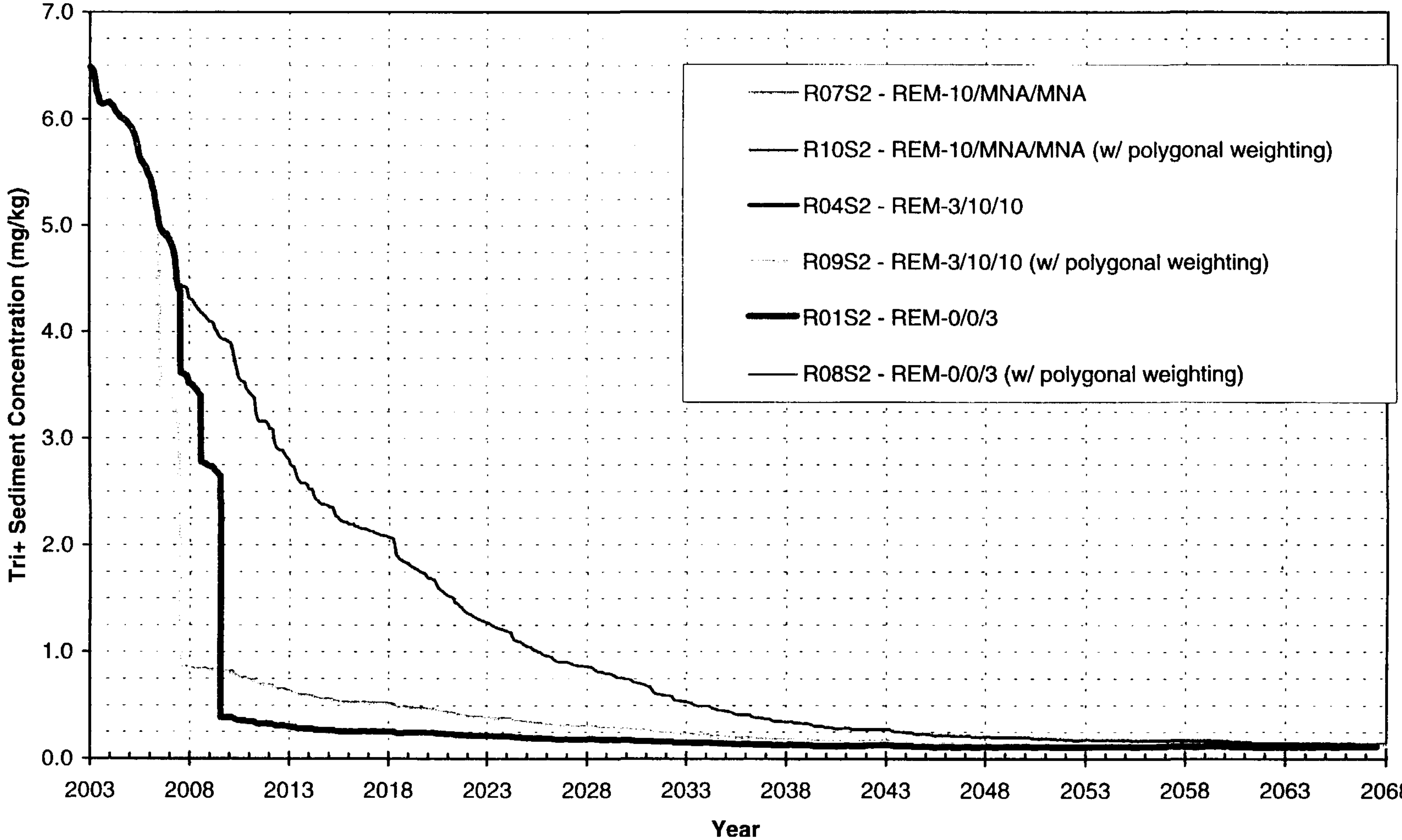
Figure RE30. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401696

Fig_RE29_thru_RE42 11/16/00

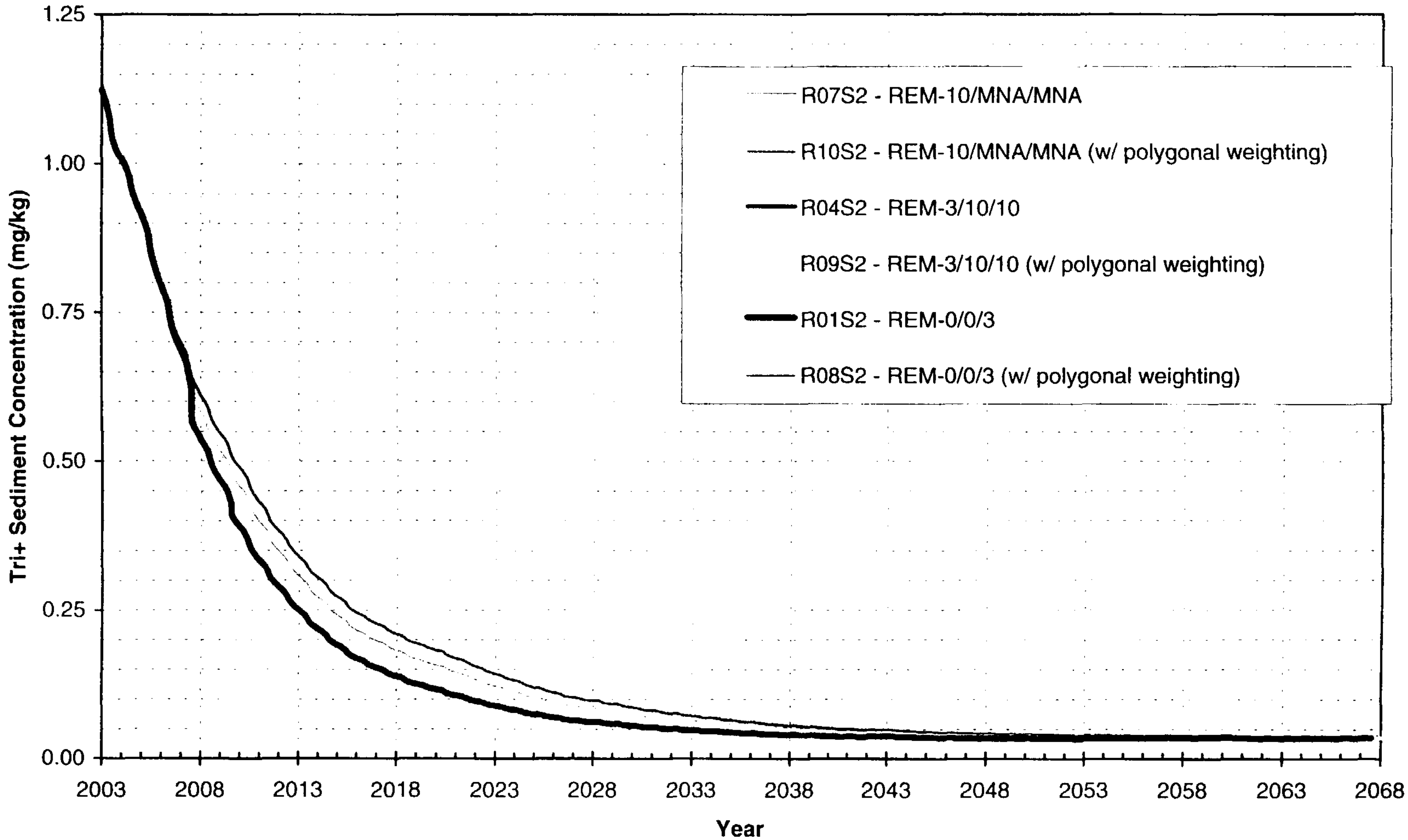
Figure RE31. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401697

Fig_RE29_thru_RE42 11/16/00

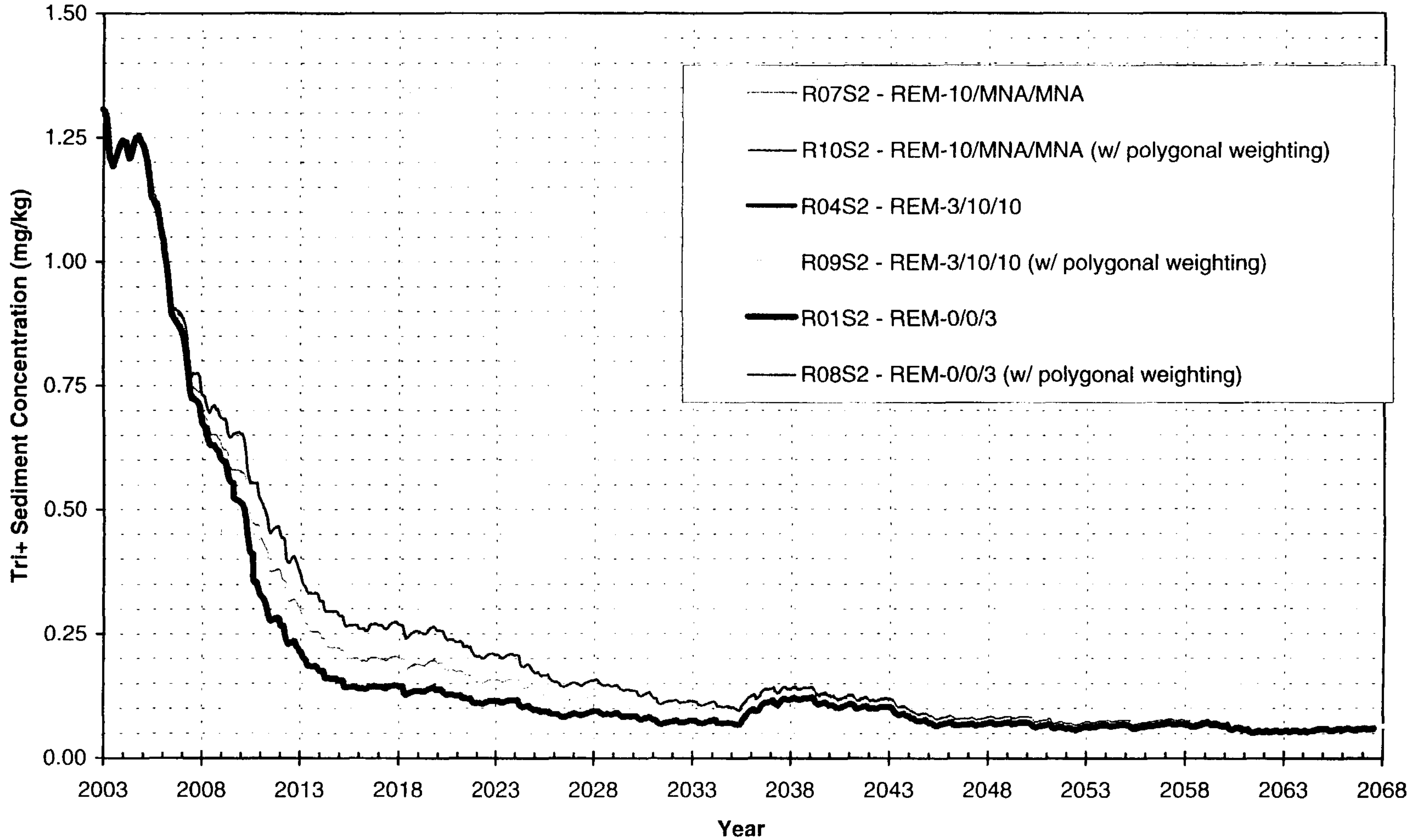
Figure RE32. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401698

Fig_RE29_thru_RE42 11/16/00

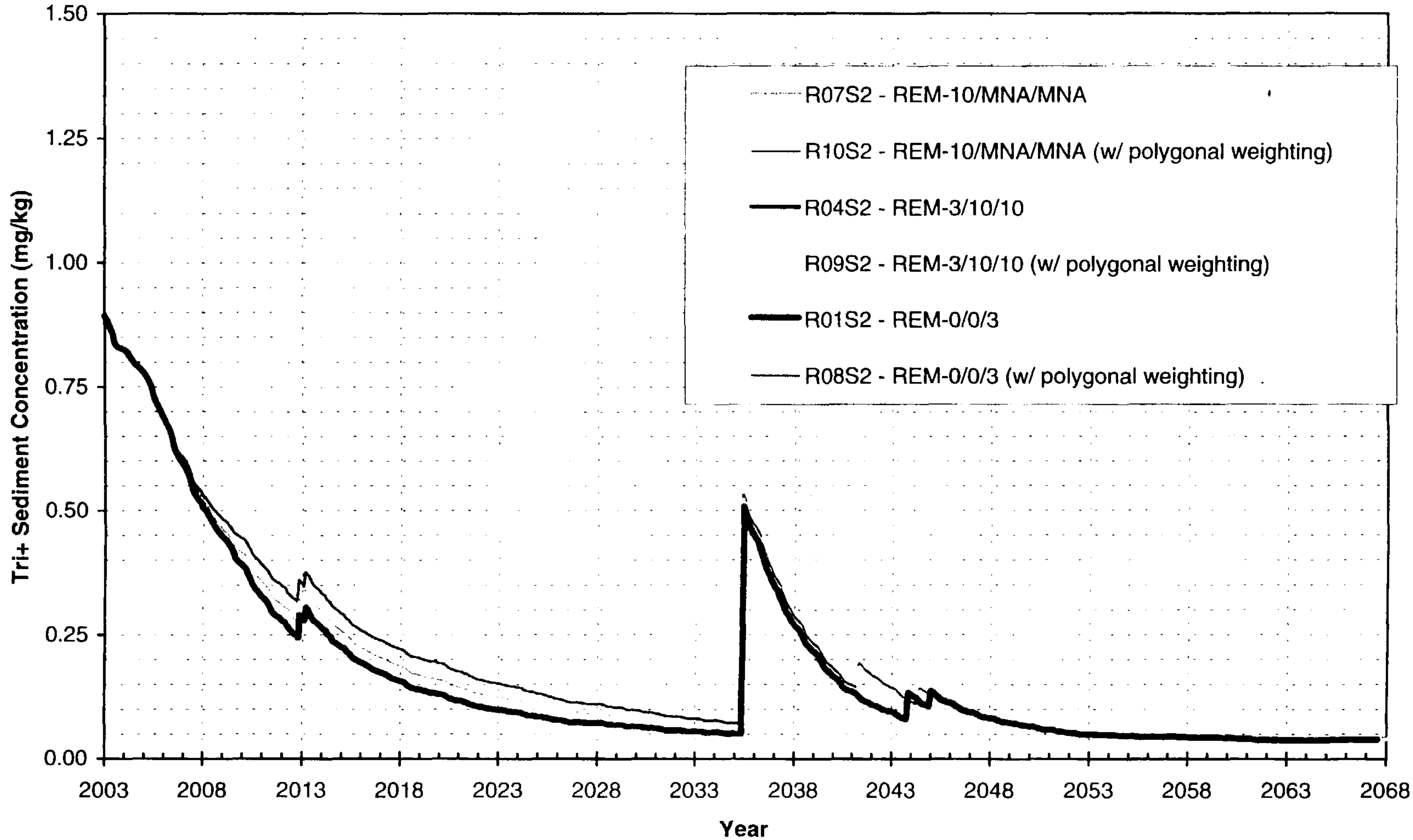
Figure RE33. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401699

Fig_RE29_thru_RE42 11/16/00

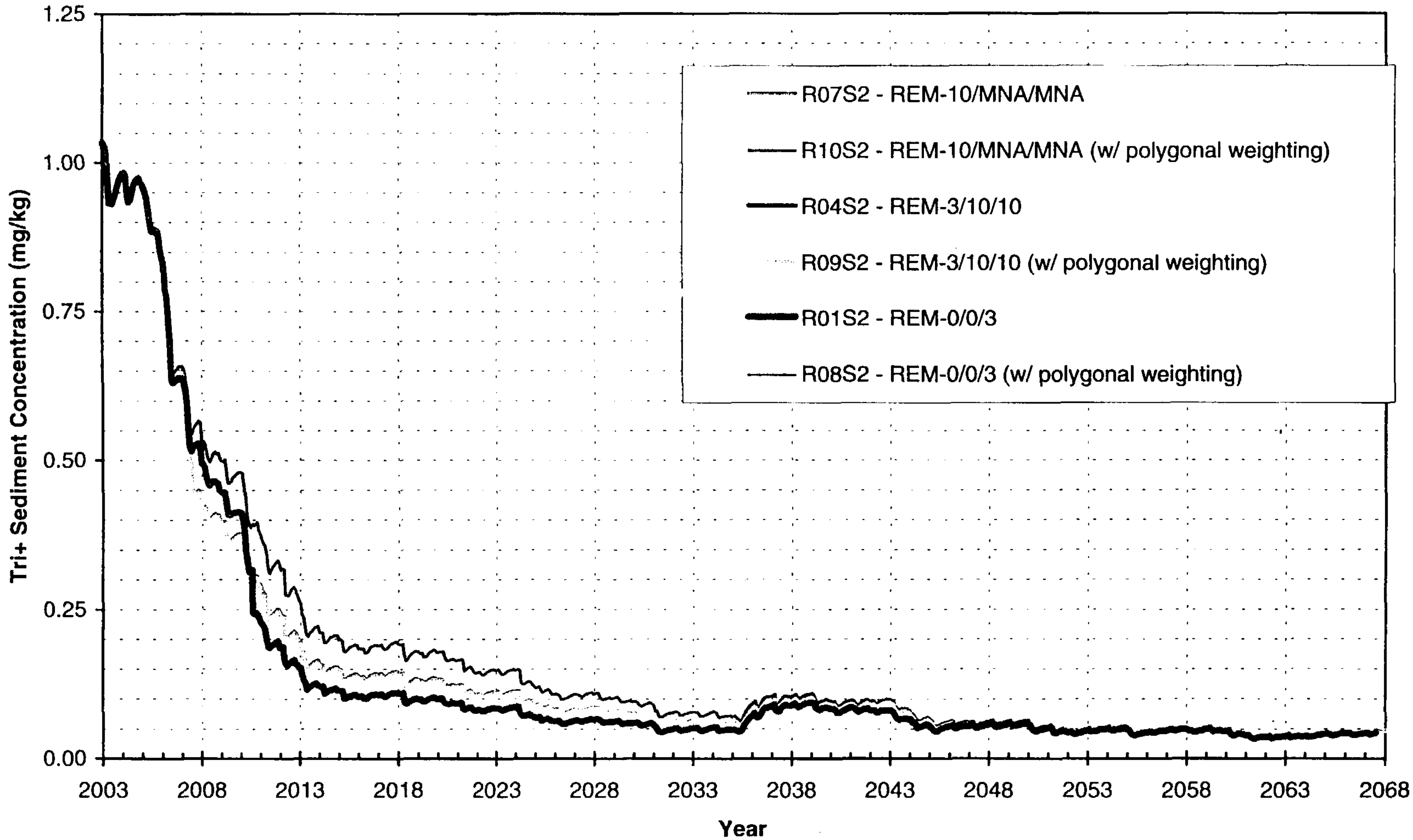
Figure RE34. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401700

Fig_RE29_thru_RE42 11/16/00

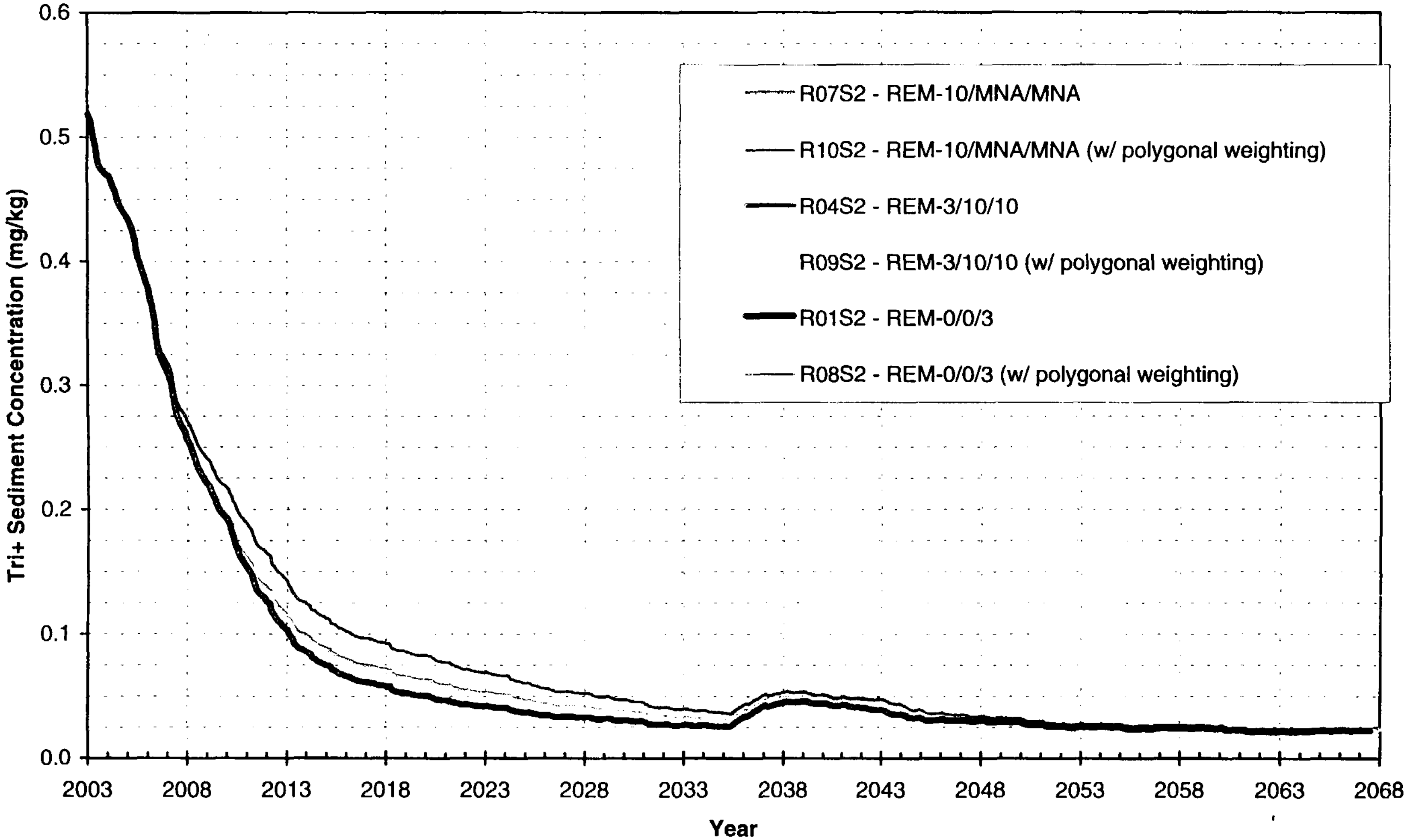
Figure RE35. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401701

Fig_RE29_thru_RE42 11/16/00

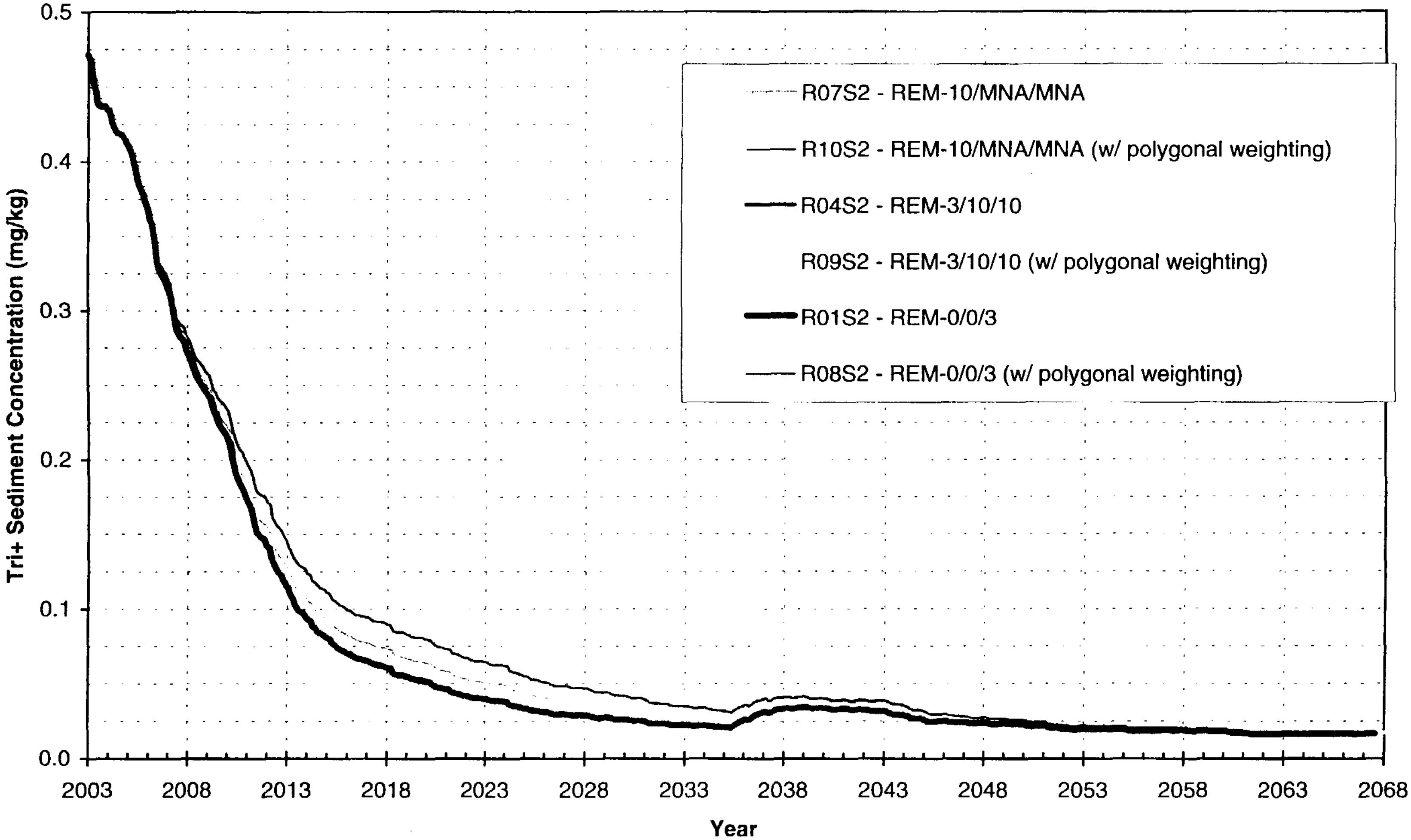
Figure RE36. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401702

Fig_RE29_thru_RE42 11/16/00

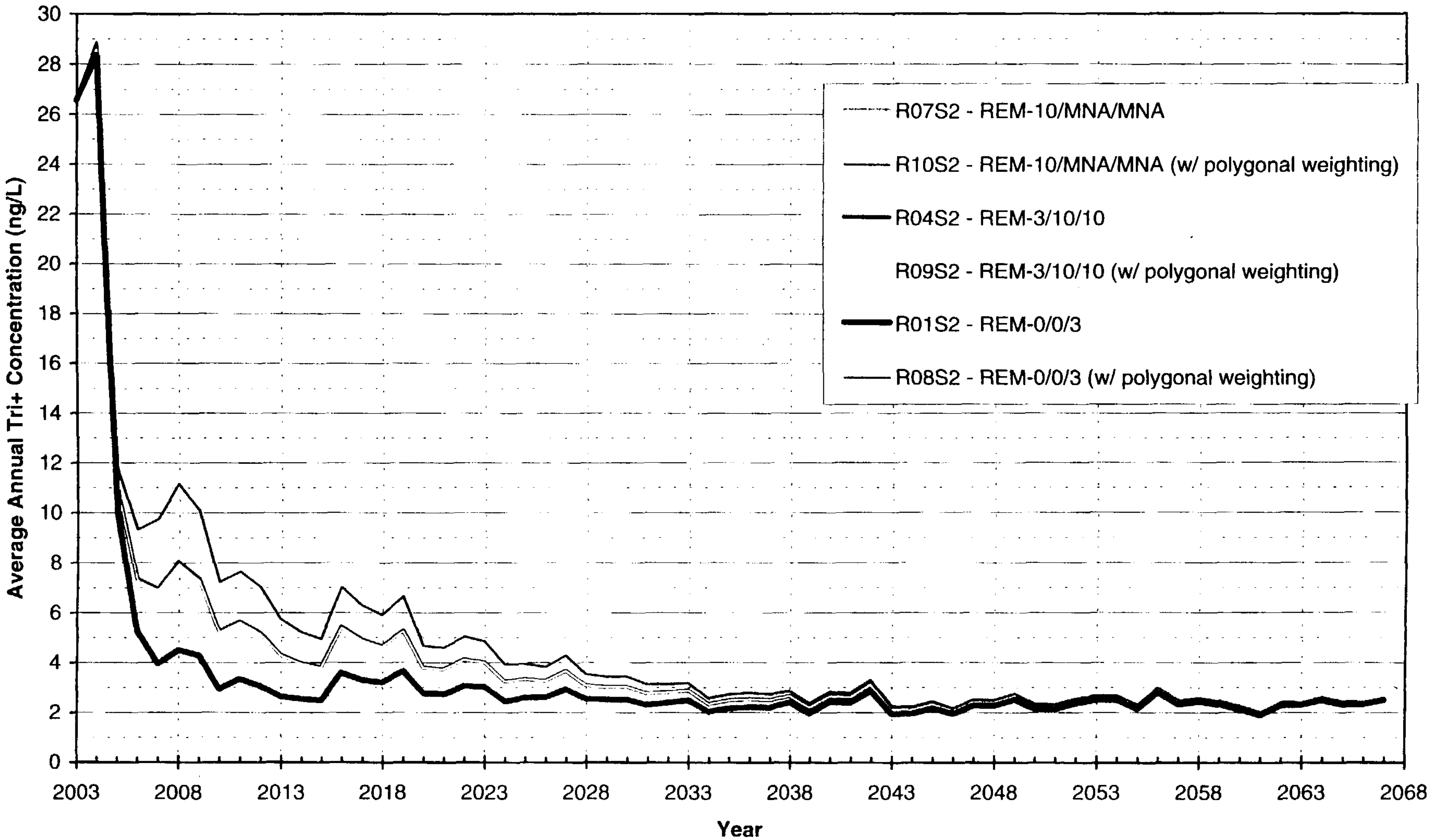
Figure RE37. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401703

Fig_RE29 thru_RE42 11/16/00

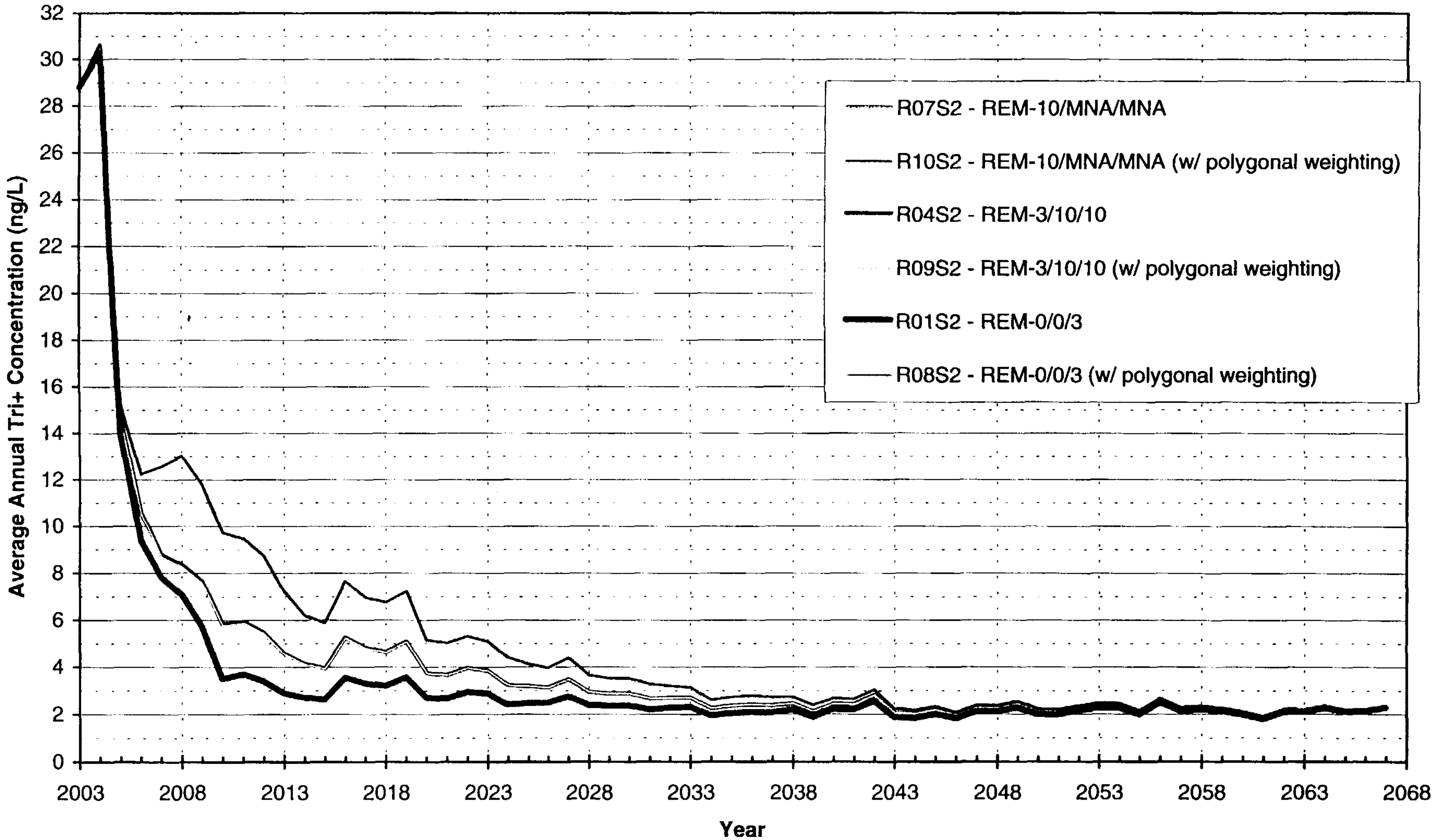
Figure RE38. Comparison Between Water Column Forecasts at Thompson Island Dam - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401704

Fig_RE29_thru_RE42 11/16/00

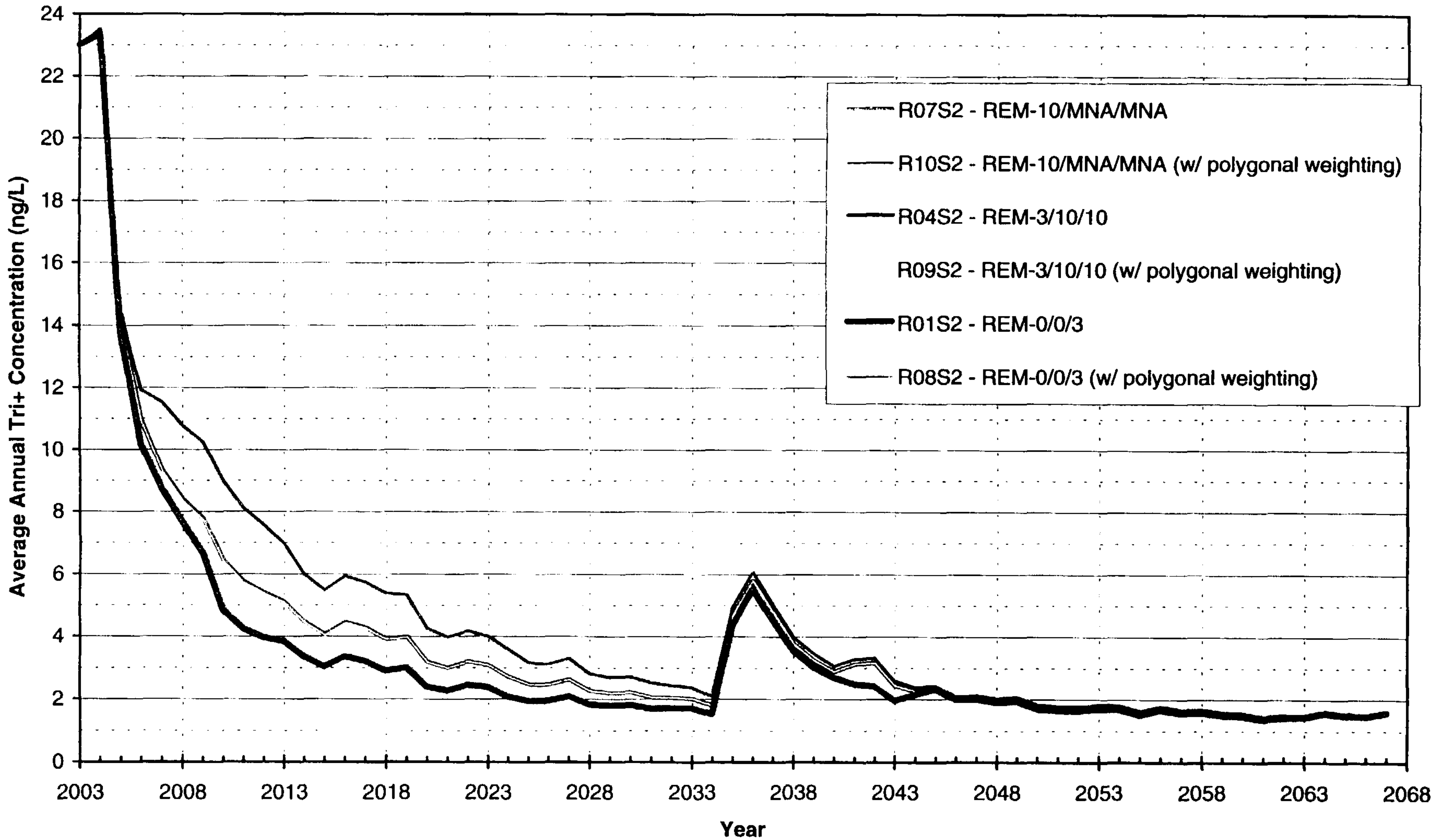
Figure RE39. Comparison Between Water Column Forecasts at Northumberland Dam - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401705

Fig_RE29_thru_RE42 11/16/00

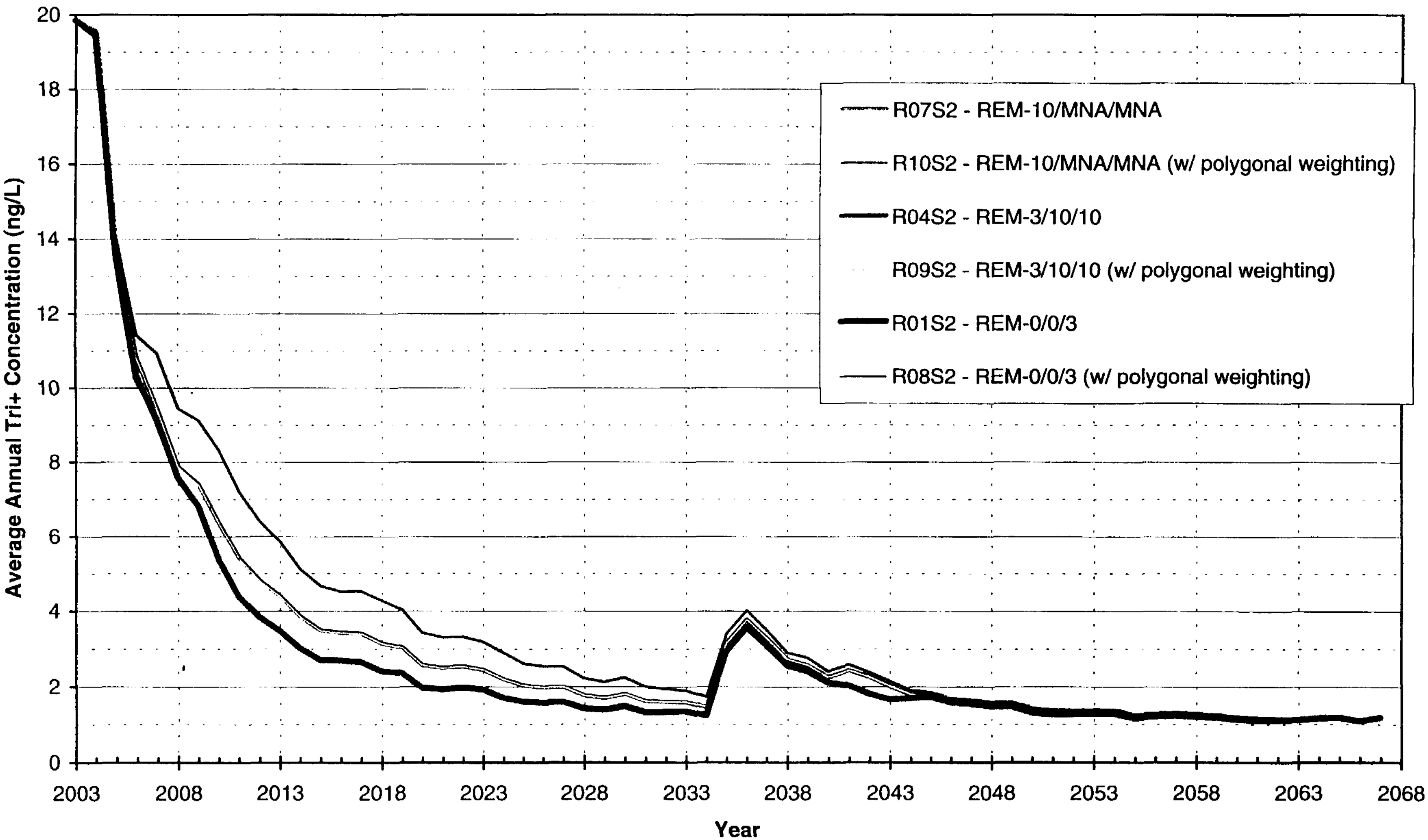
Figure RE40. Comparison Between Water Column Forecasts at Stillwater - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401706

Fig_RE29_thru_RE42 11/16/00

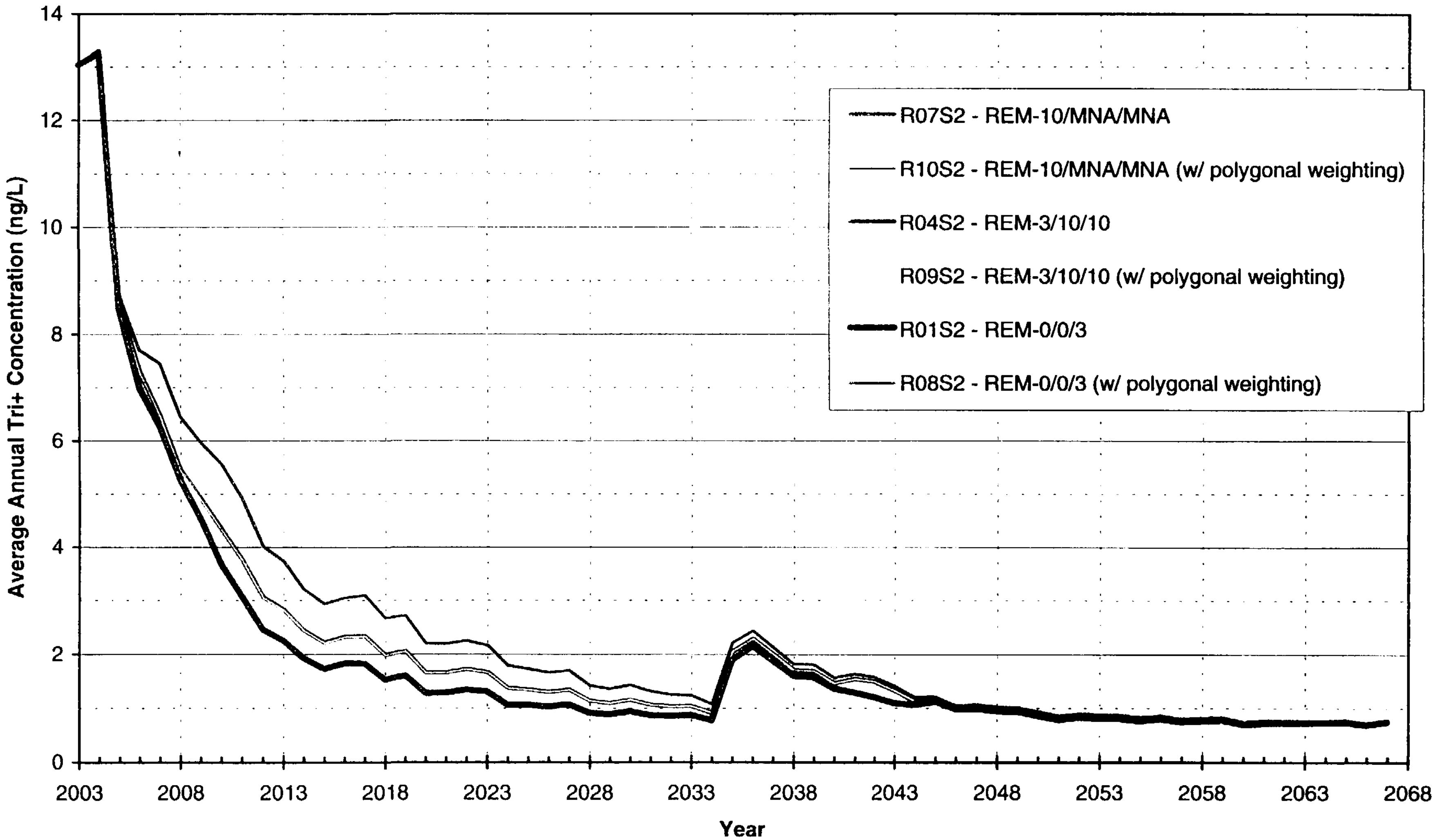
Figure RE41. Comparison Between Water Column Forecasts at Waterford - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401707

Fig_RE29_thru_RE42 11/16/00

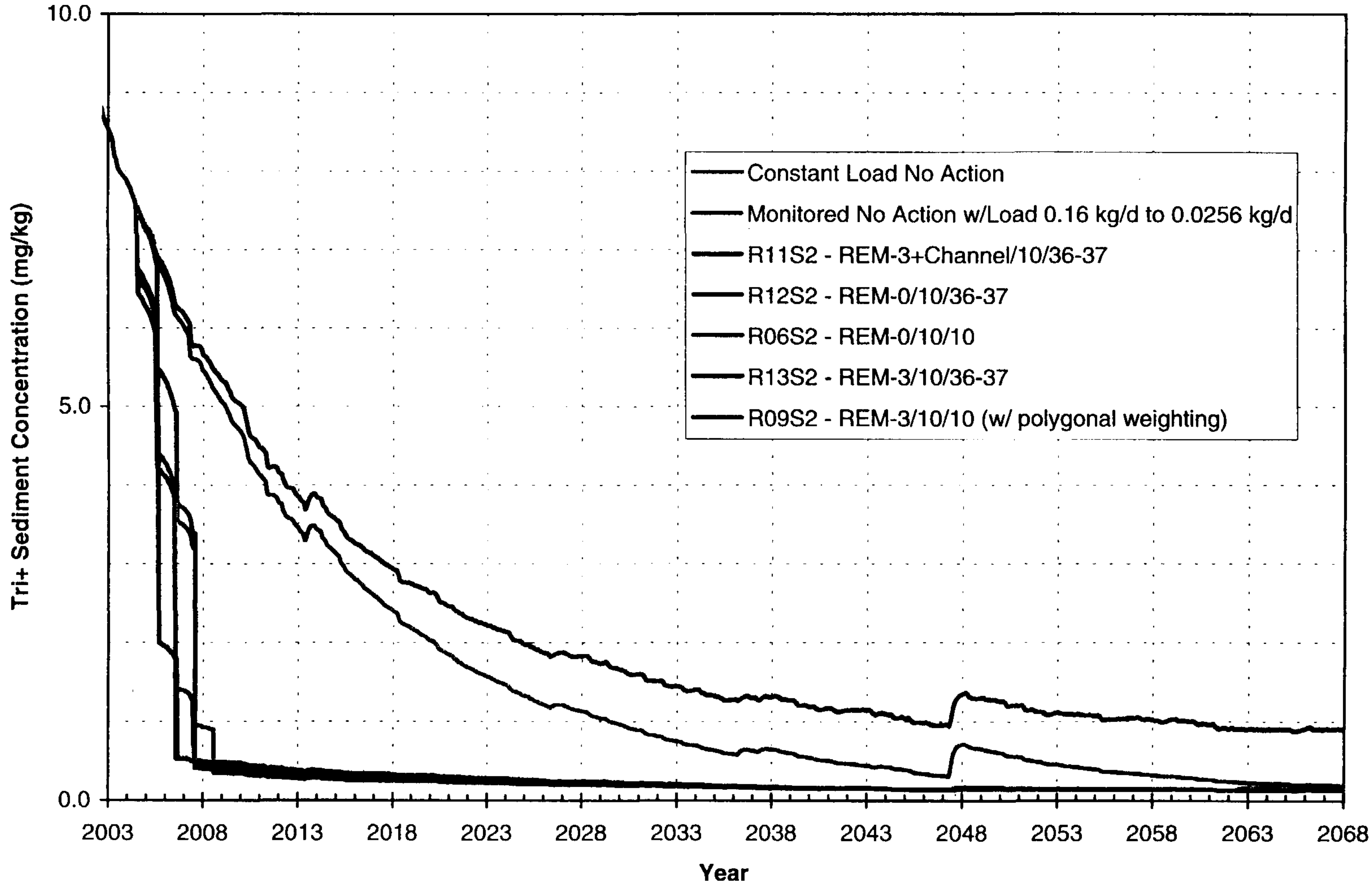
Figure RE42. Comparison Between Water Column Forecasts at Federal Dam - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401708

Fig_RE29_thru_RE42 11/16/00

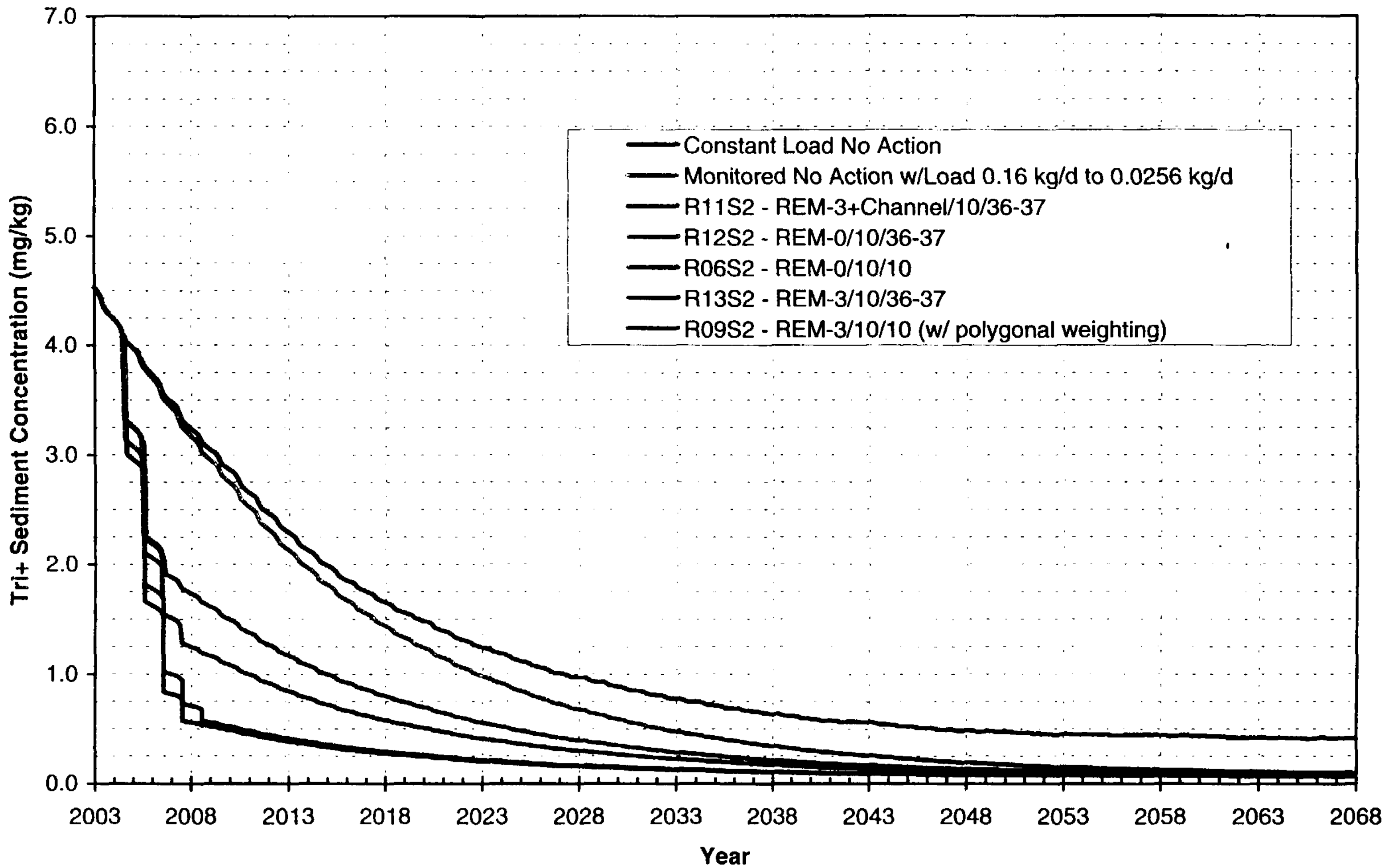
Figure RE43. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



401709

FIG_RE43_THRU_RE56 11/16/00

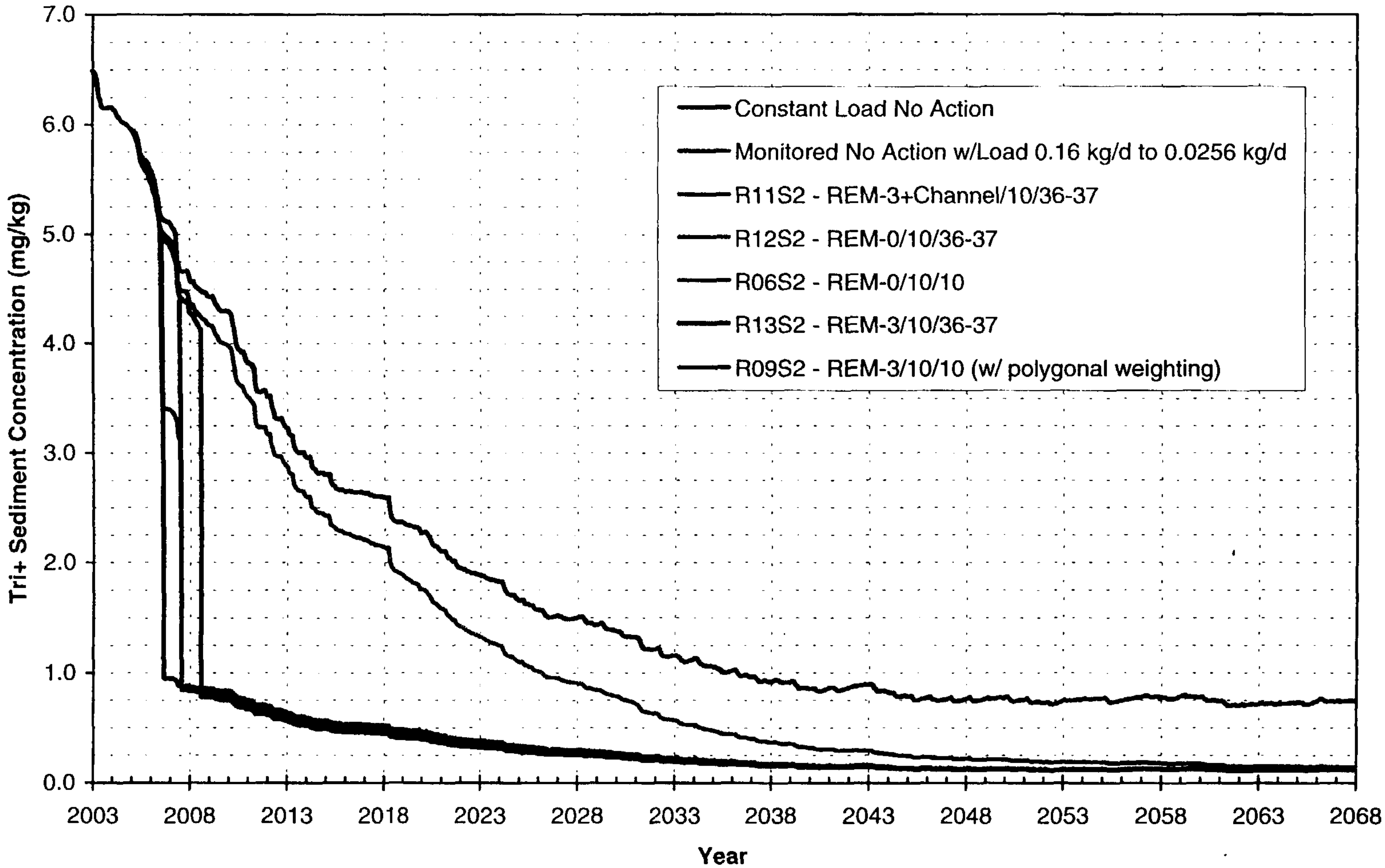
Figure RE44. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments- Channel Dredging in River Section 1/River Section 3 Removal



401710

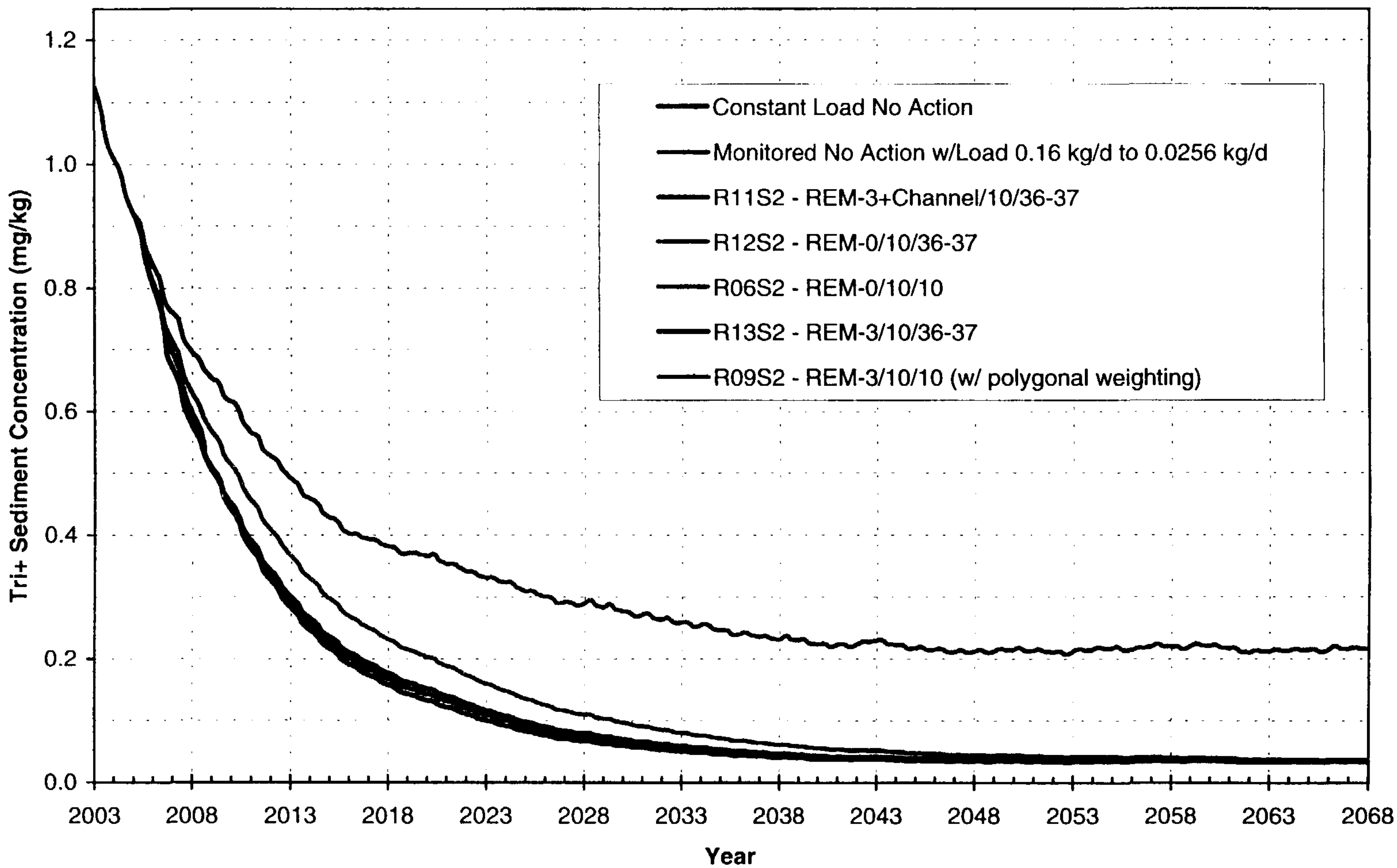
FIG_RE43_THRU_RE56 11/16/00

Figure RE45. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments-Channel Dredging in River Section 1/River Section 3 Removal



401711

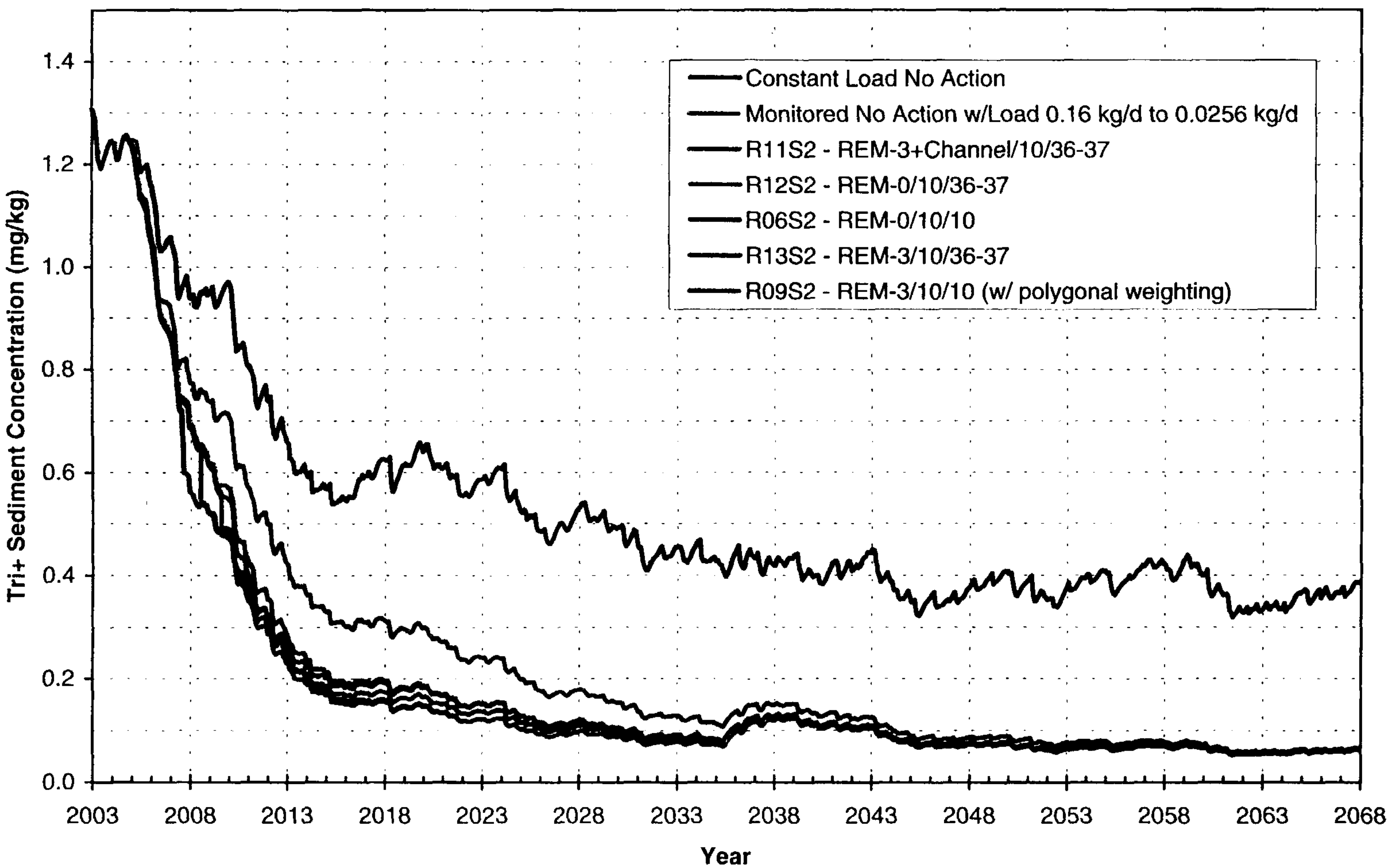
Figure RE46. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



401712

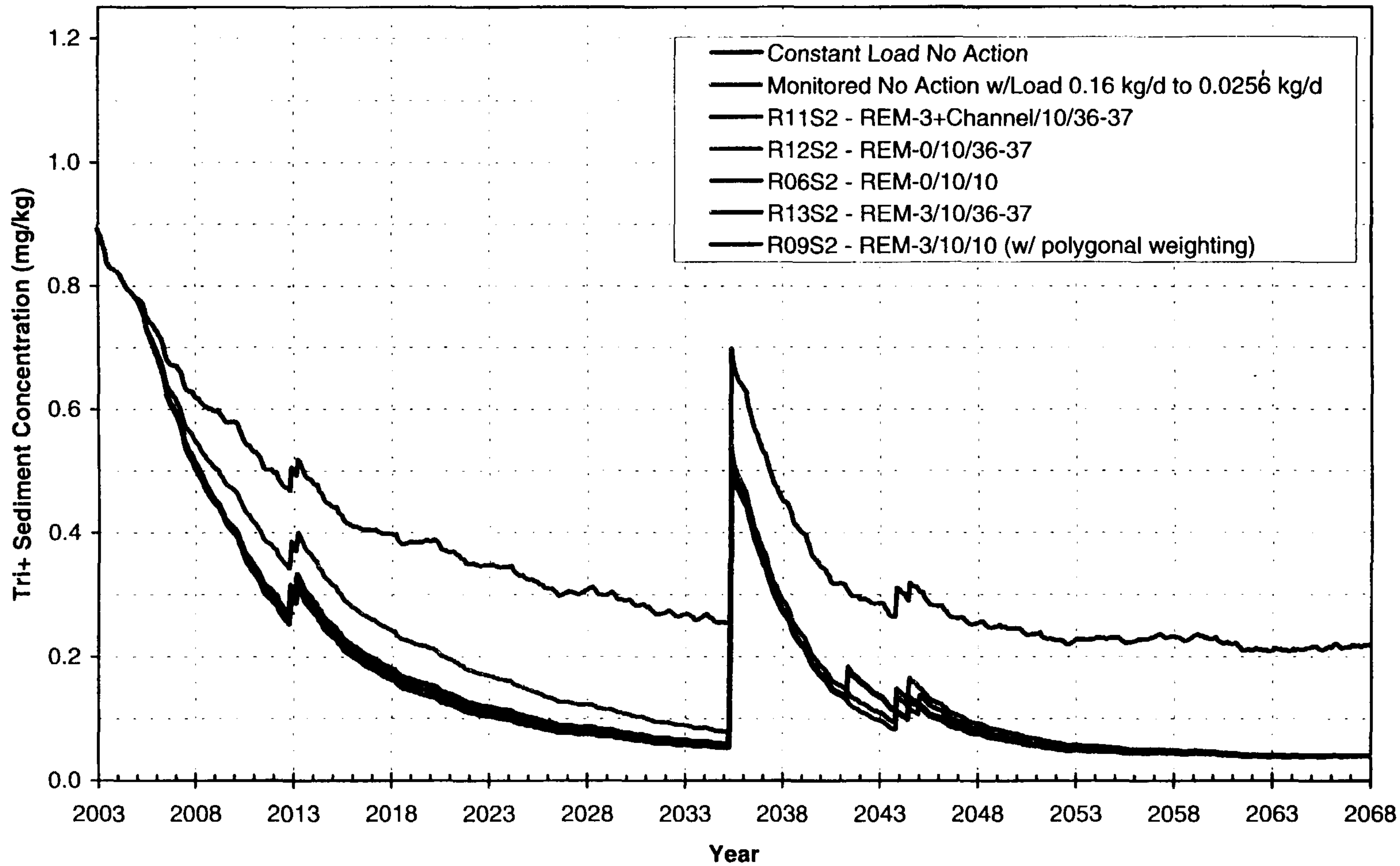
FIG_RE43_THRU_RE56 11/16/00

Figure RE47. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



401713

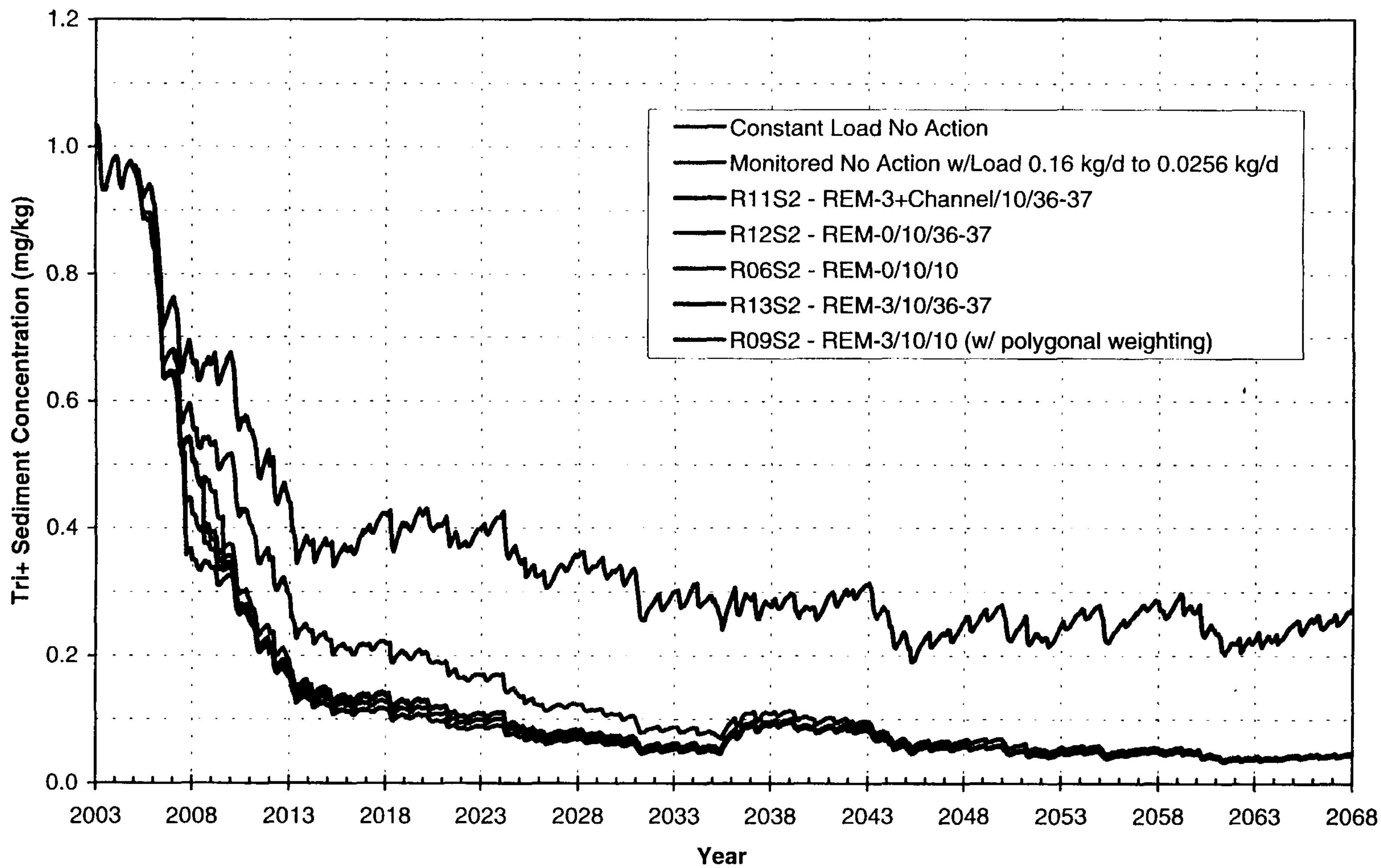
Figure RE48. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



401714

FIG RE43_THRU_RE56 11/16/00

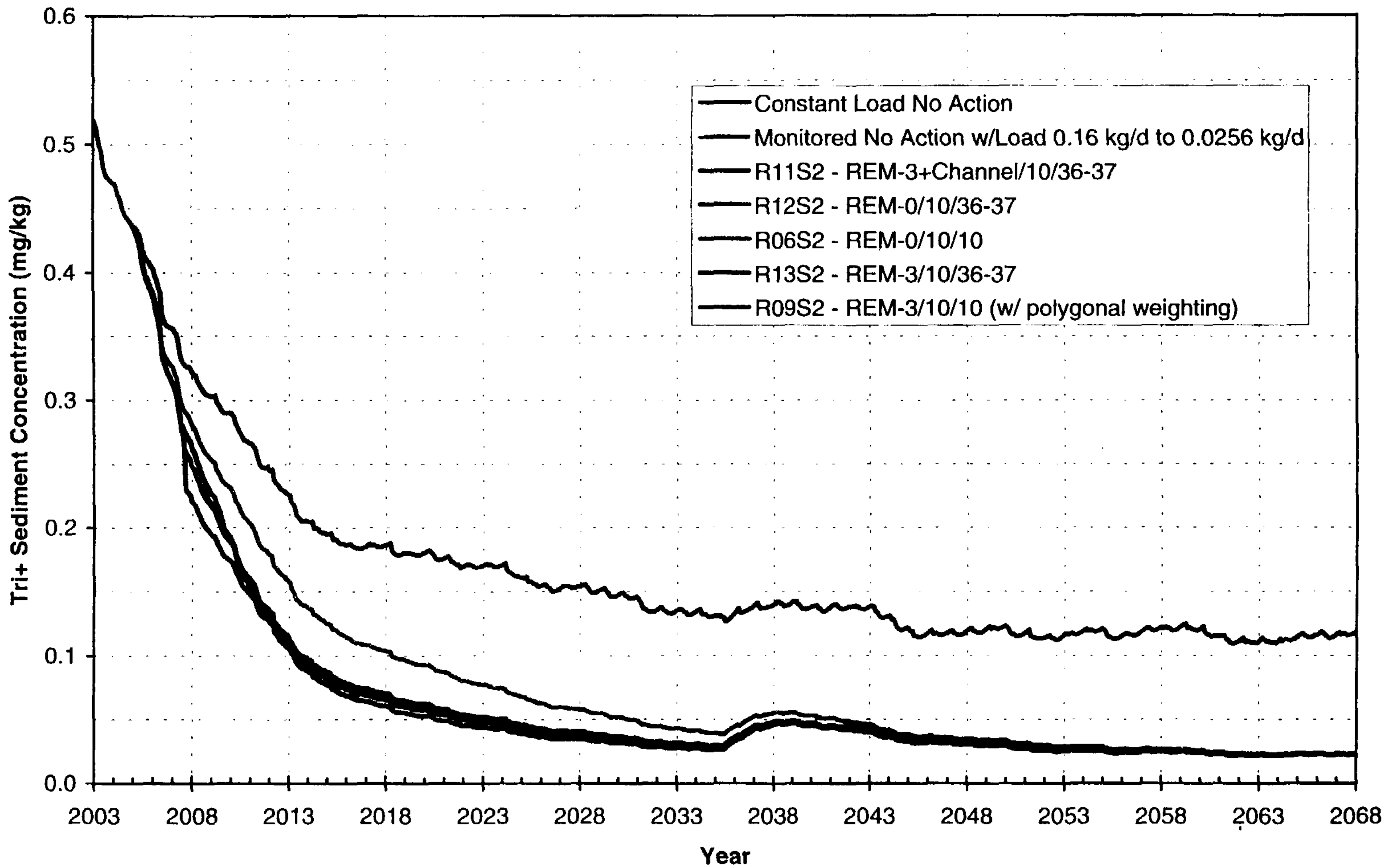
Figure RE49. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



401715

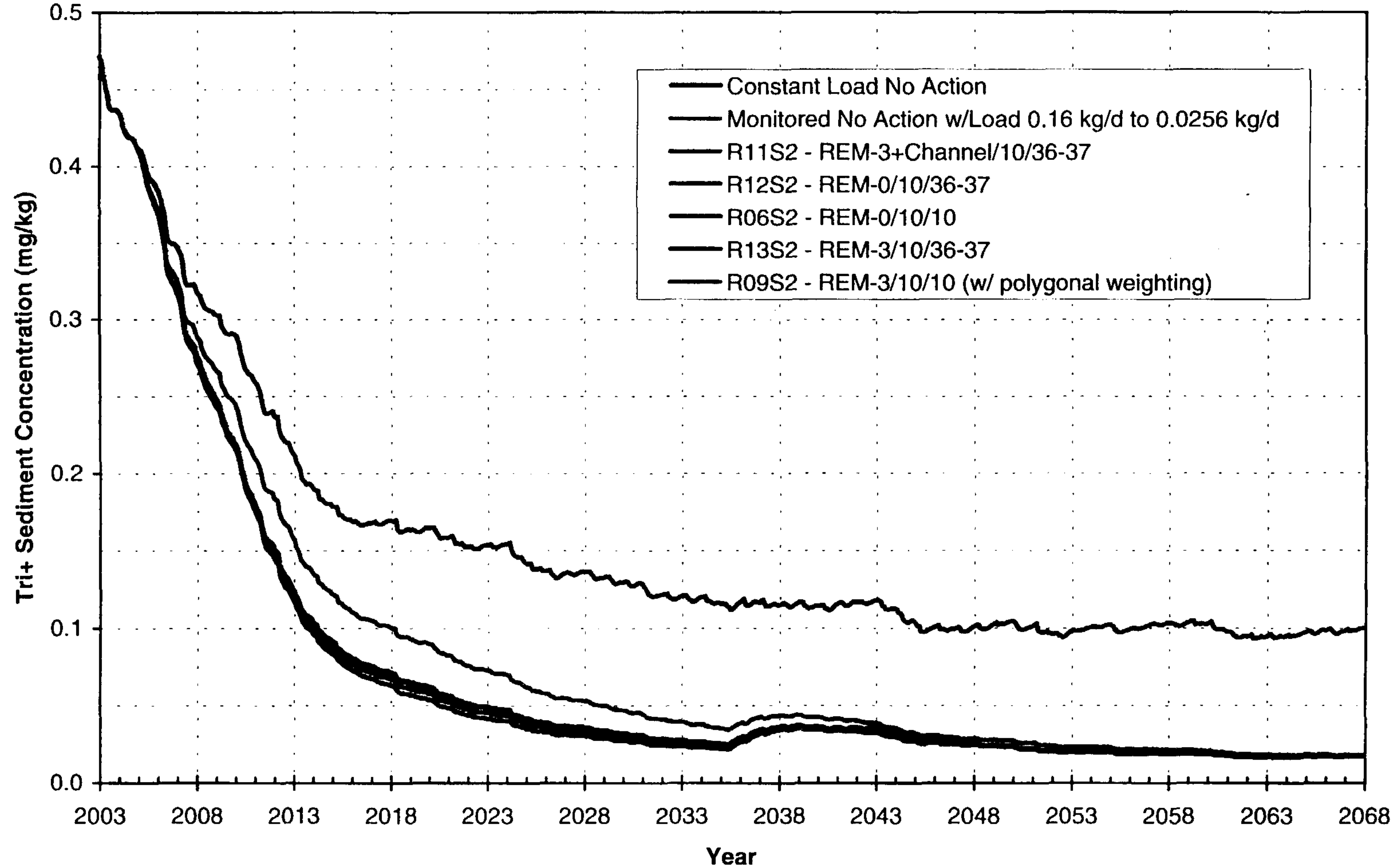
FIG_RE43_THRU_RE56 11/16/00

Figure RE50. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



FIG_RE43_THRU_RE56 11/16/00

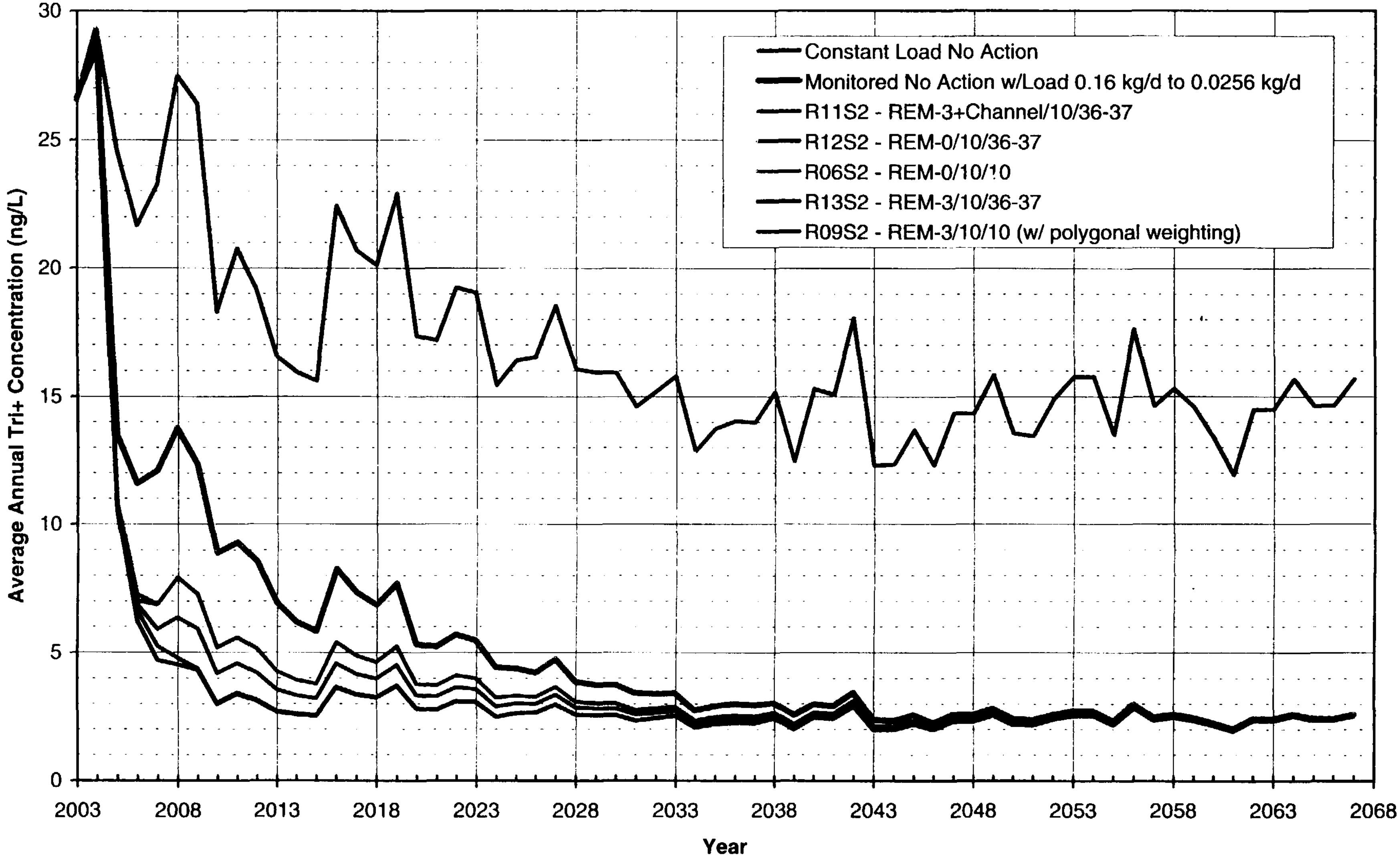
Figure RE51. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Channel Dredging in River Section 1/River Section 3 Removal



401717

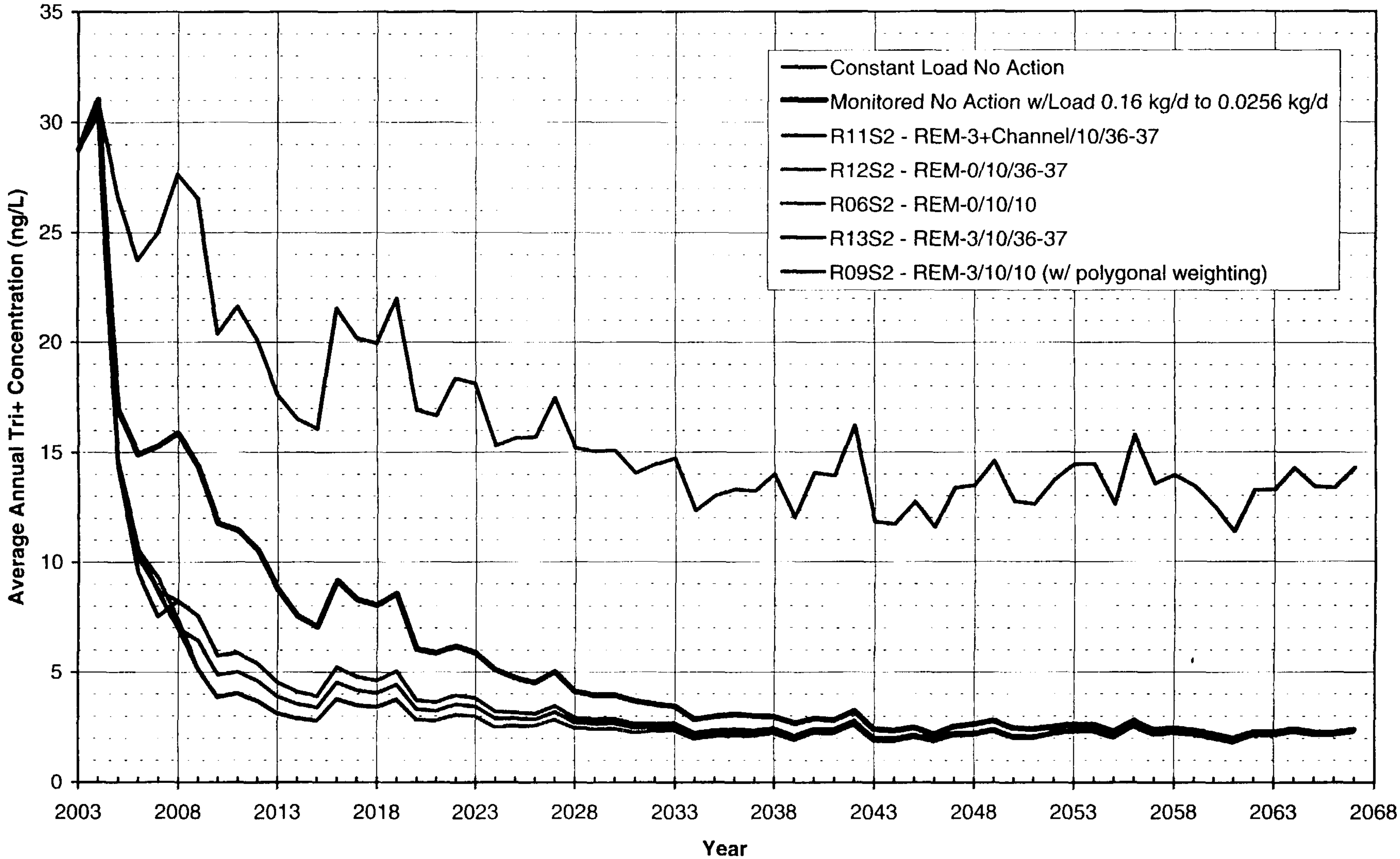
FIG_RE43_THRU_RE56 11/16/00

Figure RE52. Comparison Between Water Column Forecast at Thompson Island Dam - Channel Dredging in River Section 1/River Section 3 Removal



401718

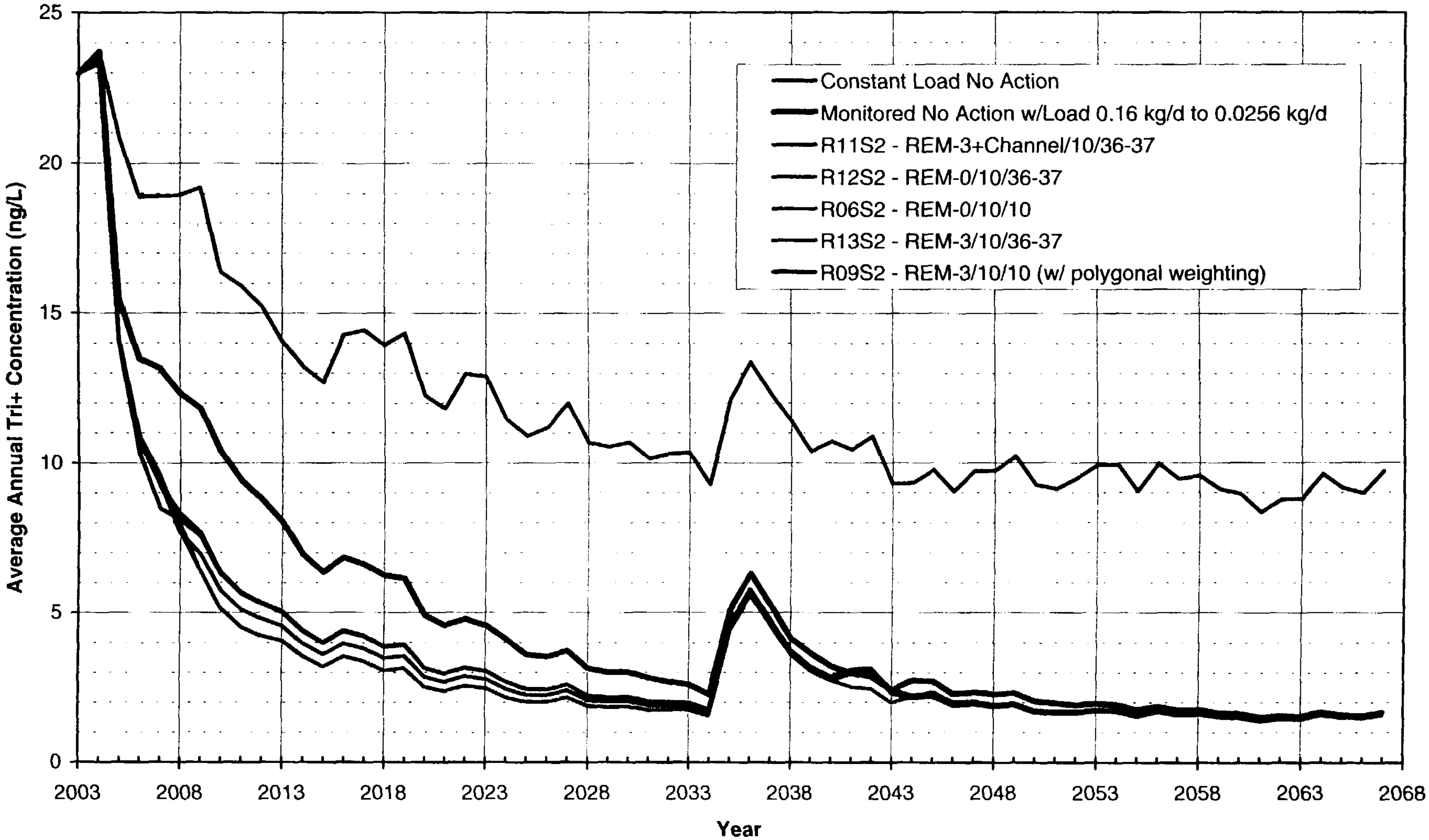
Figure RE53. Comparison Between Water Column Forecast at Northumberland Dam - Channel Dredging in River Section 1/River Section 3 Removal



401719

FIG_RE43_THRU_RE56 11/16/00

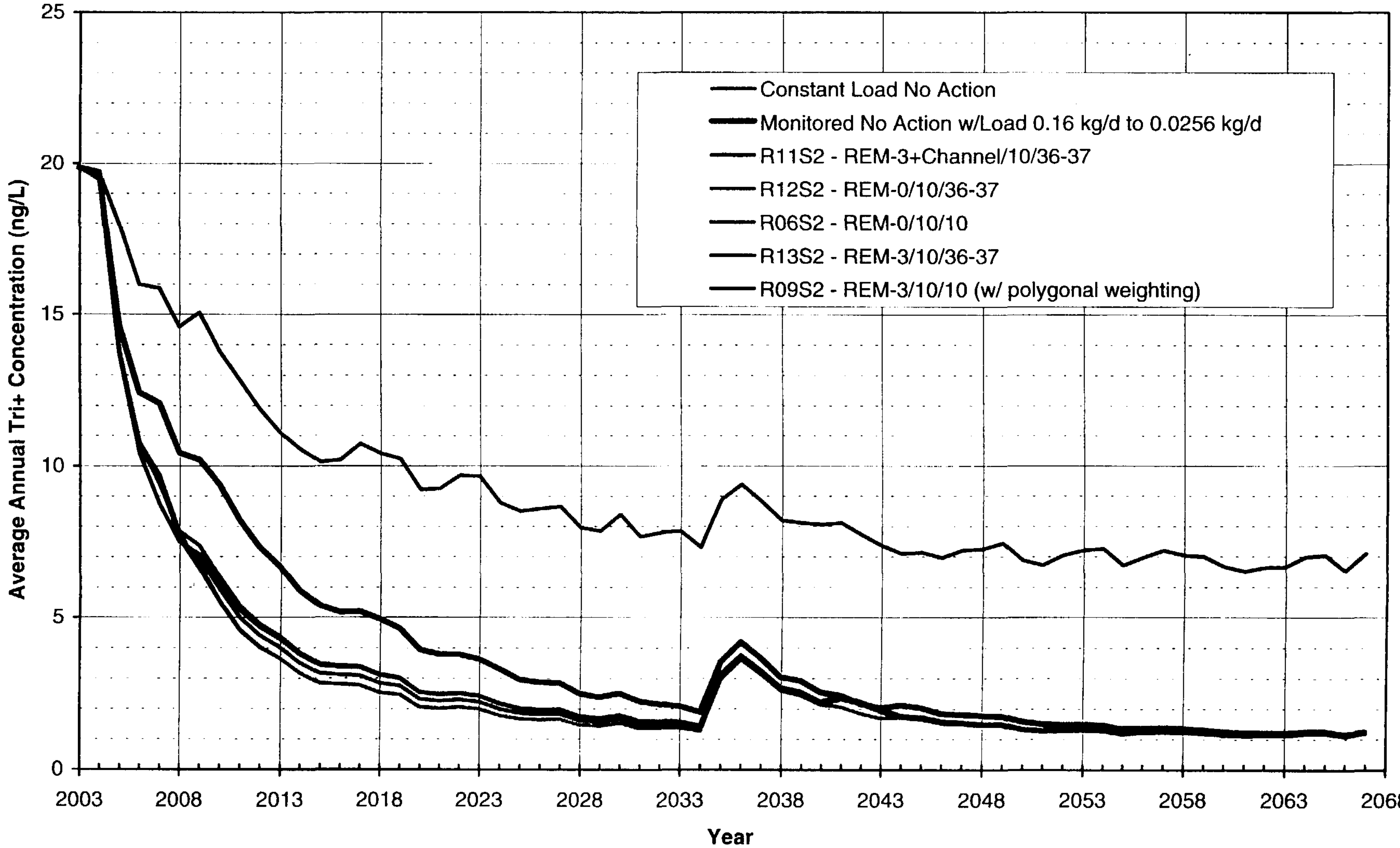
Figure RE54. Comparison Between Water Column Forecast at Stillwater - Channel Dredging in River Section 1/River Section 3 Removal



401720

FIG_RE43_THRU_RE56 11/16/00

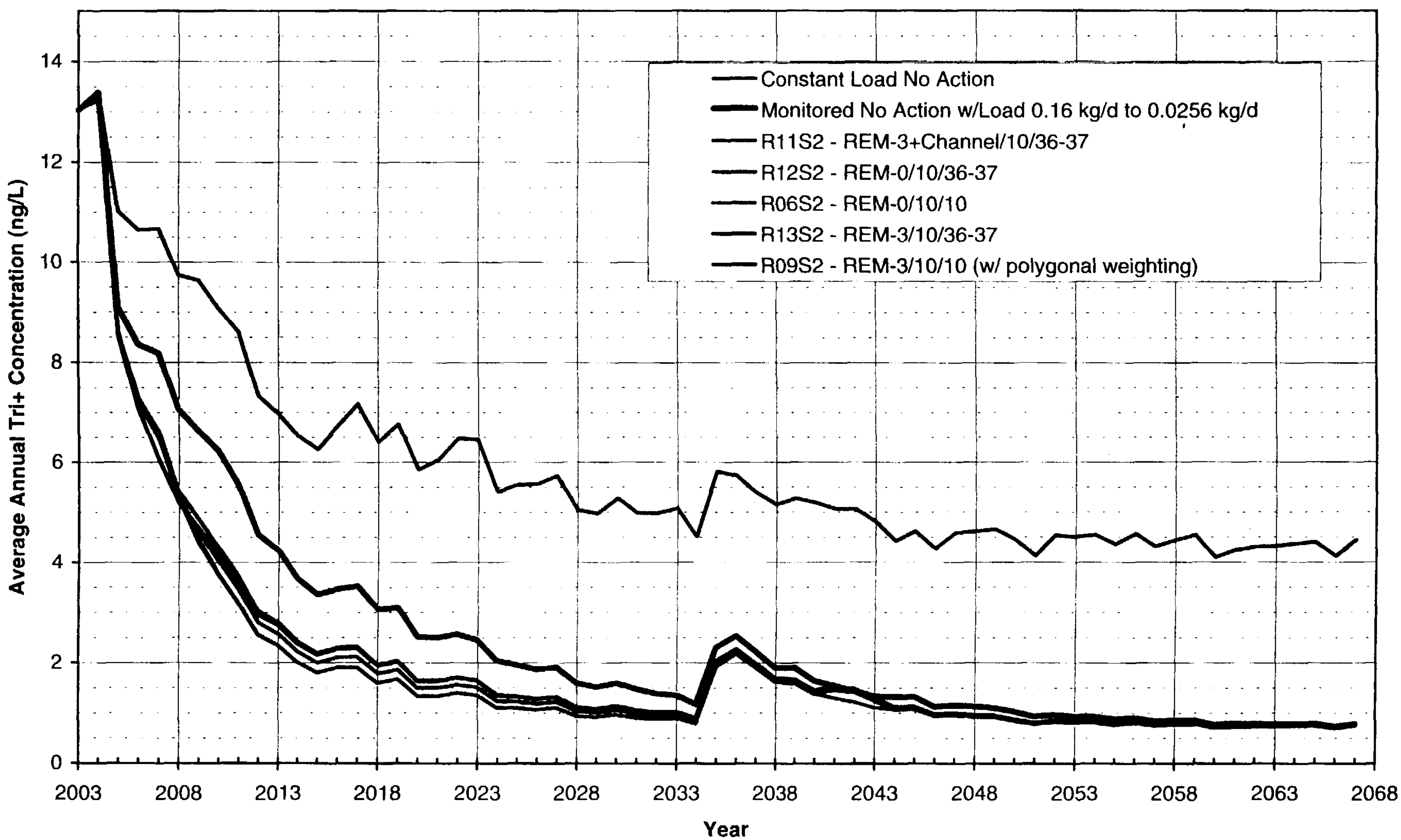
Figure RE55. Comparison Between Water Column Forecast at Waterford - Channel Dredging in River Section 1/River Section 3 Removal



401721

FIG_RE43_THRU_RE56 11/16/00

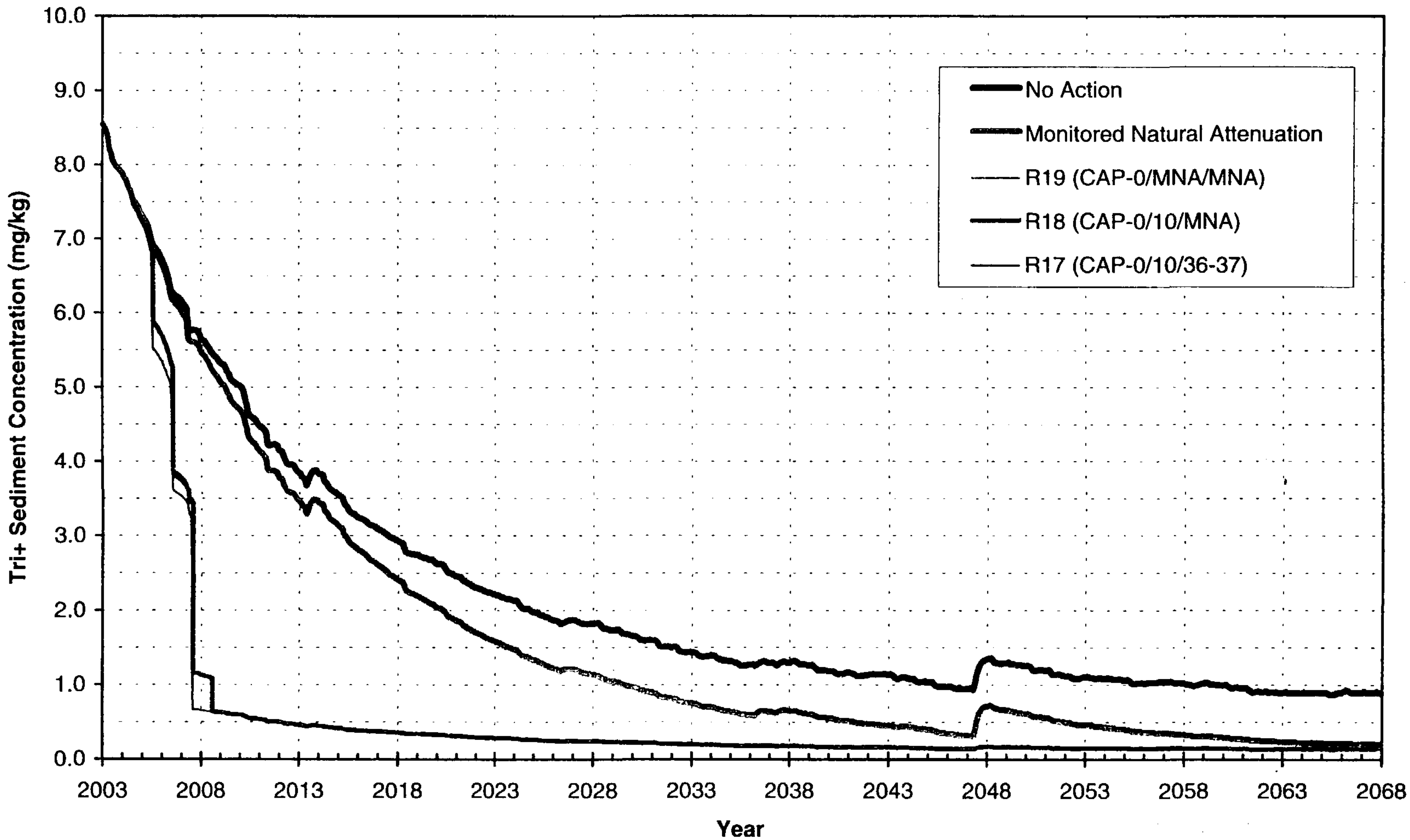
Figure RE56. Comparison Between Water Column Forecast at Federal Dam - Channel Dredging in River Section 1/River Section 3 Removal



FIG_RE43_THRU_RE56 11/16/00

401722

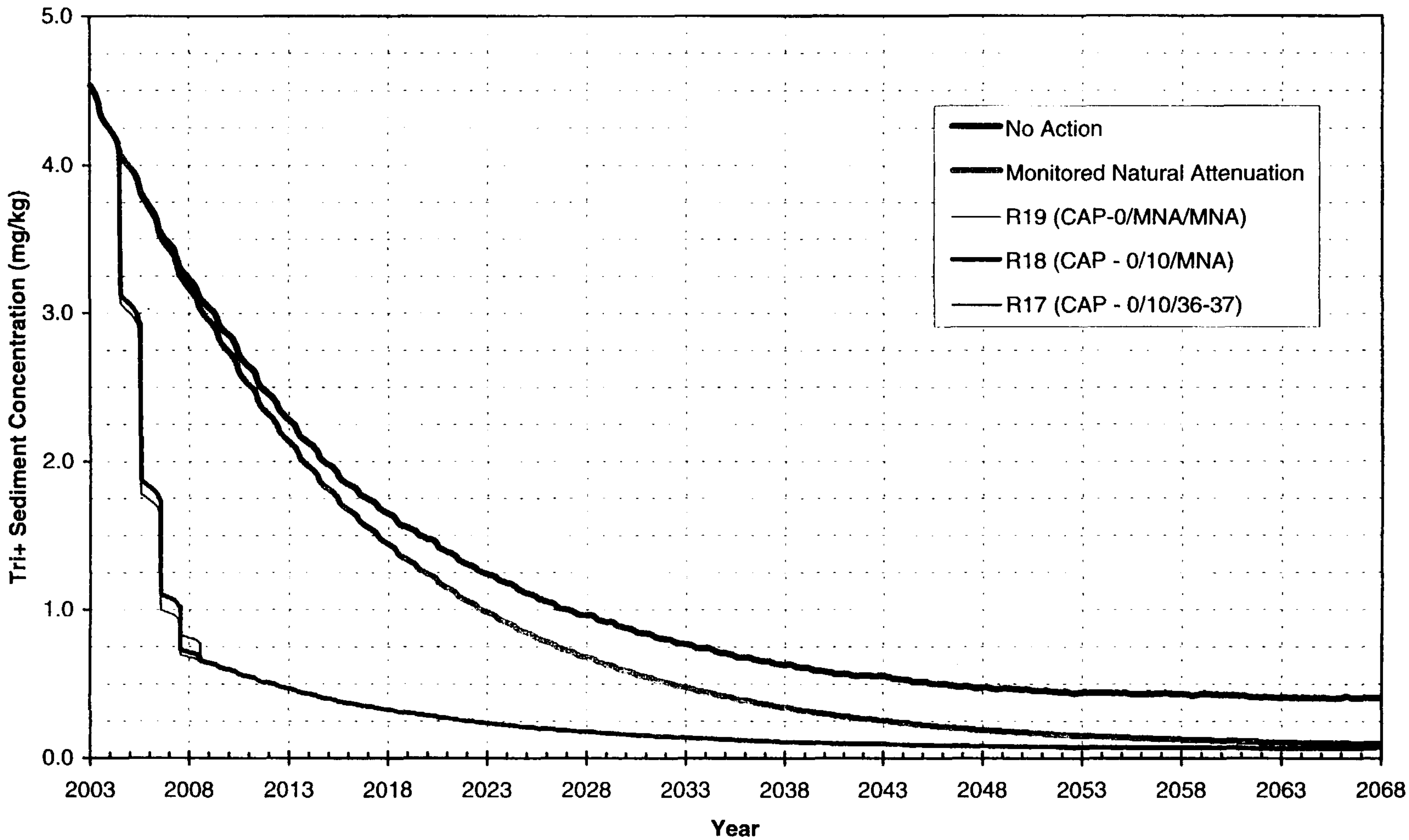
Figure RE57. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Cap Scenarios



401723

re57_re65_2 11/16/00

Figure RE58. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Cap Scenarios



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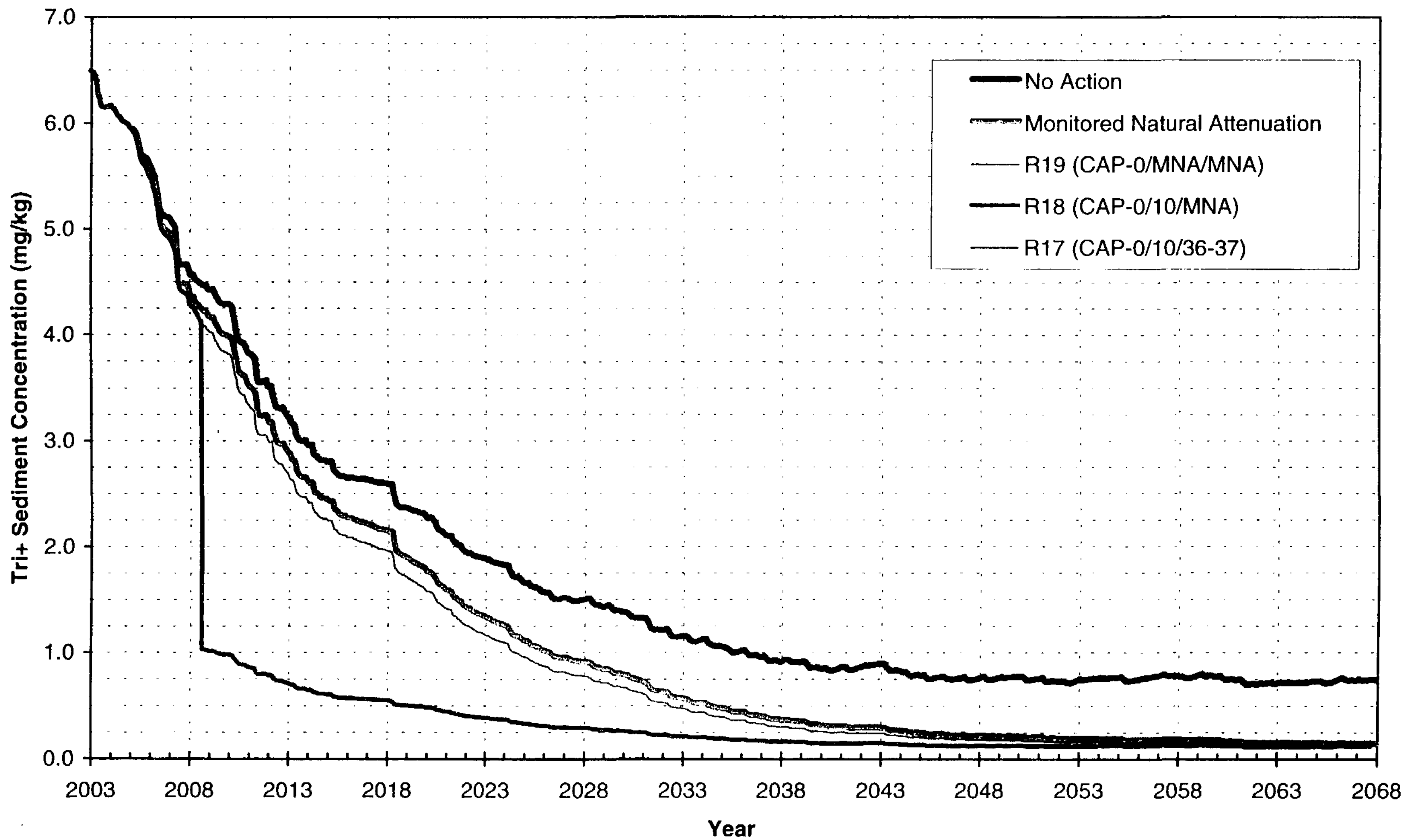
re57_re65_2 11/16/00

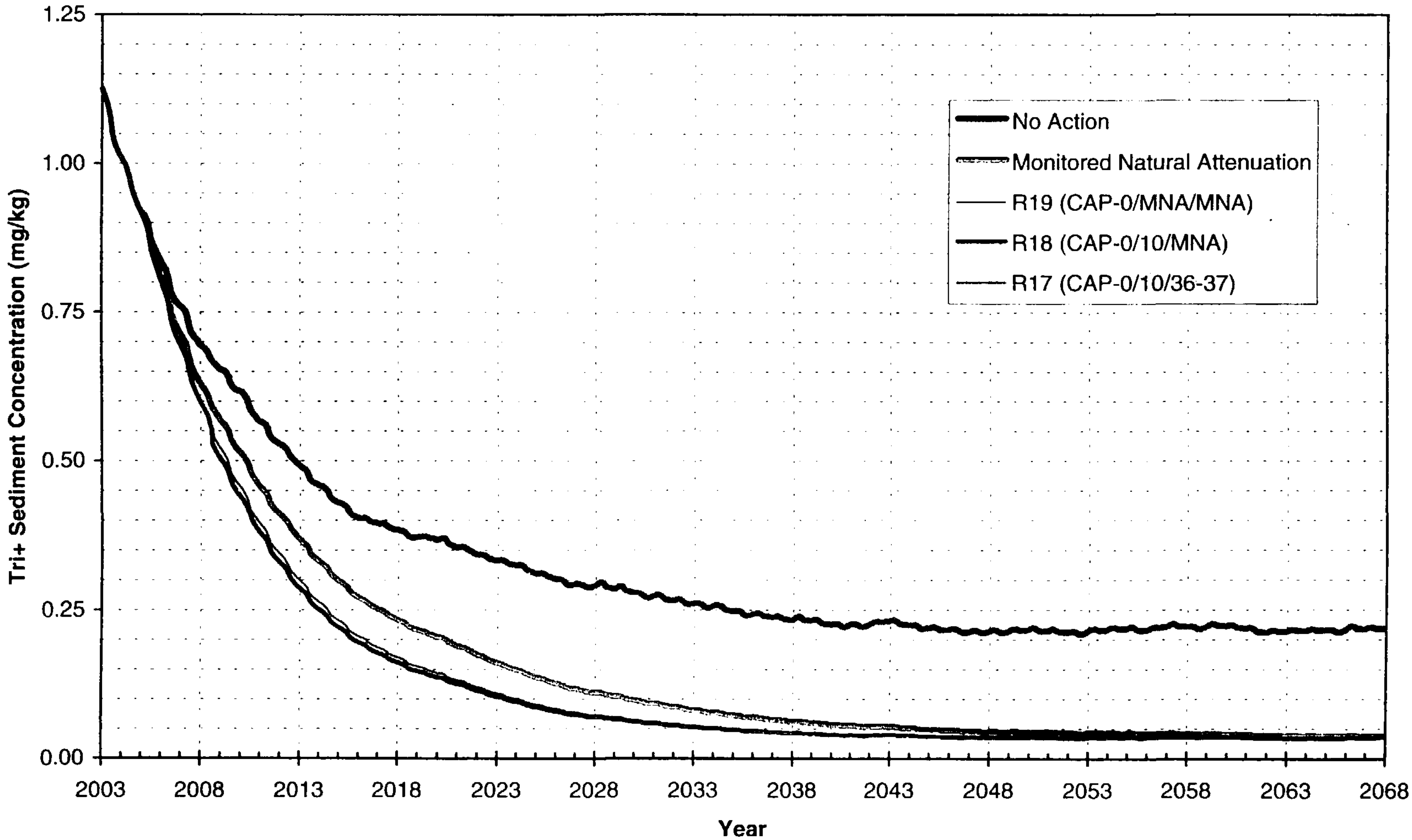
Figure RE59. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Cap Scenarios



401725

re57_re65_2 11/16/00

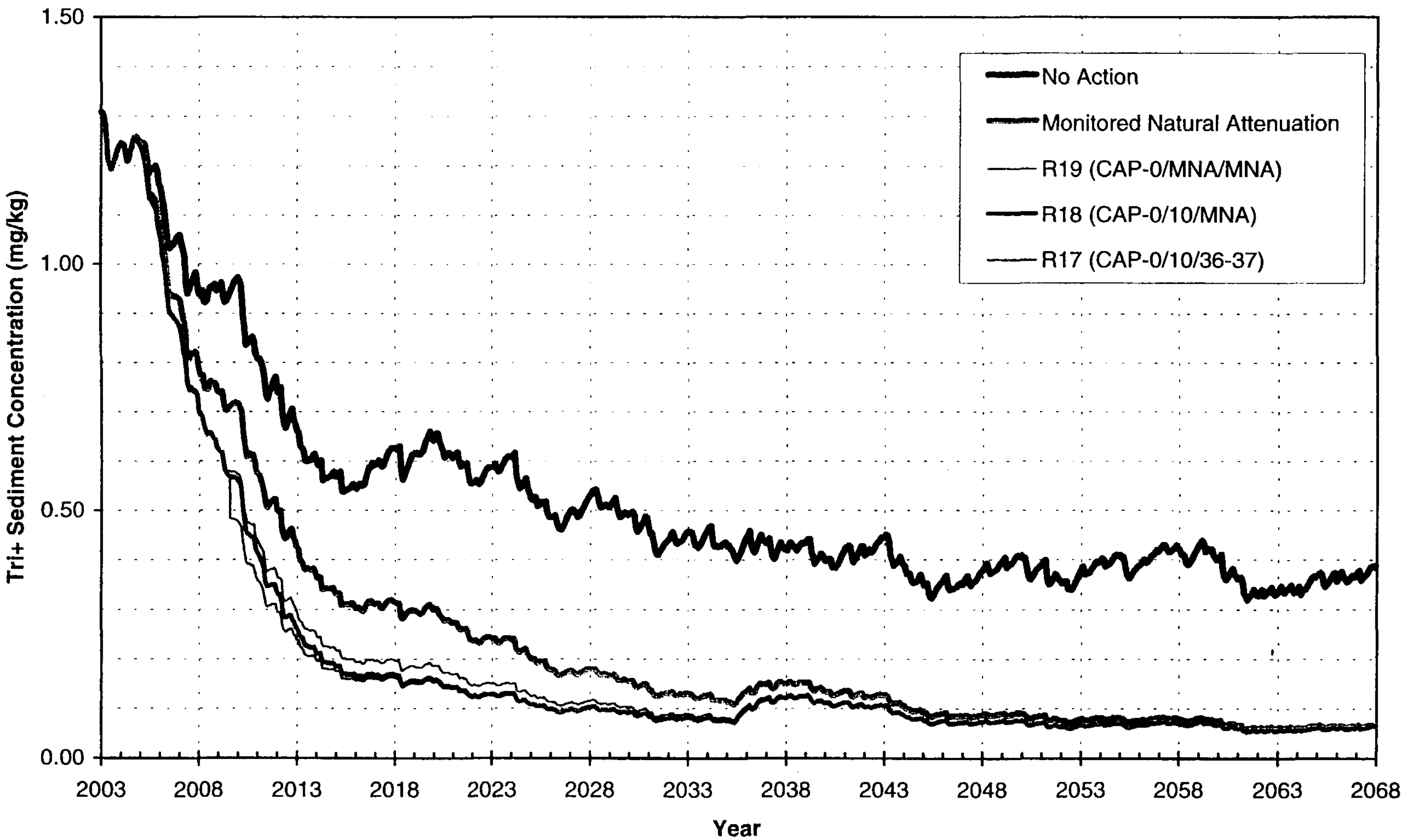
Figure RE60. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Cap Scenarios



401726

re57_re65_2 11/16/00

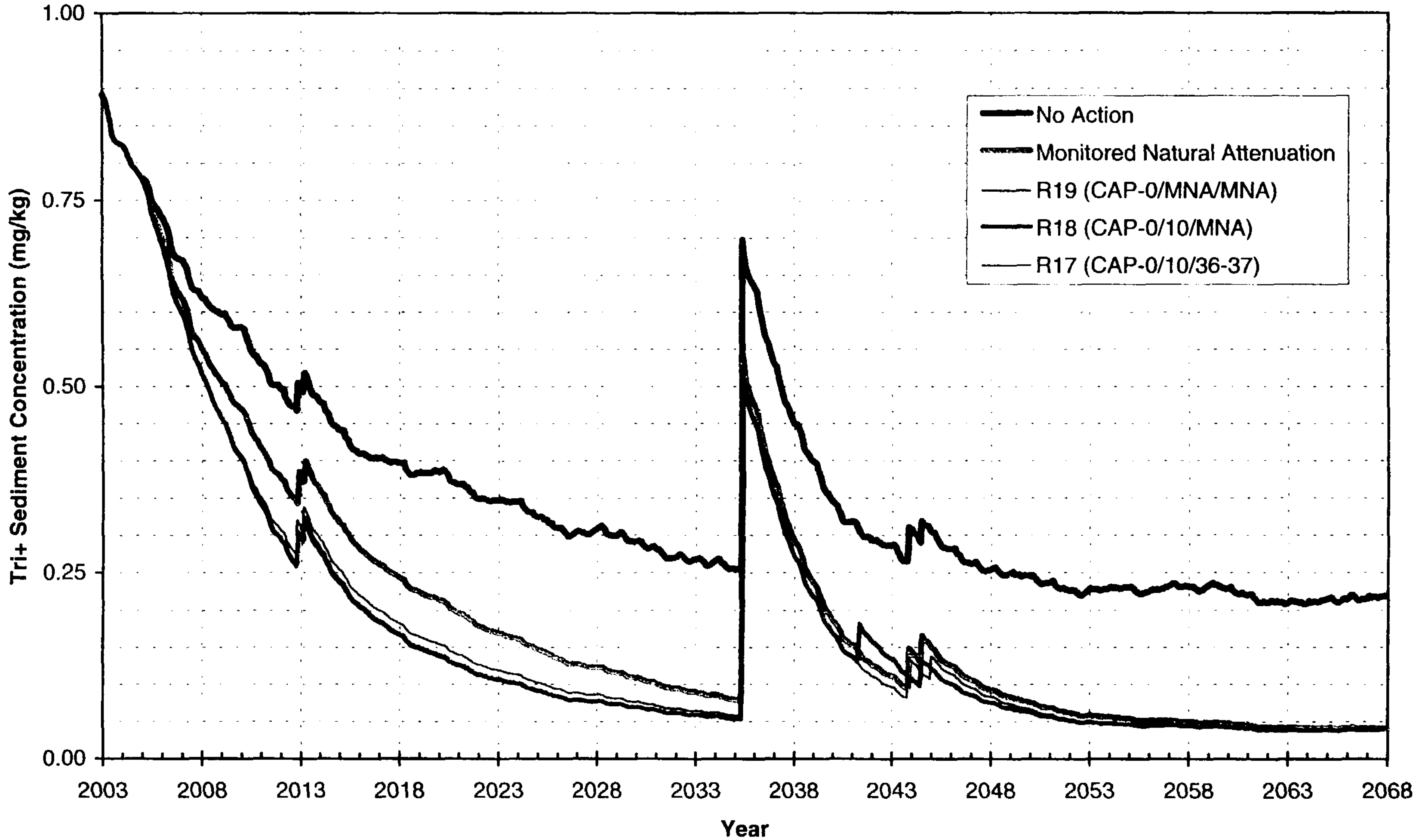
Figure RE61. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Cap Scenarios



401727

re57_re65_2 11/16/00

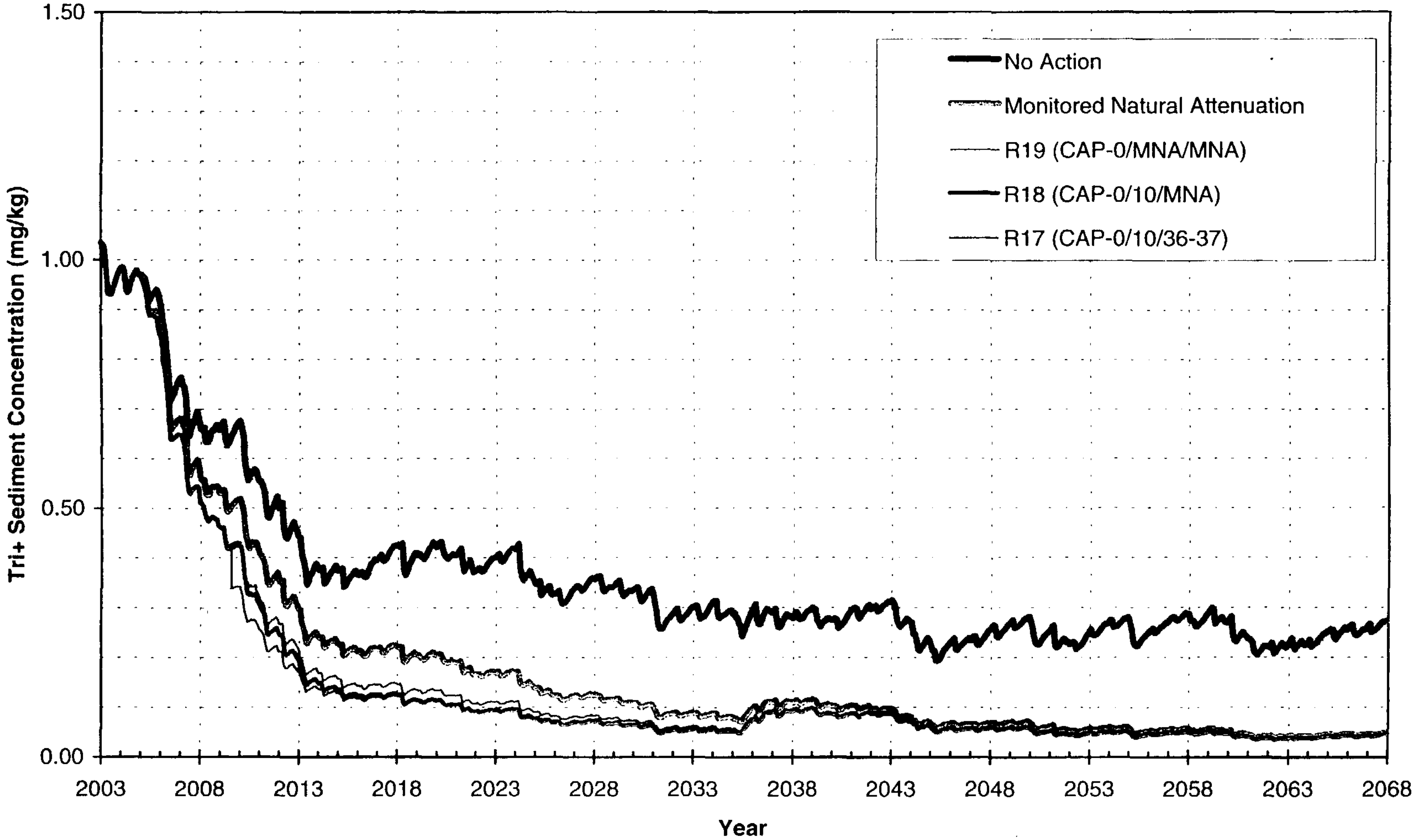
Figure RE62. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Cap Scenarios



401728

re57_re65_2 11/16/00

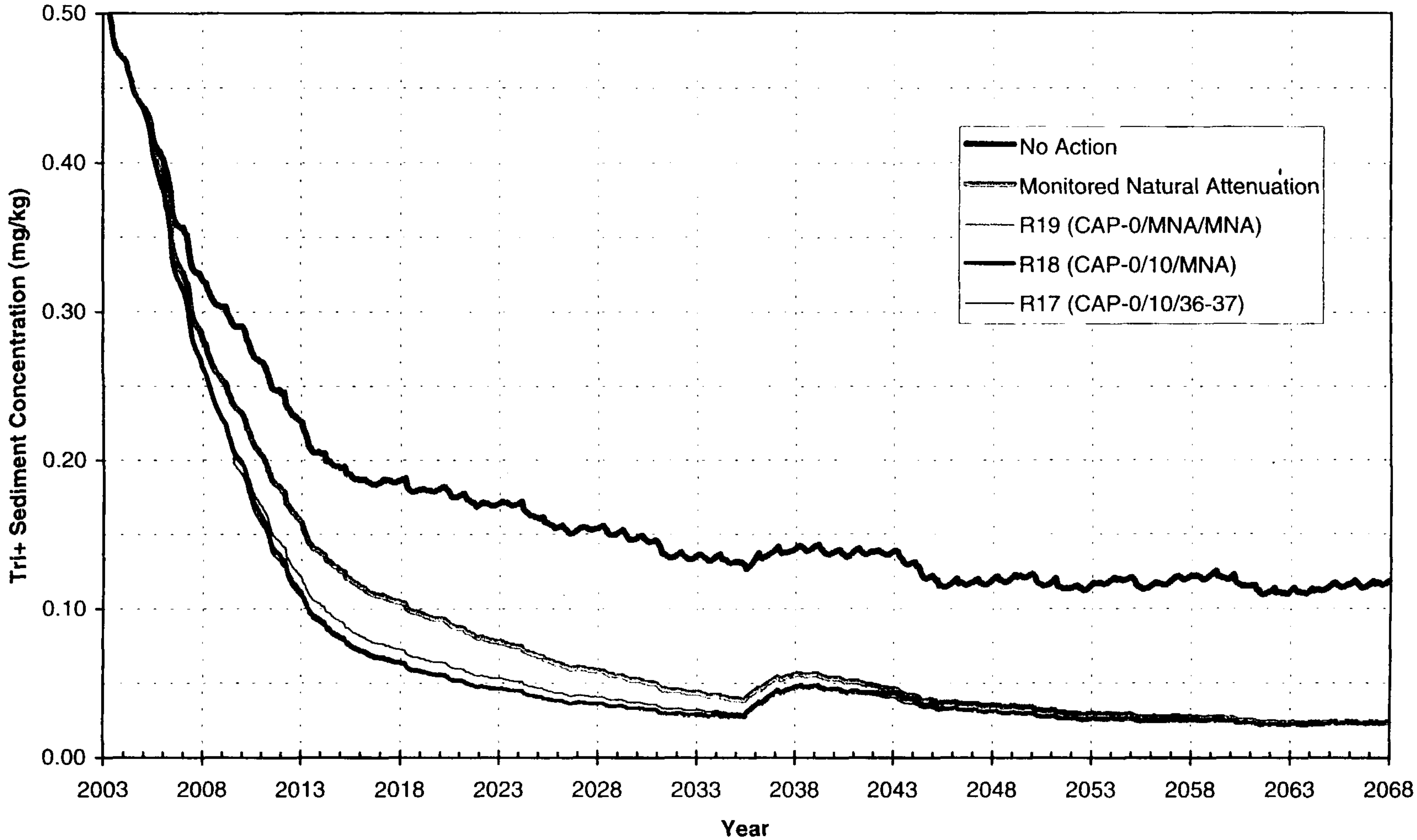
Figure RE63. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Cap Scenarios



401729

re57_re65_2 11/16/00

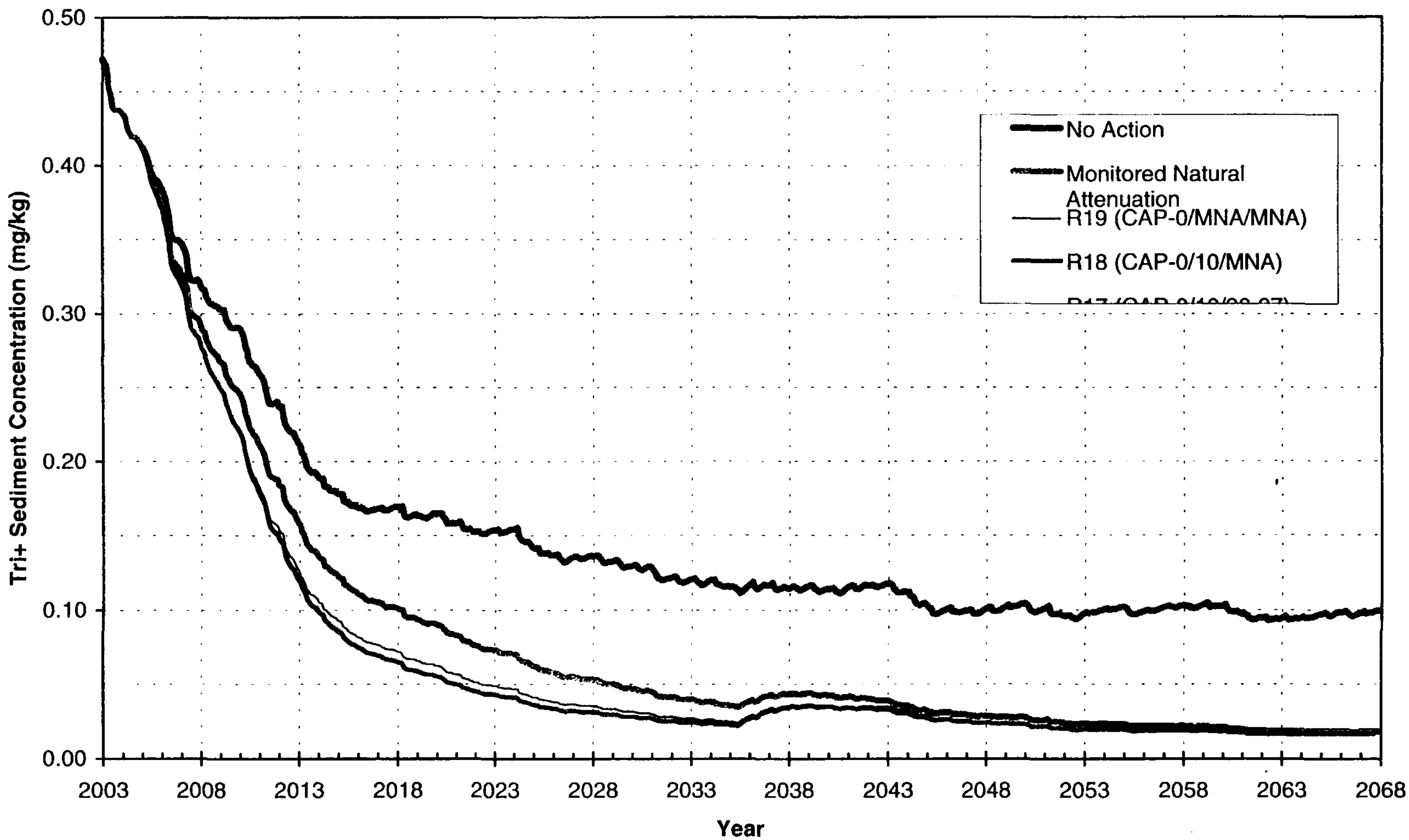
Figure RE64. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Cap Scenarios



401730

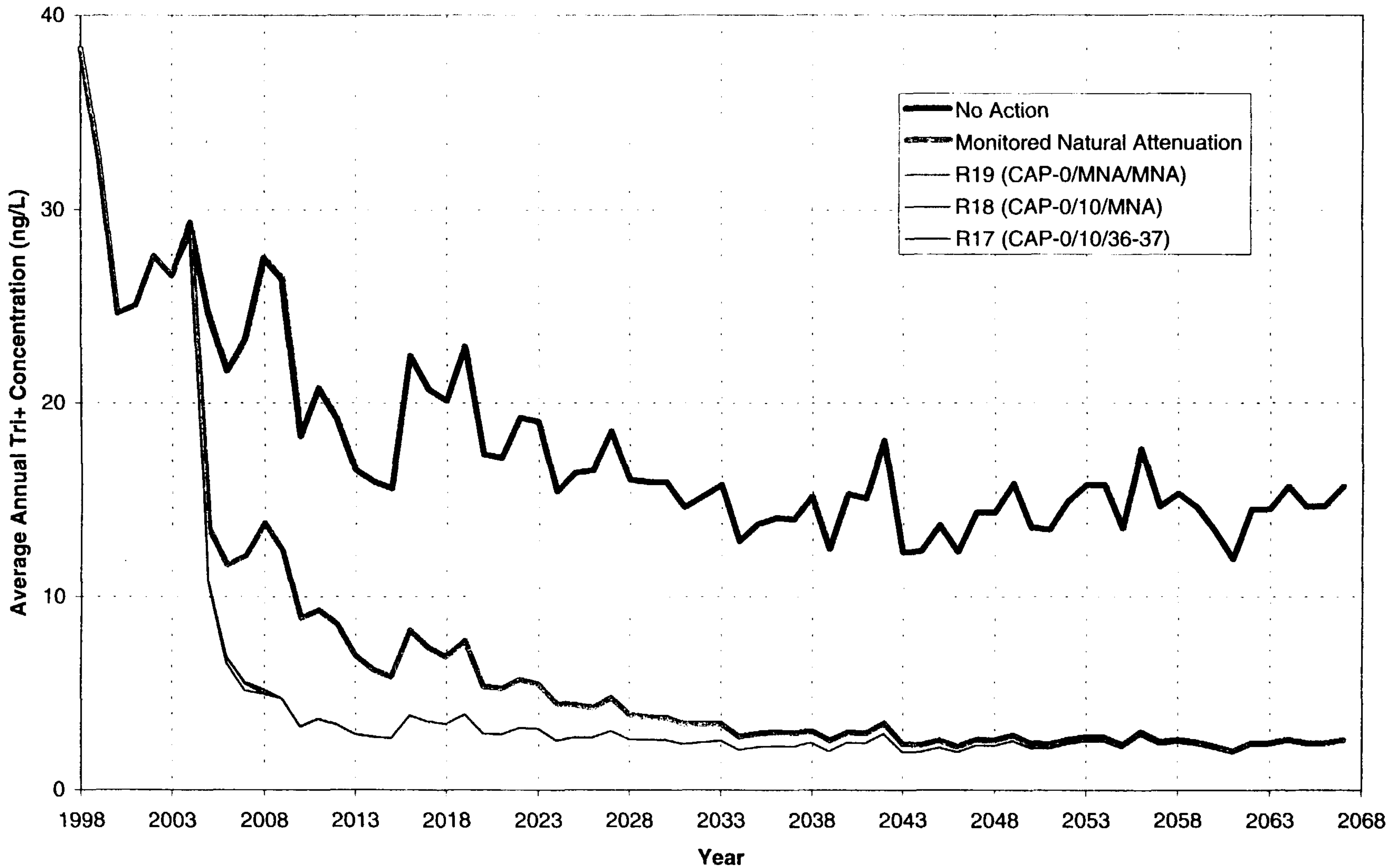
re57_re65_3 11/16/00

Figure RE65. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Cap Scenarios



401731

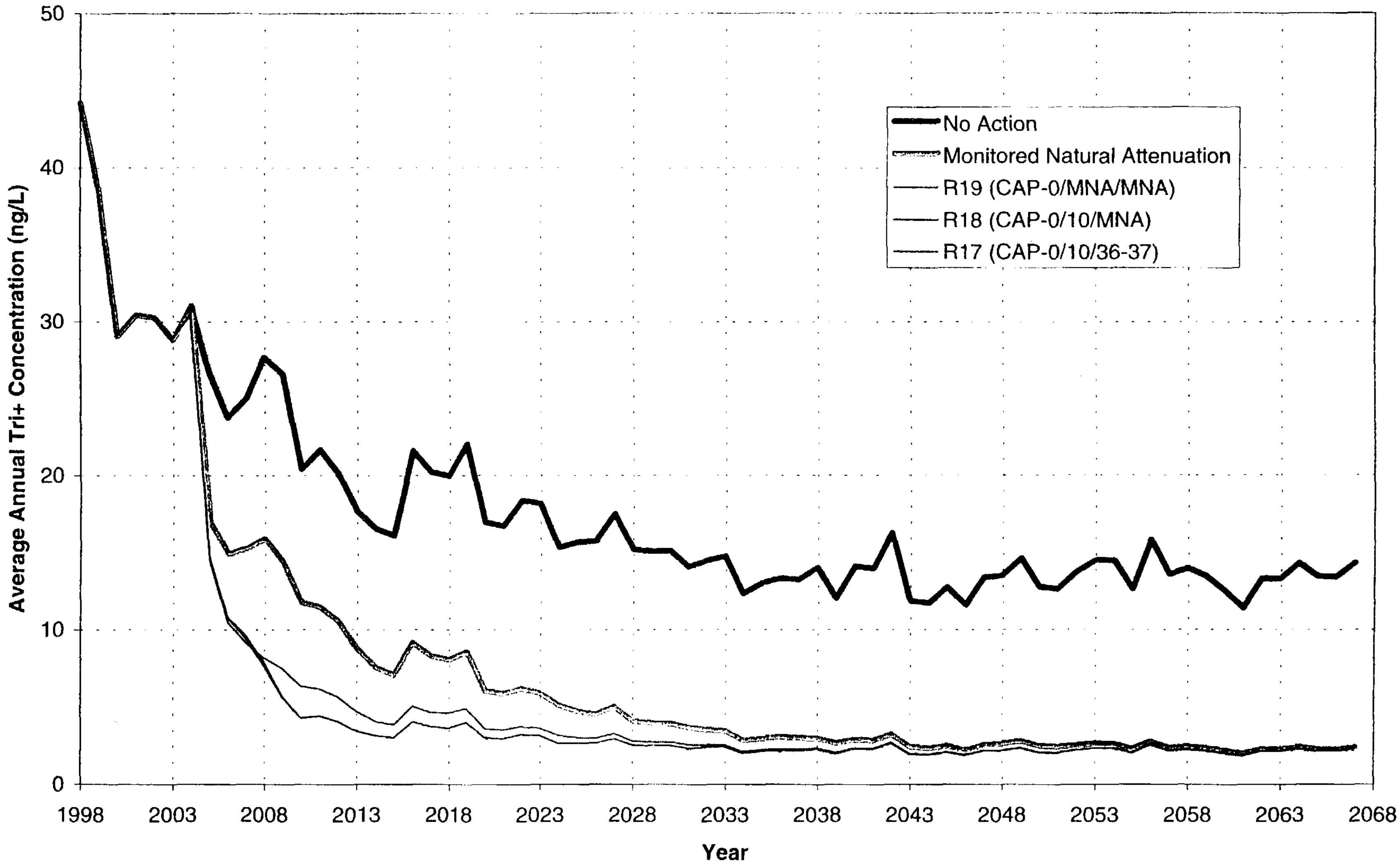
Figure RE66. Comparison Between Water Column Forecasts at Thompson Island Dam - Cap Scenarios



401732

re66_re70 11/16/00

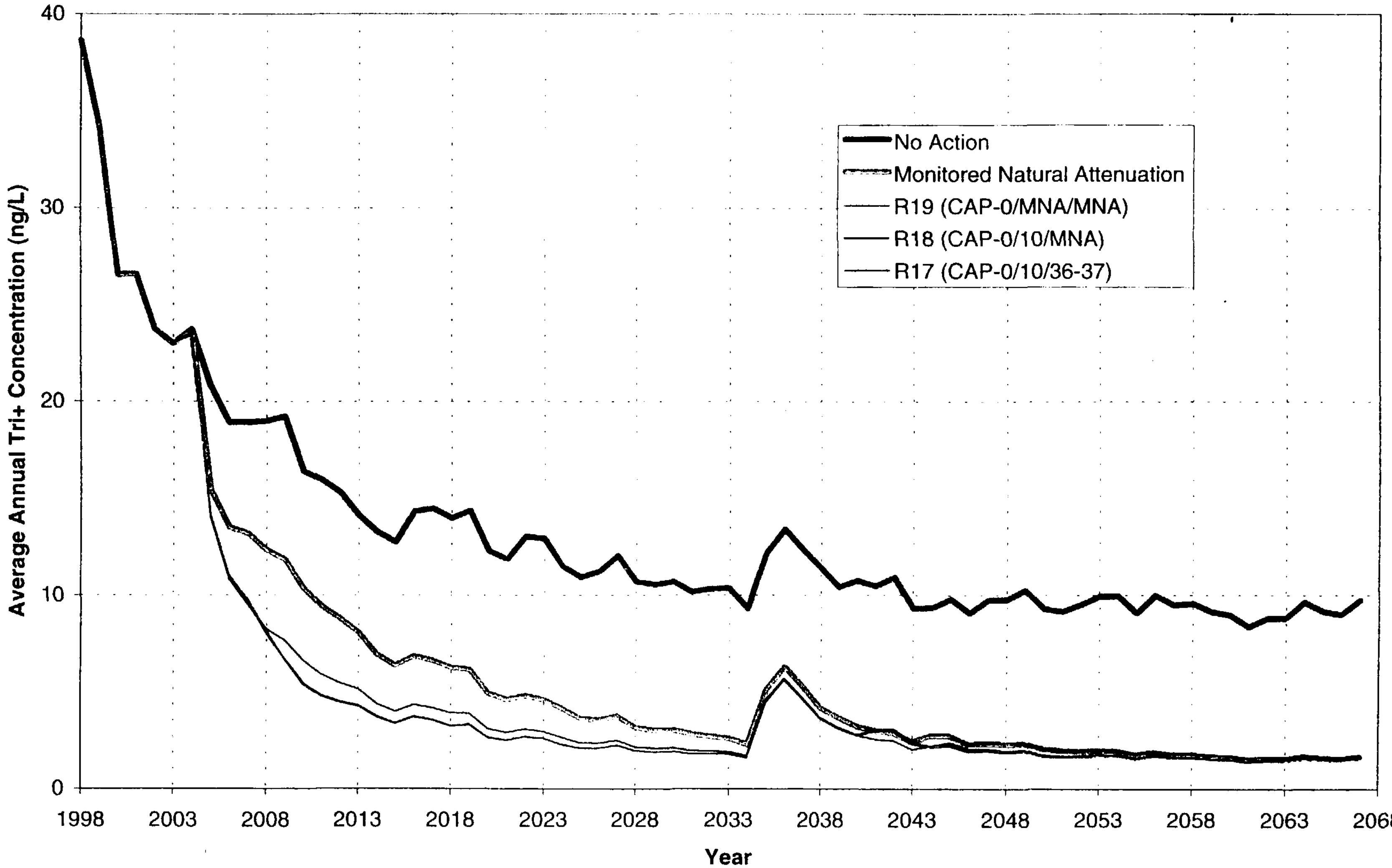
Figure RE67. Comparison Between Water Column Forecasts at Northumberland Dam - Cap Scenarios



401733

re66_re70 11/16/00

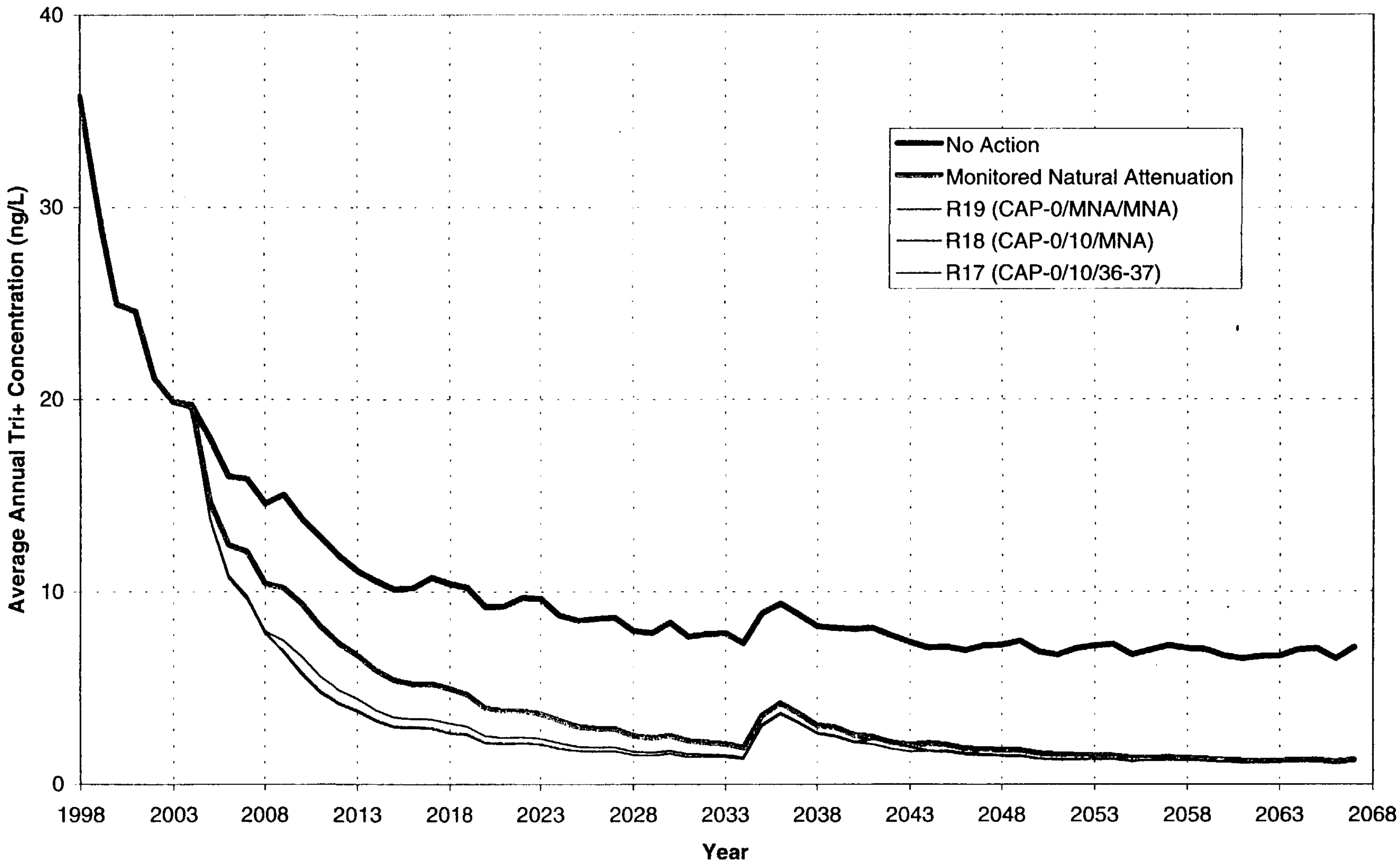
Figure RE68. Comparison Between Water Column Forecasts at Stillwater - Cap Scenarios



re66_re70 11/16/00

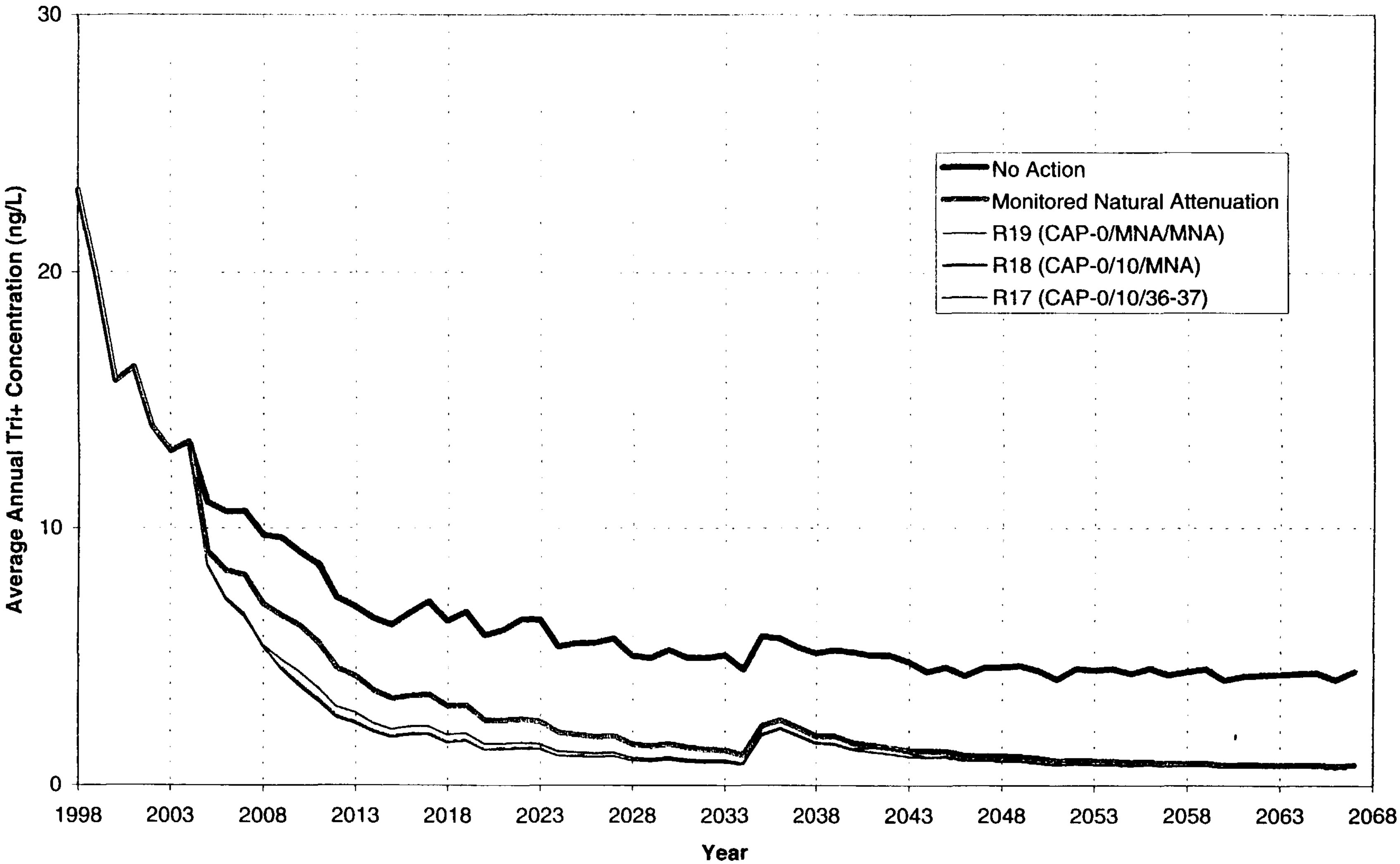
401734

Figure RE69. Comparison Between Water Column Forecasts at Waterford - Cap Scenarios



re66_re70 11/16/00

Figure RE70. Comparison Between Water Column Forecasts at Federal Dam - Cap Scenarios



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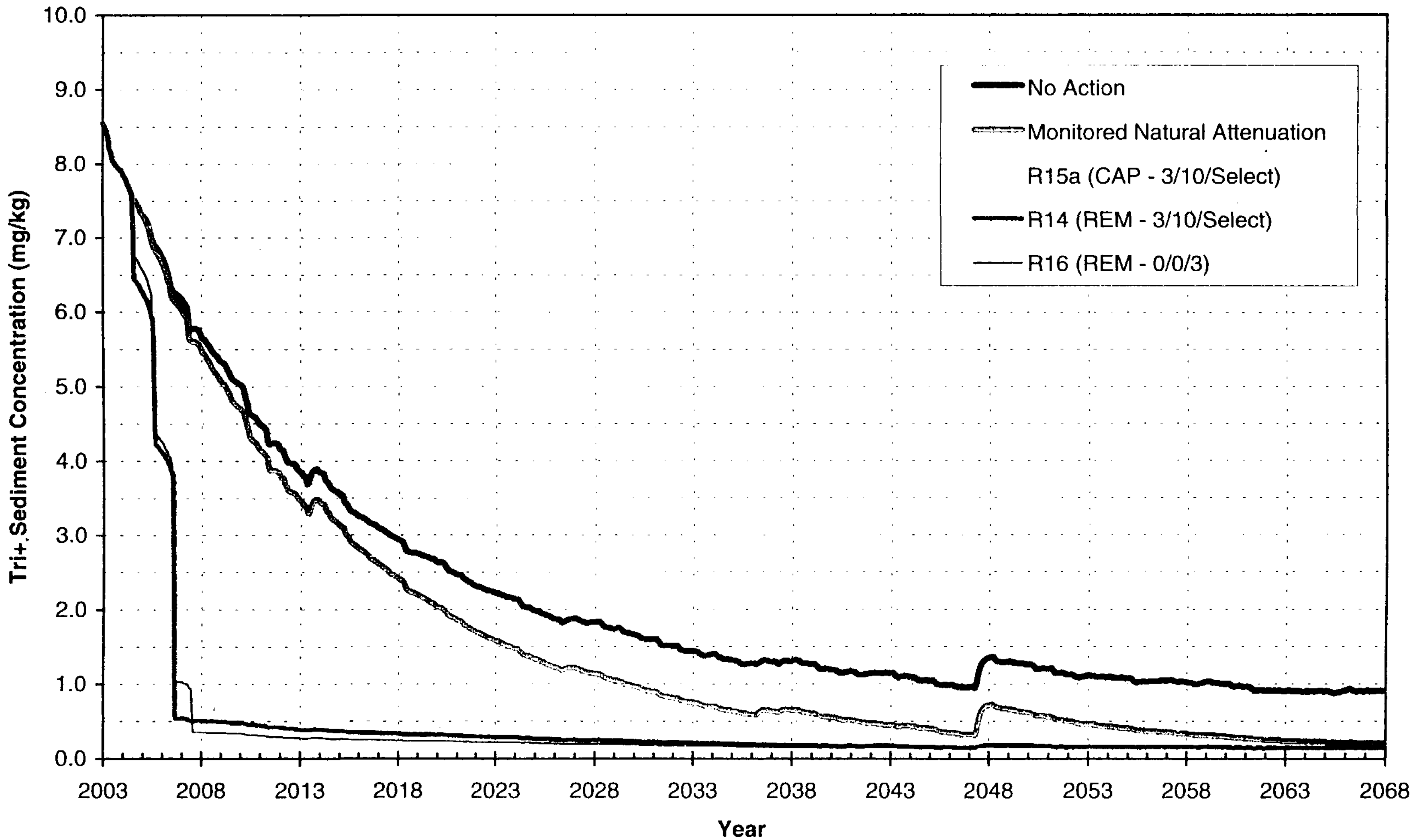
re66_re70 11/16/00

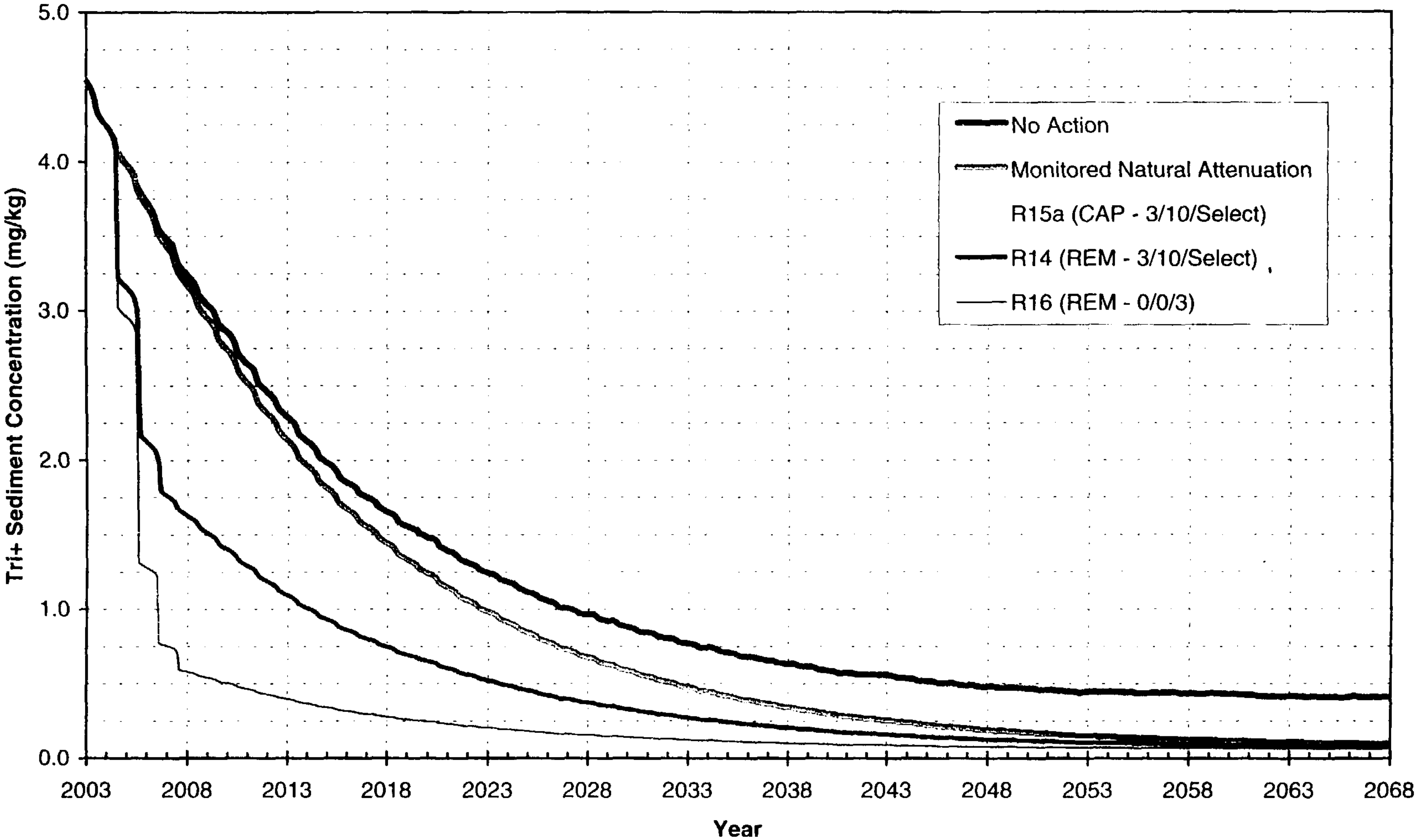
Figure RE71. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



401737

re71_re79_2 11/16/00

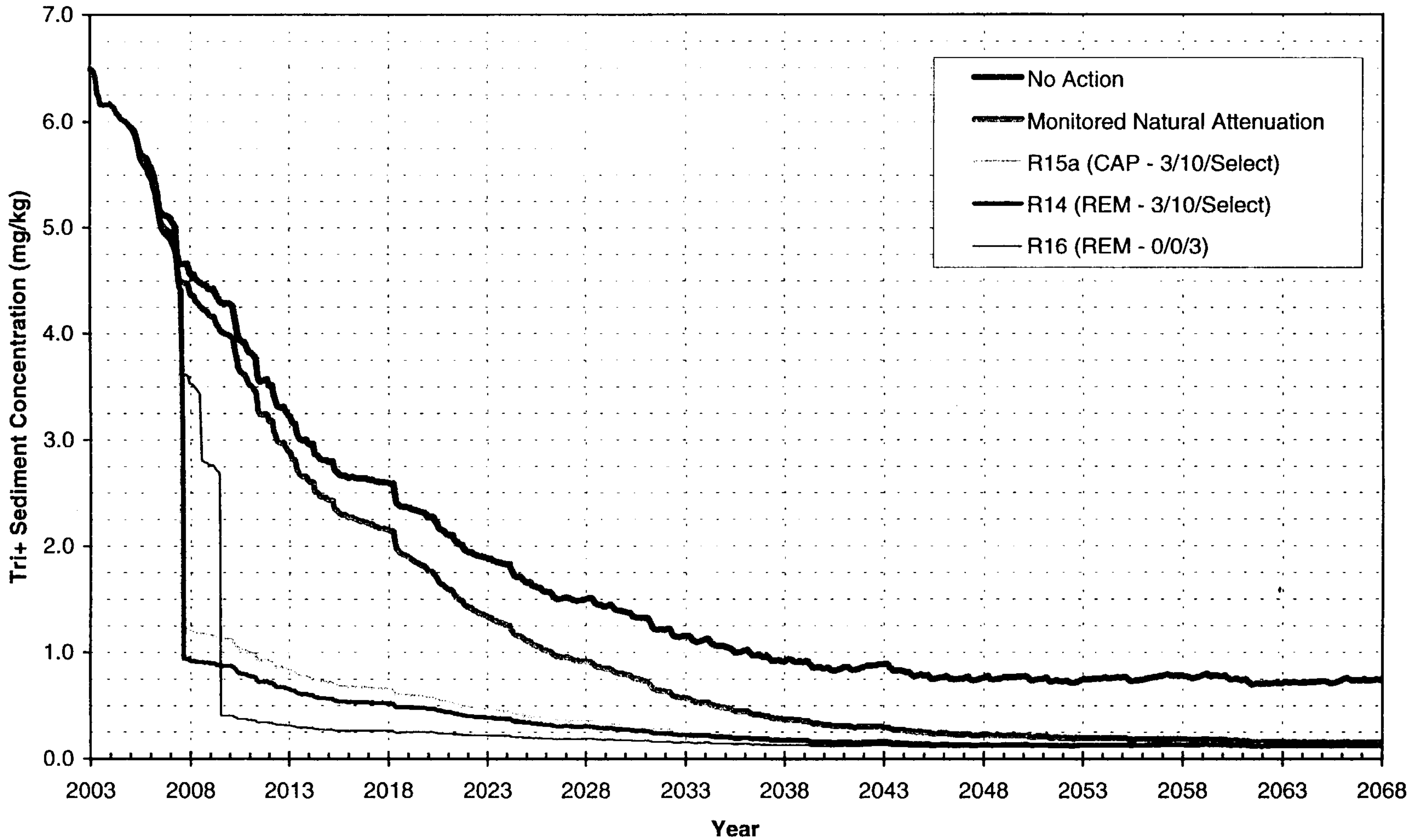
Figure RE72. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



401738

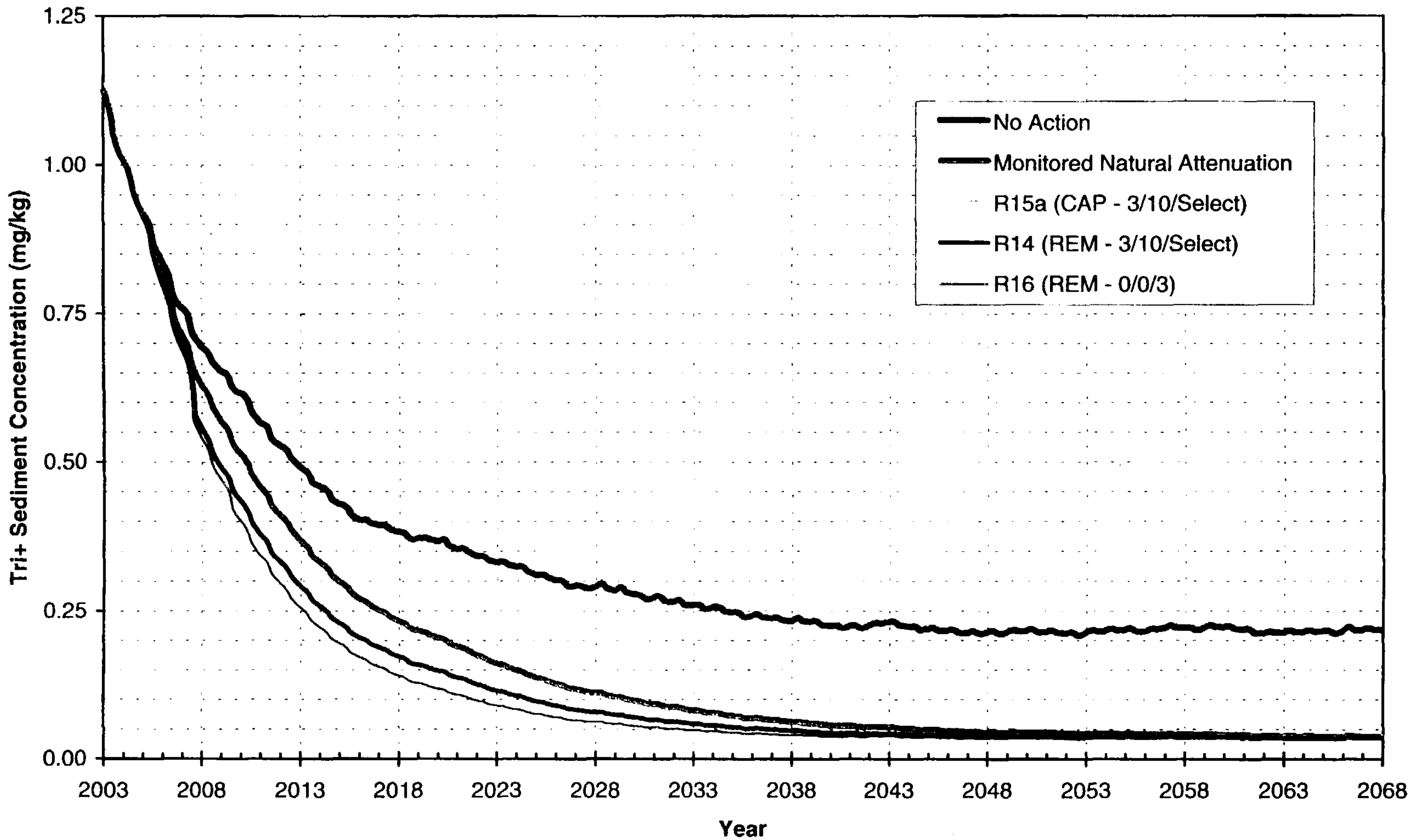
re71_re79_2 11/16/00

Figure RE73. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



401739

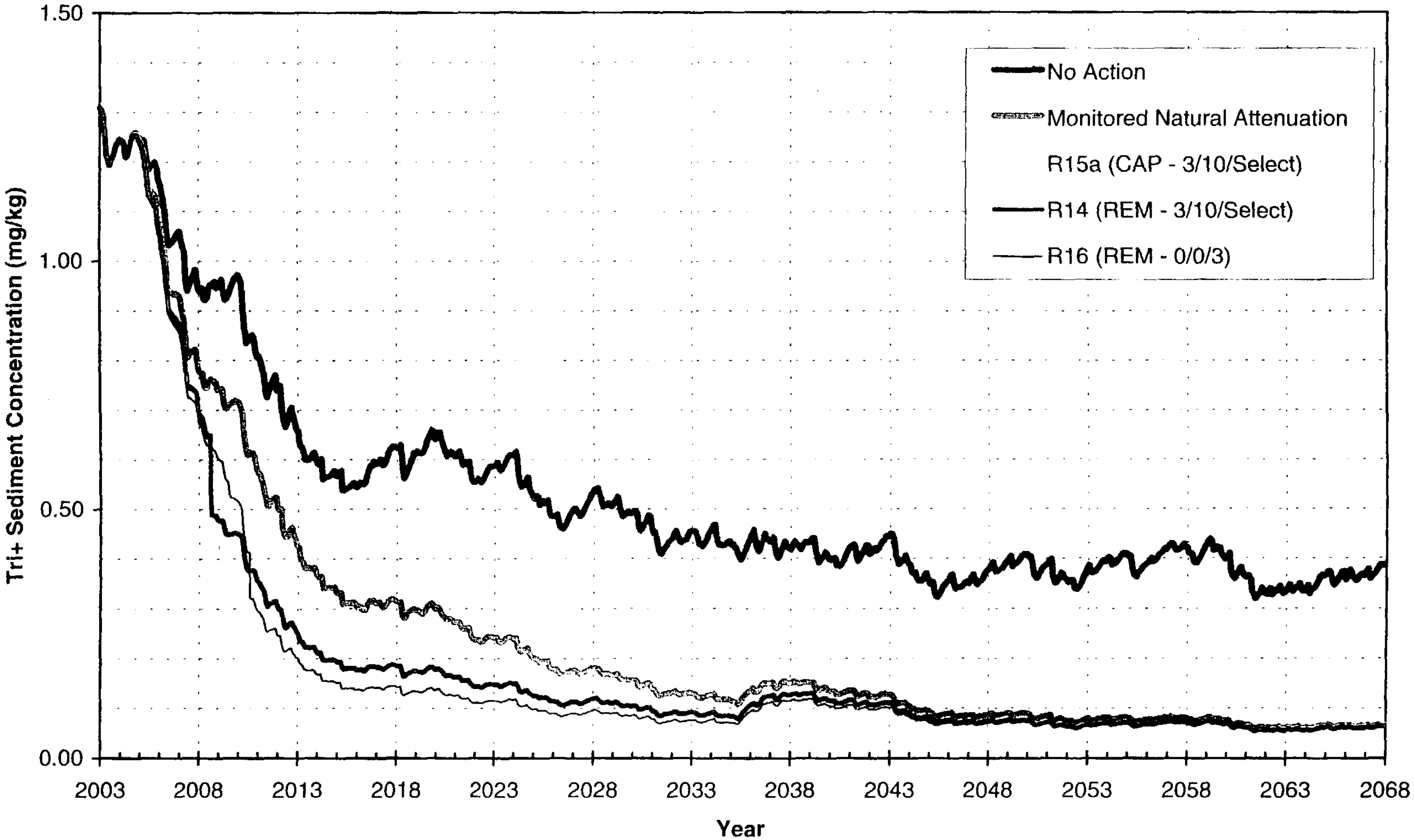
Figure RE74. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



401740

re71_re79_2 11/16/00

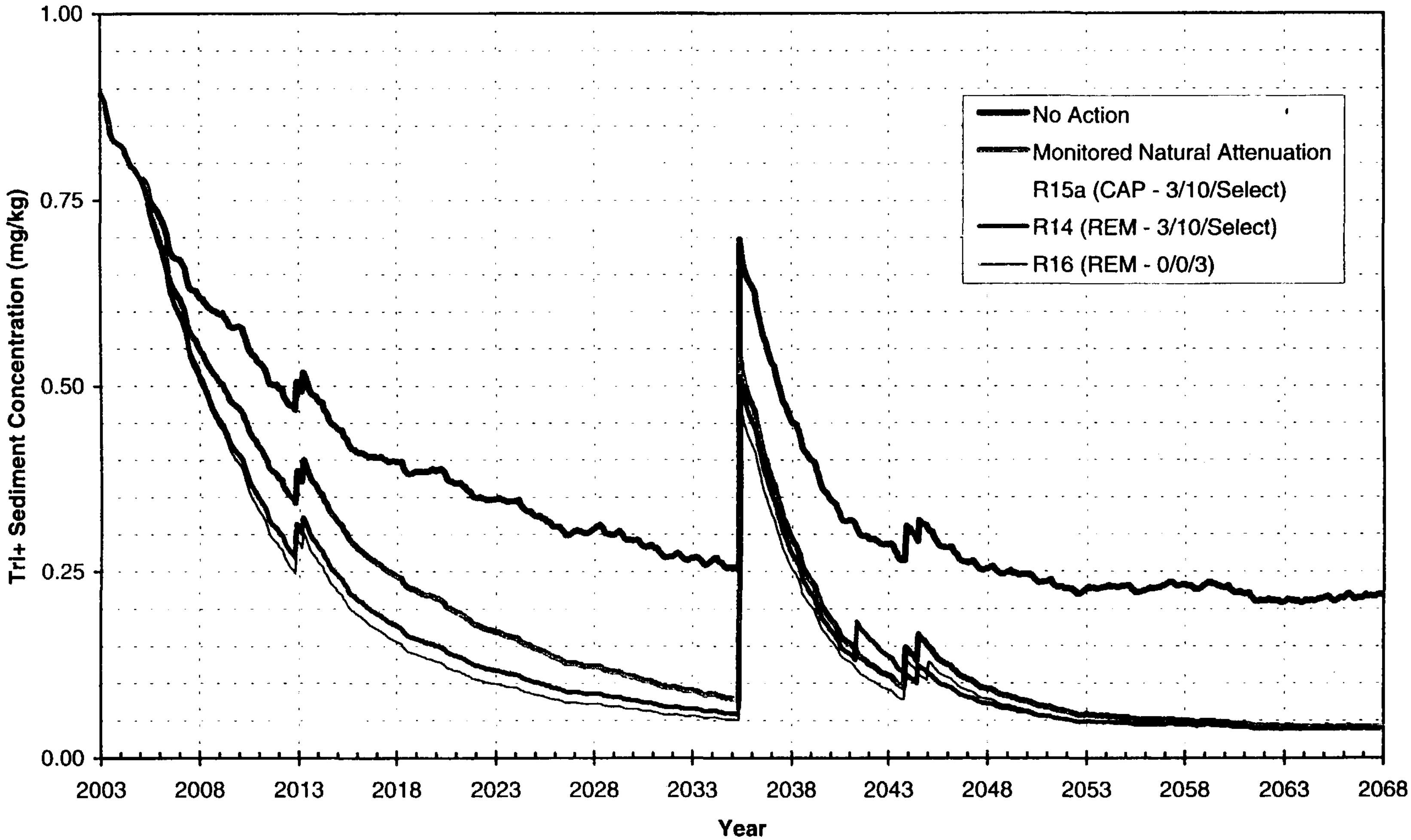
Figure RE75. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



re71_re79_2 11/16/00

401741

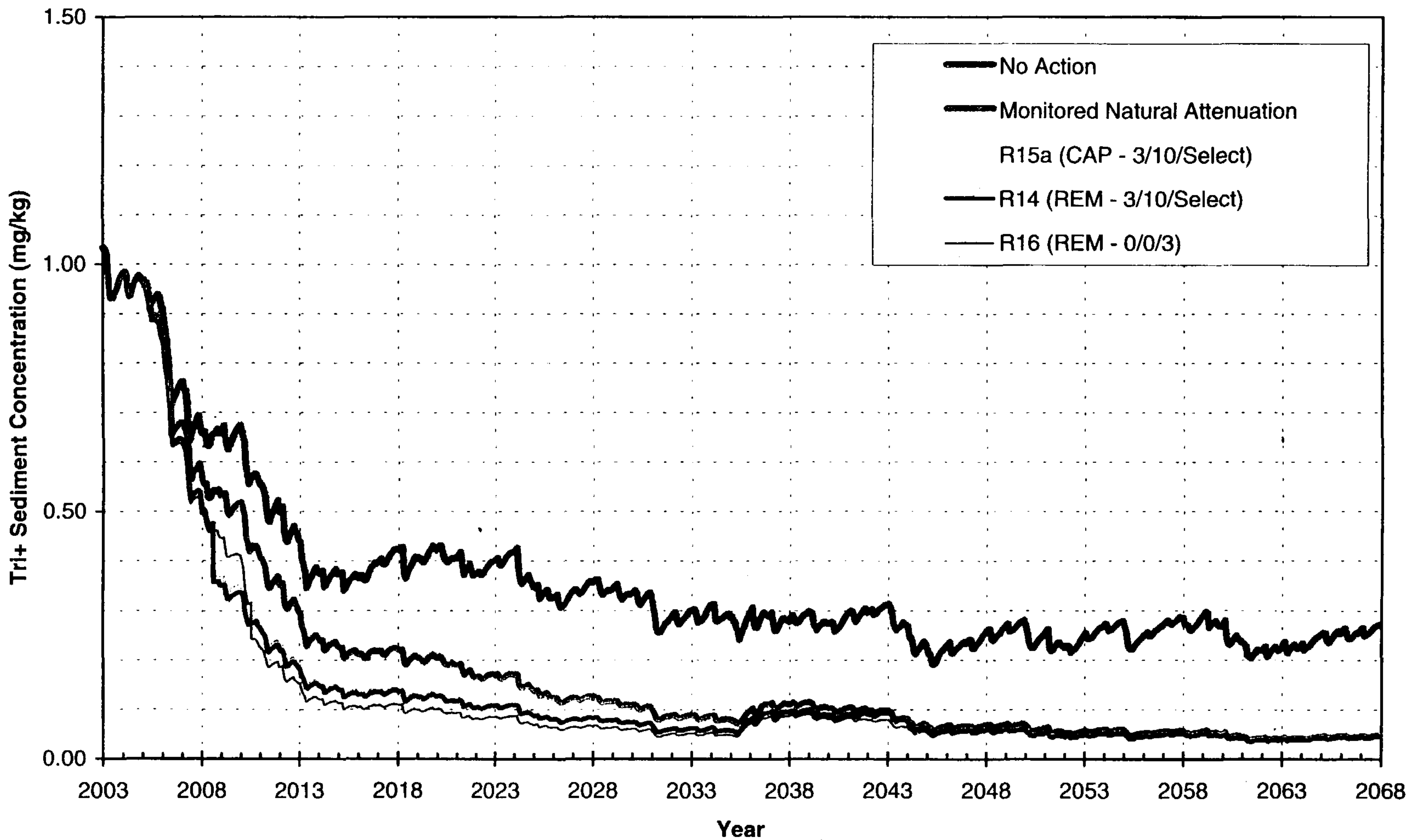
Figure RE76. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



401742

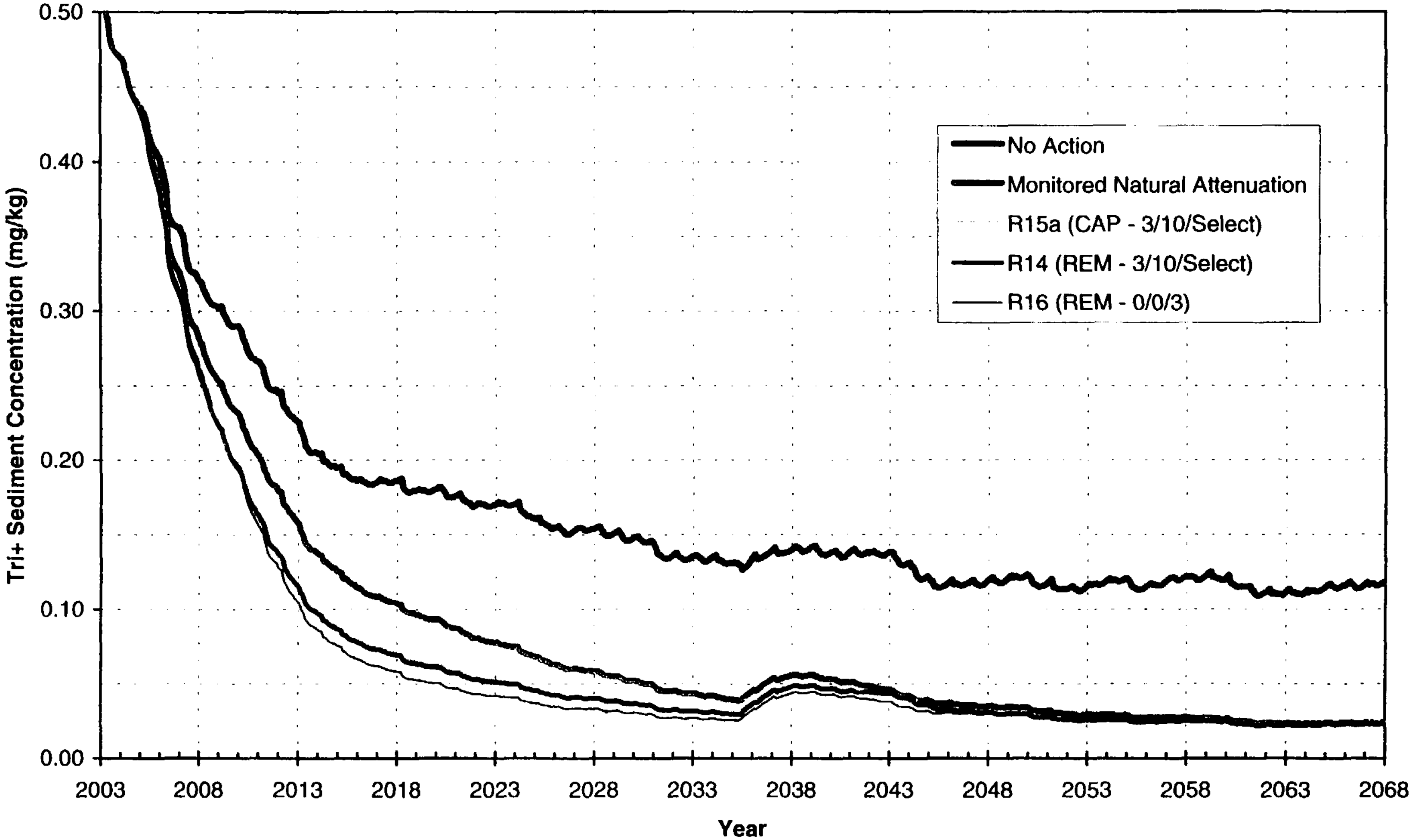
re79_2 11/16/00

Figure RE77. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



401743

Figure RE78. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



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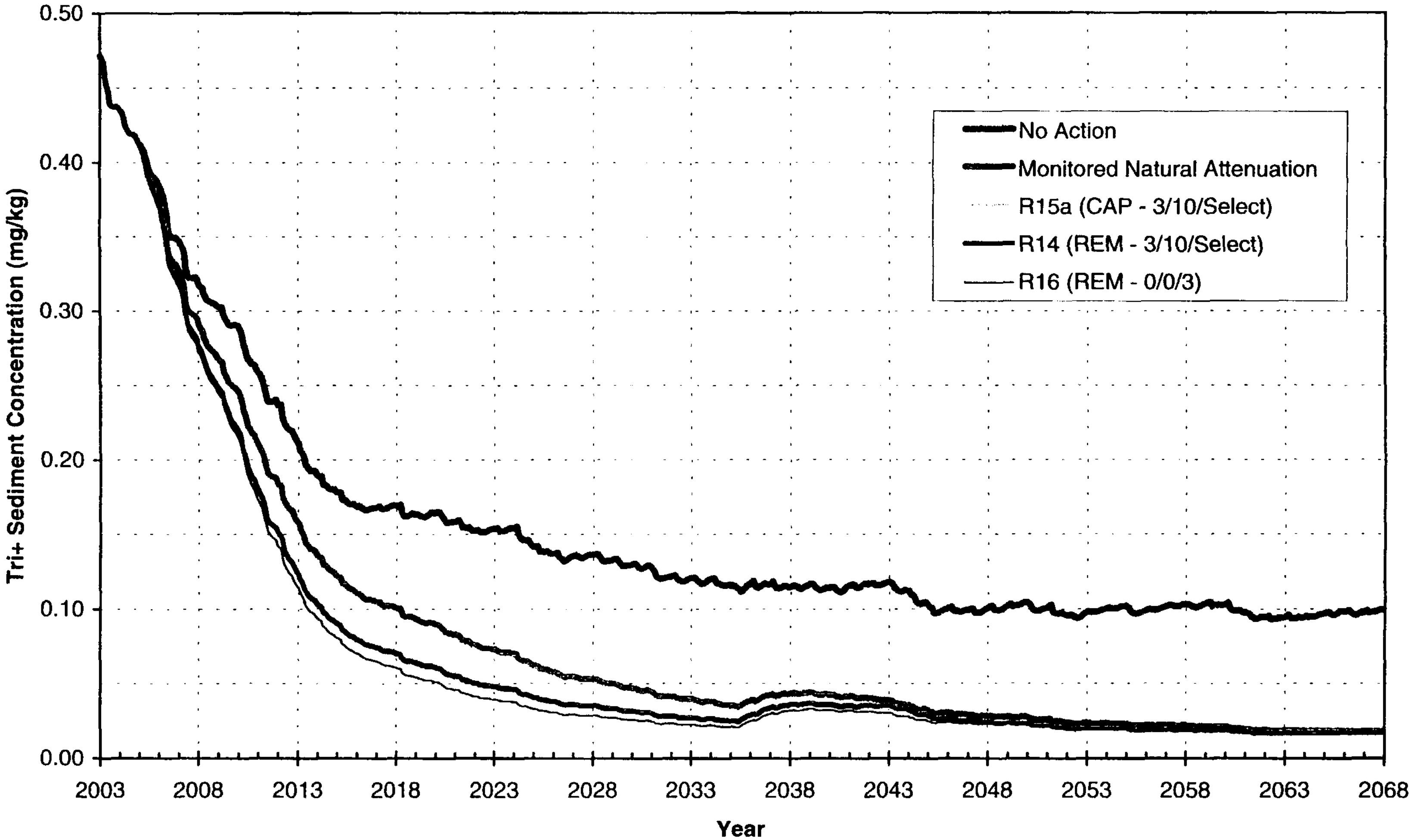
re71 re79_2 11/16/00

Figure RE79. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Alternatives Retained for Detailed Analyses



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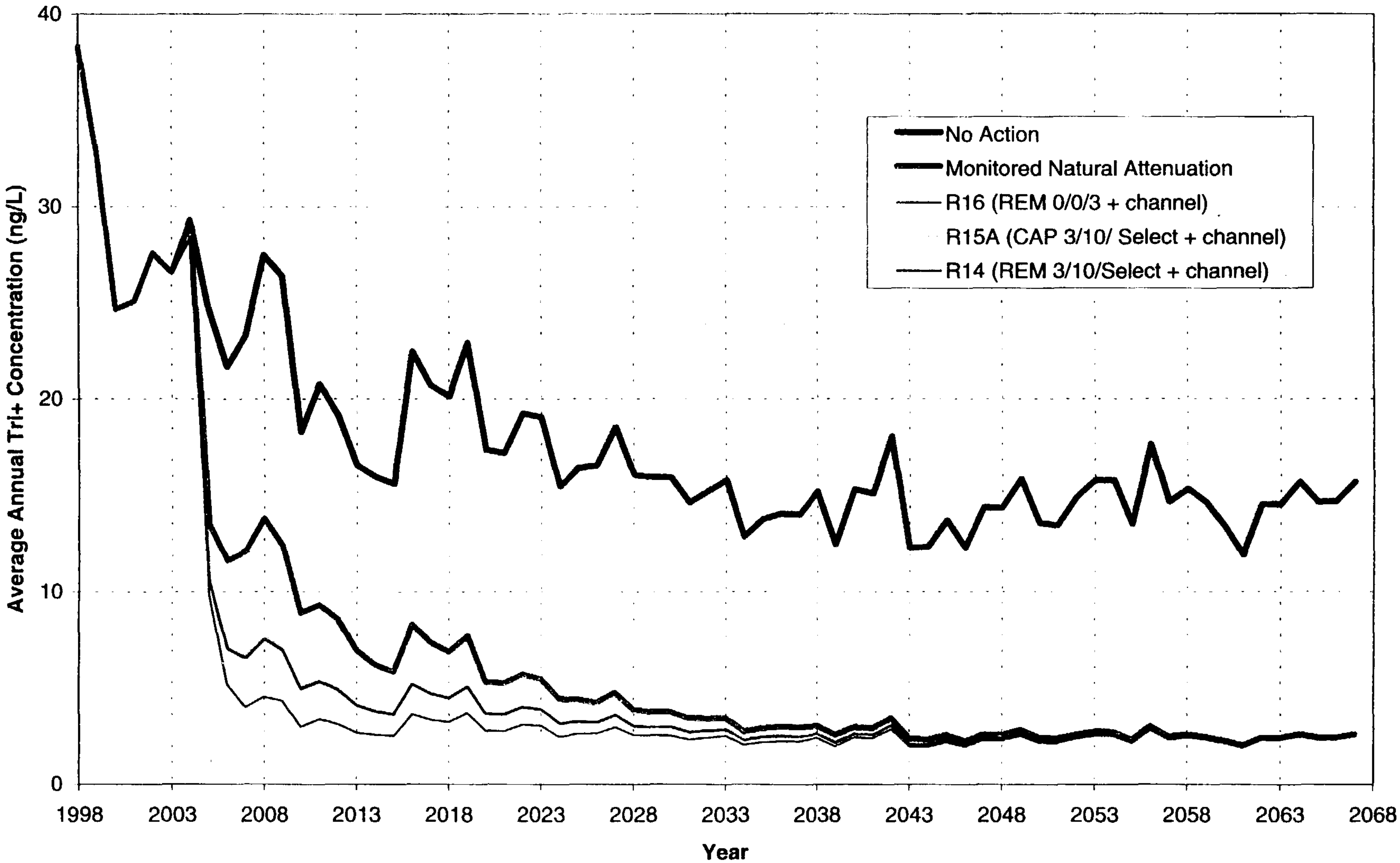
re71_re79_2 11/16/00

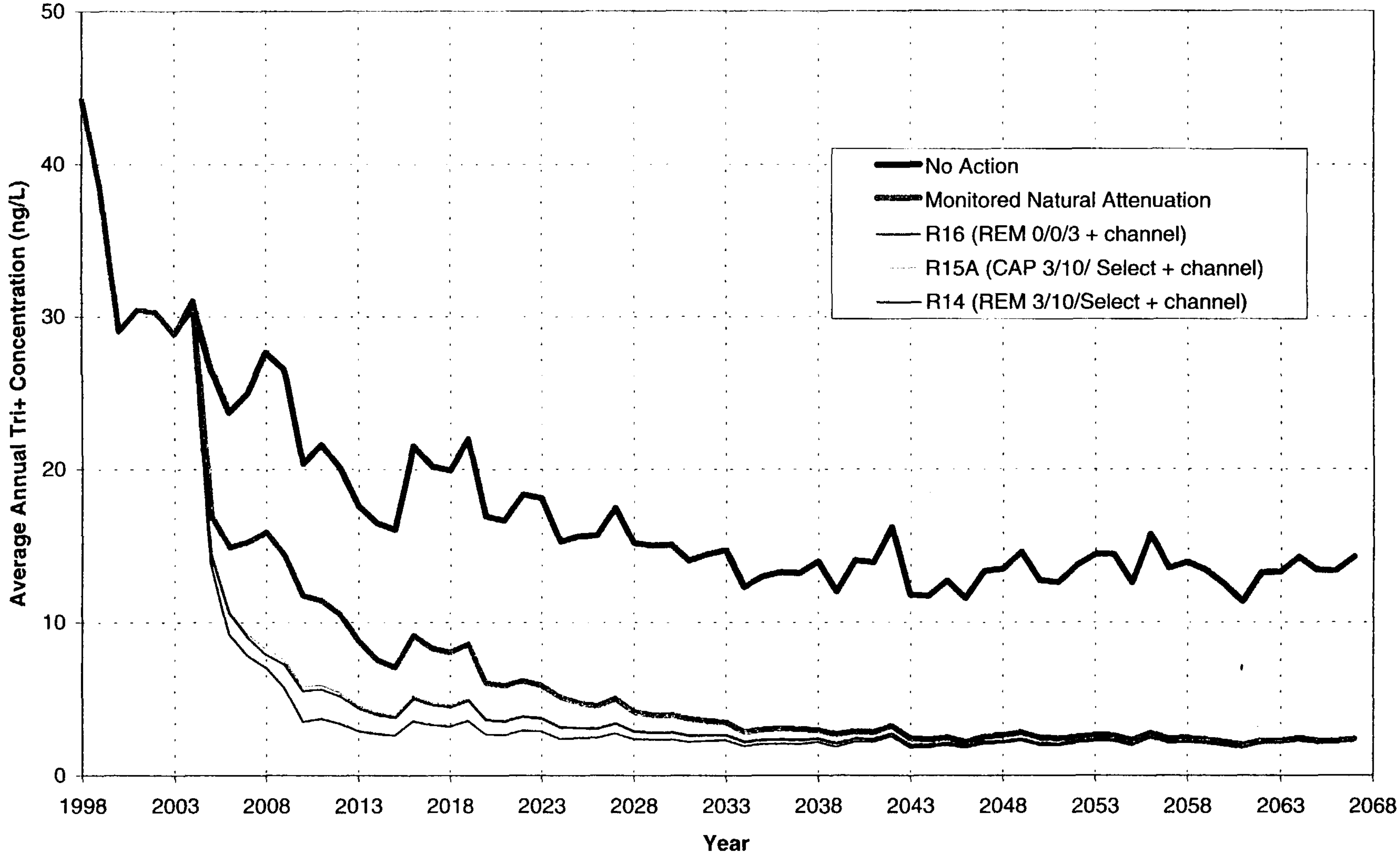
Figure RE80. Comparison Between Water Column Forecasts at Thompson Island Dam - Alternatives Retained for Detailed Analyses



401746

re80_re84 11/16/00

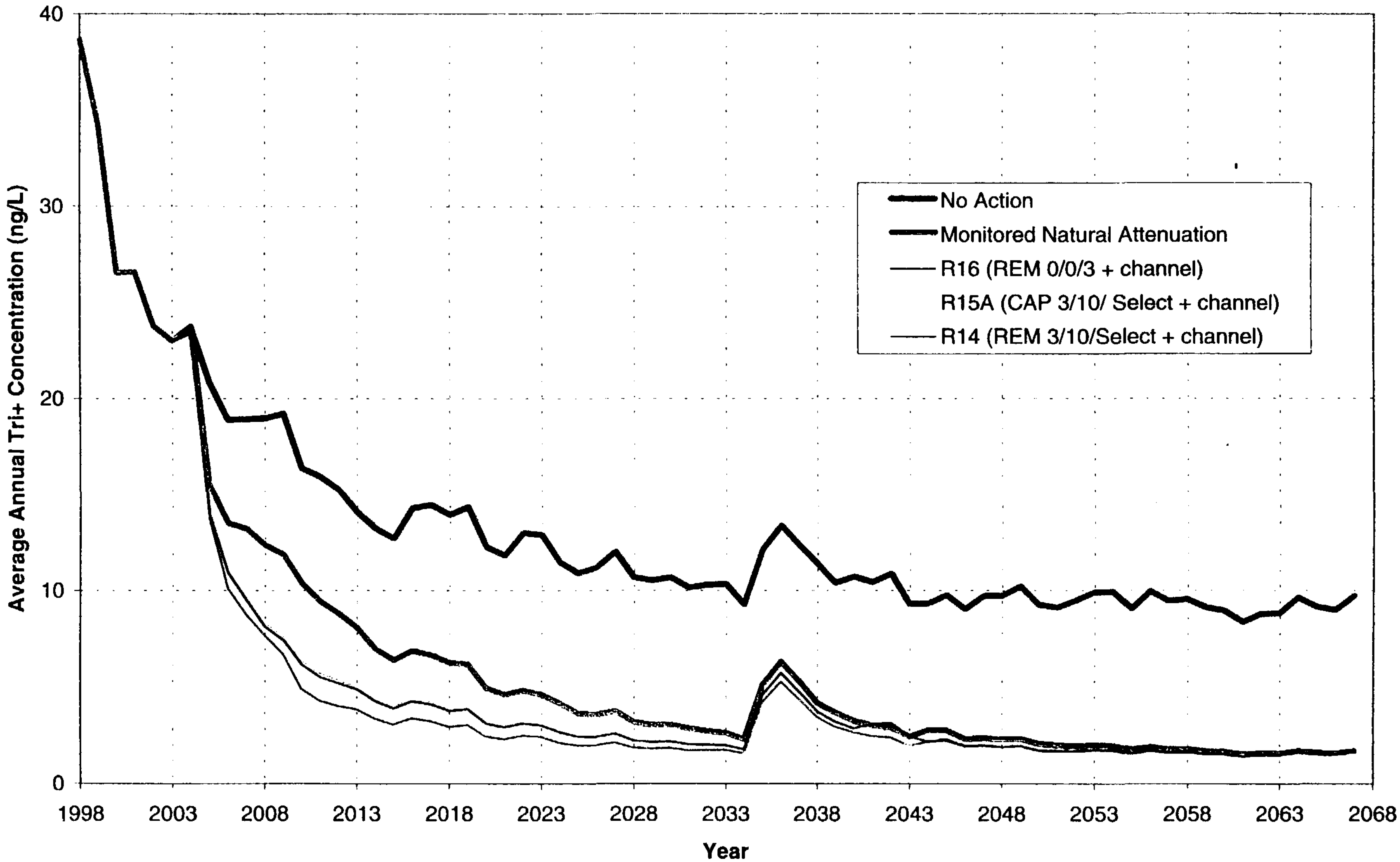
Figure RE81. Comparison Between Water Column Forecasts at Northumberland Dam - Alternatives Retained for Detailed Analyses



401747

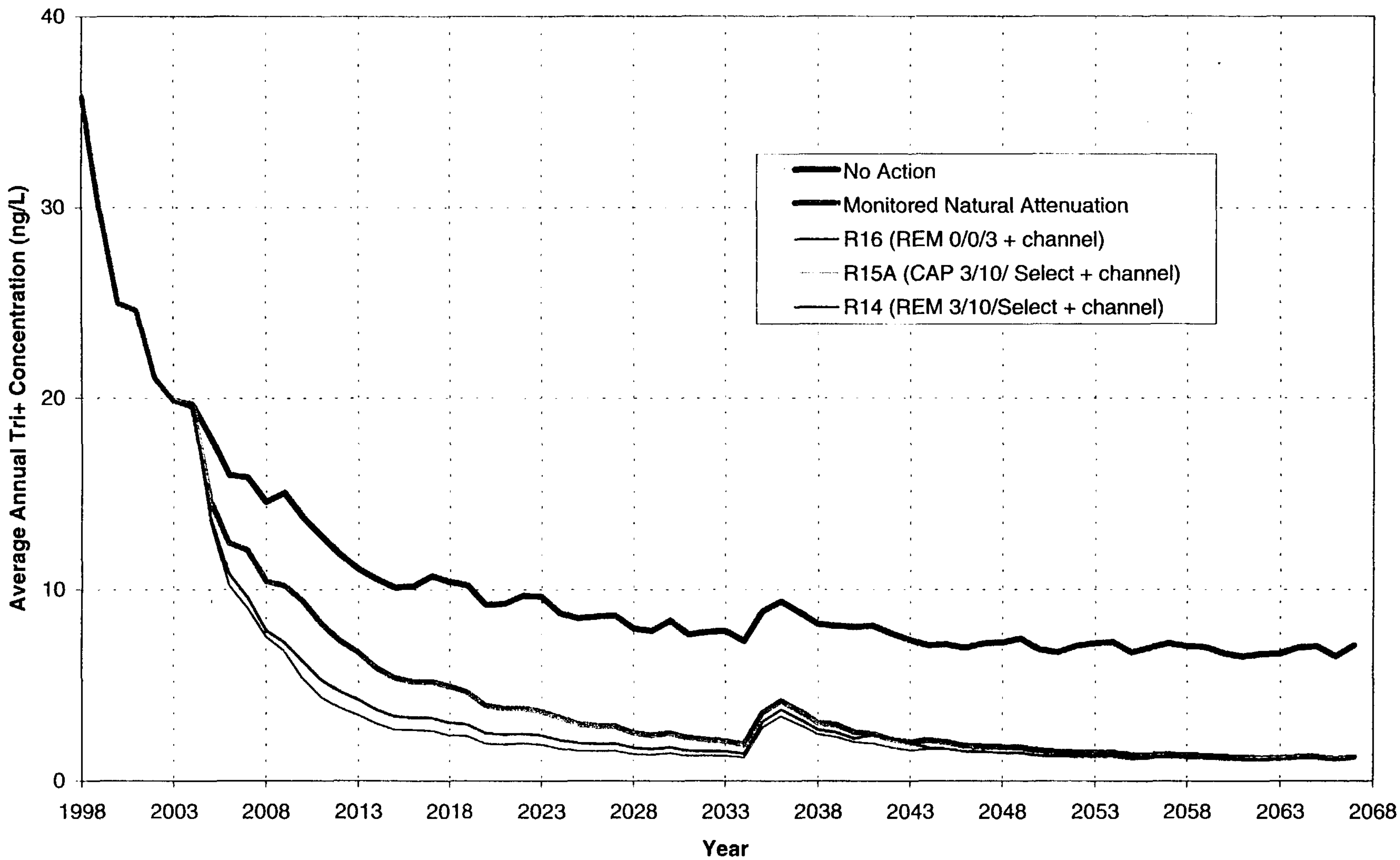
re80_re84 11/16/00

Figure RE82. Comparison Between Water Column Forecasts at Stillwater - Alternatives Retained for Detailed Analyses



401748

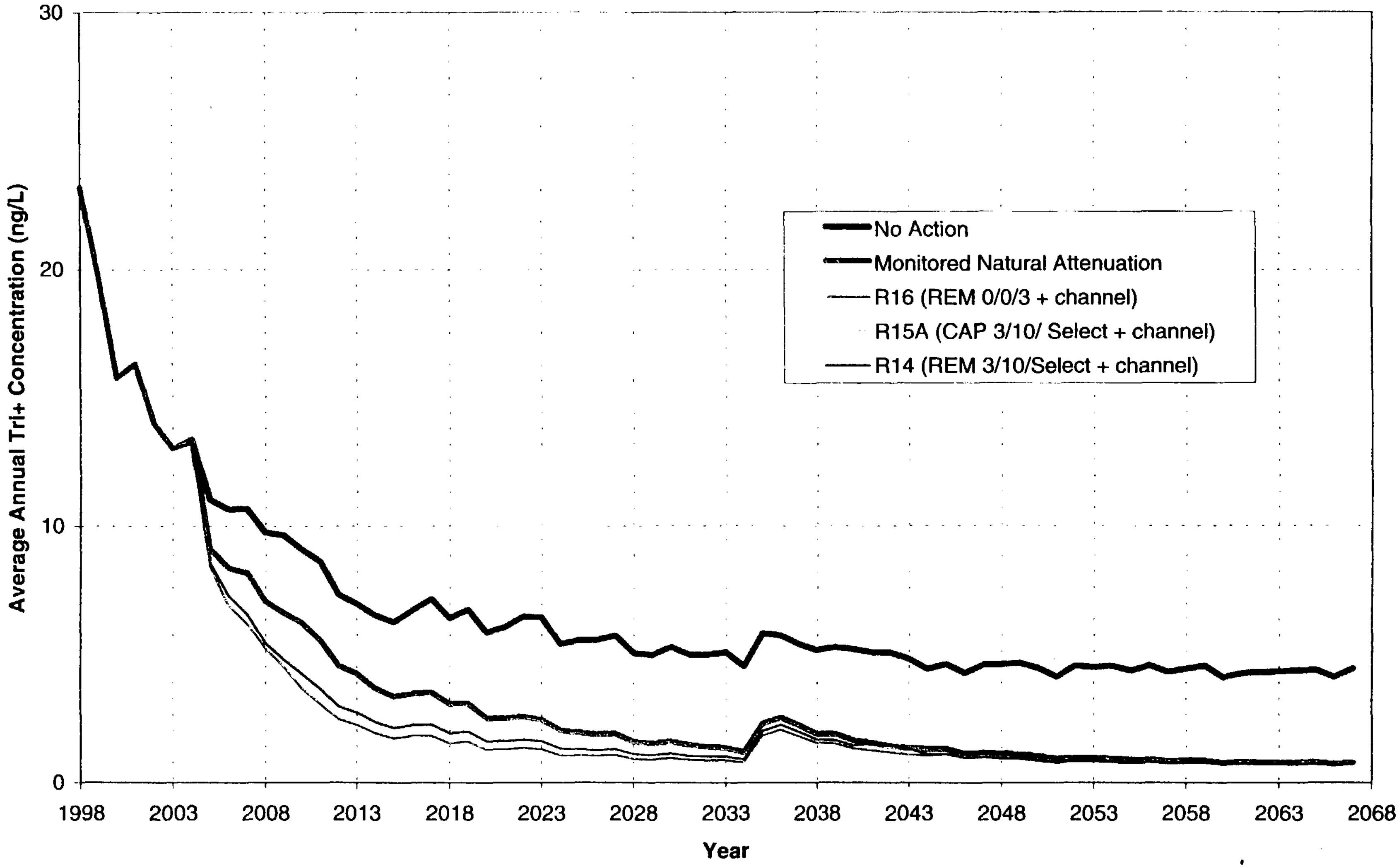
Figure RE83. Comparison Between Water Column Forecasts at Waterford - Alternatives Retained for Detailed Analyses



401749

re80_re84 11/16/00

Figure RE84. Comparison Between Water Column Forecasts at Federal Dam - Alternatives Retained for Detailed Analyses



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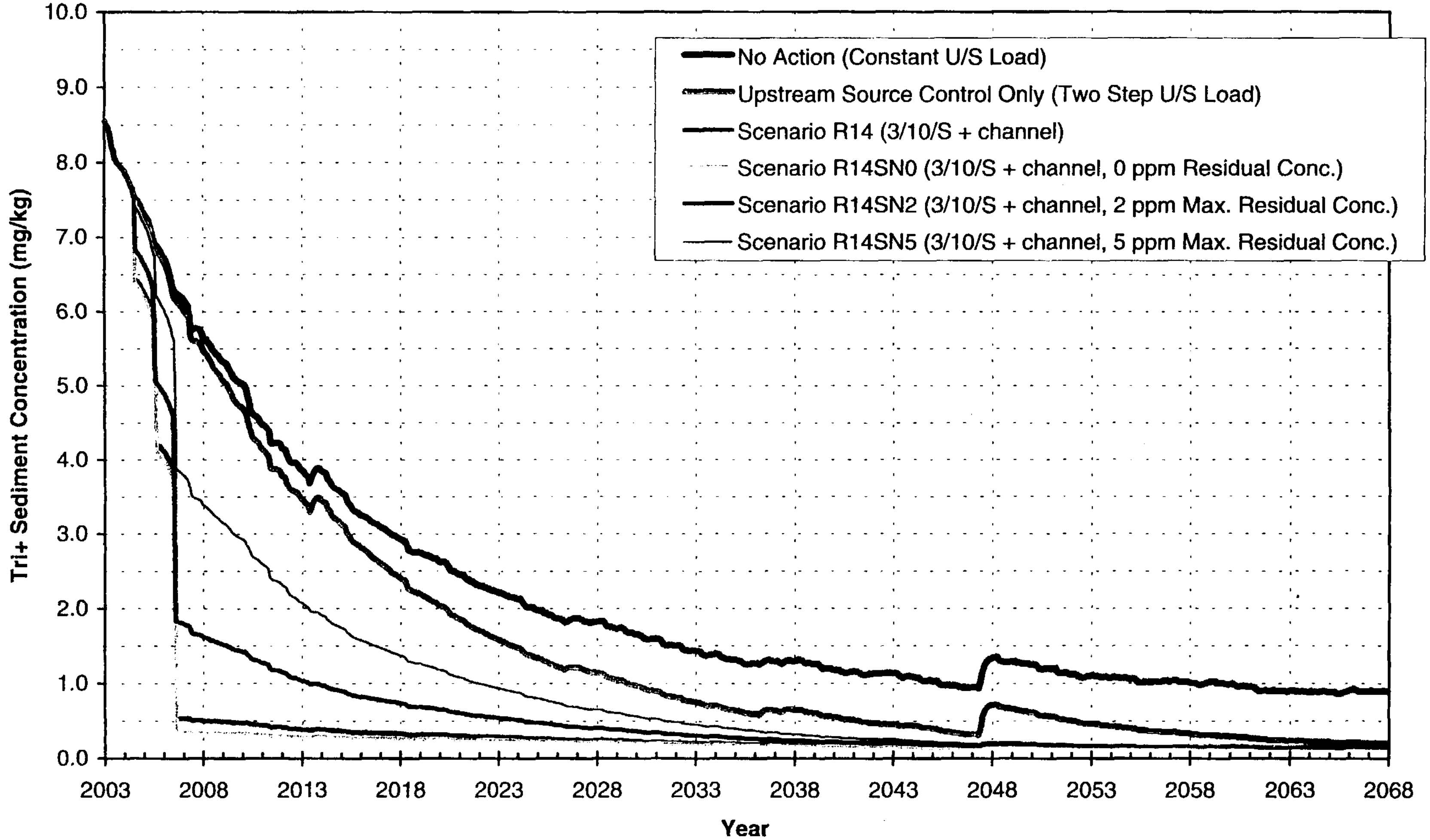
re80_re84 11/16/00

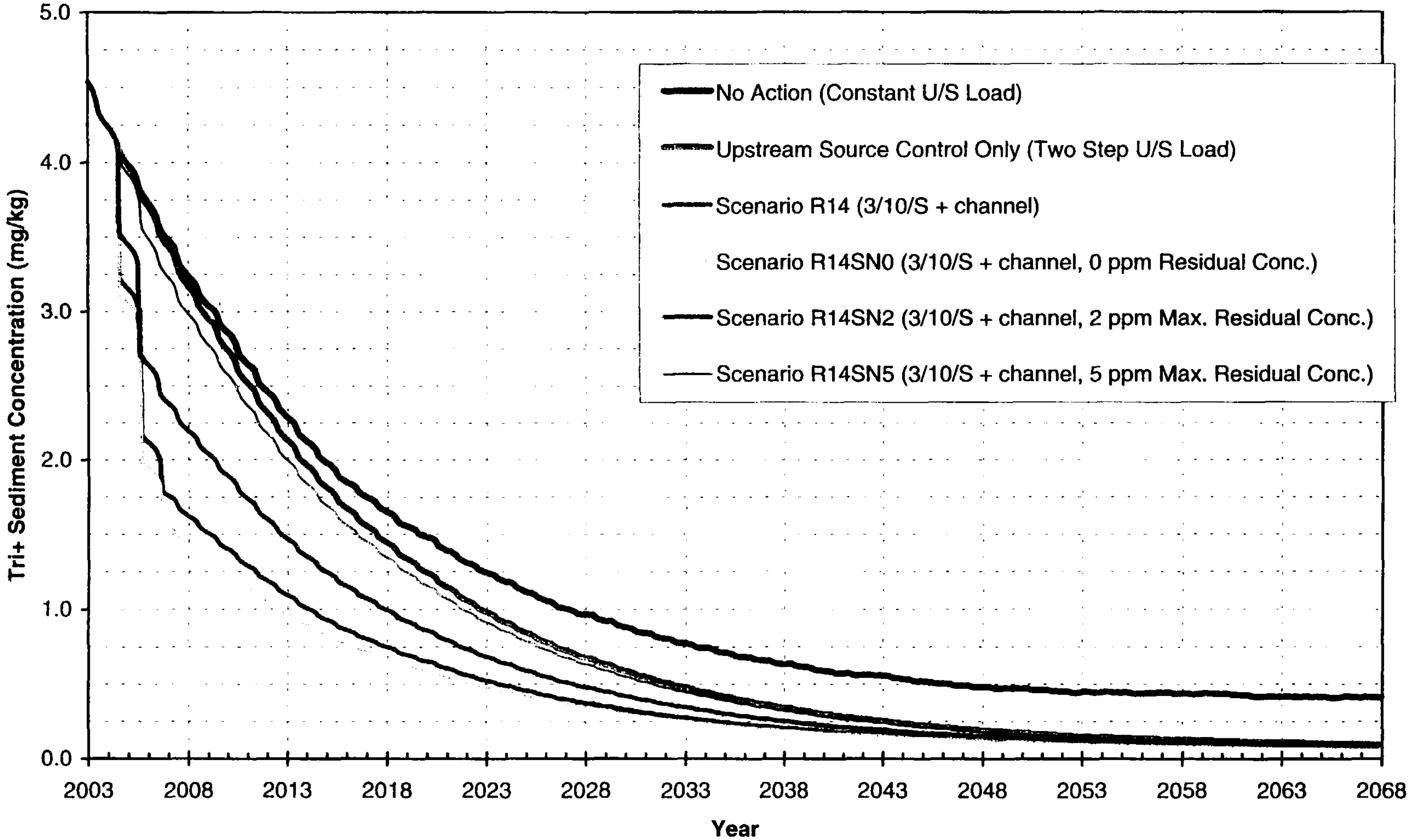
Figure RE85. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401751

re85_re98_2 11/16/00

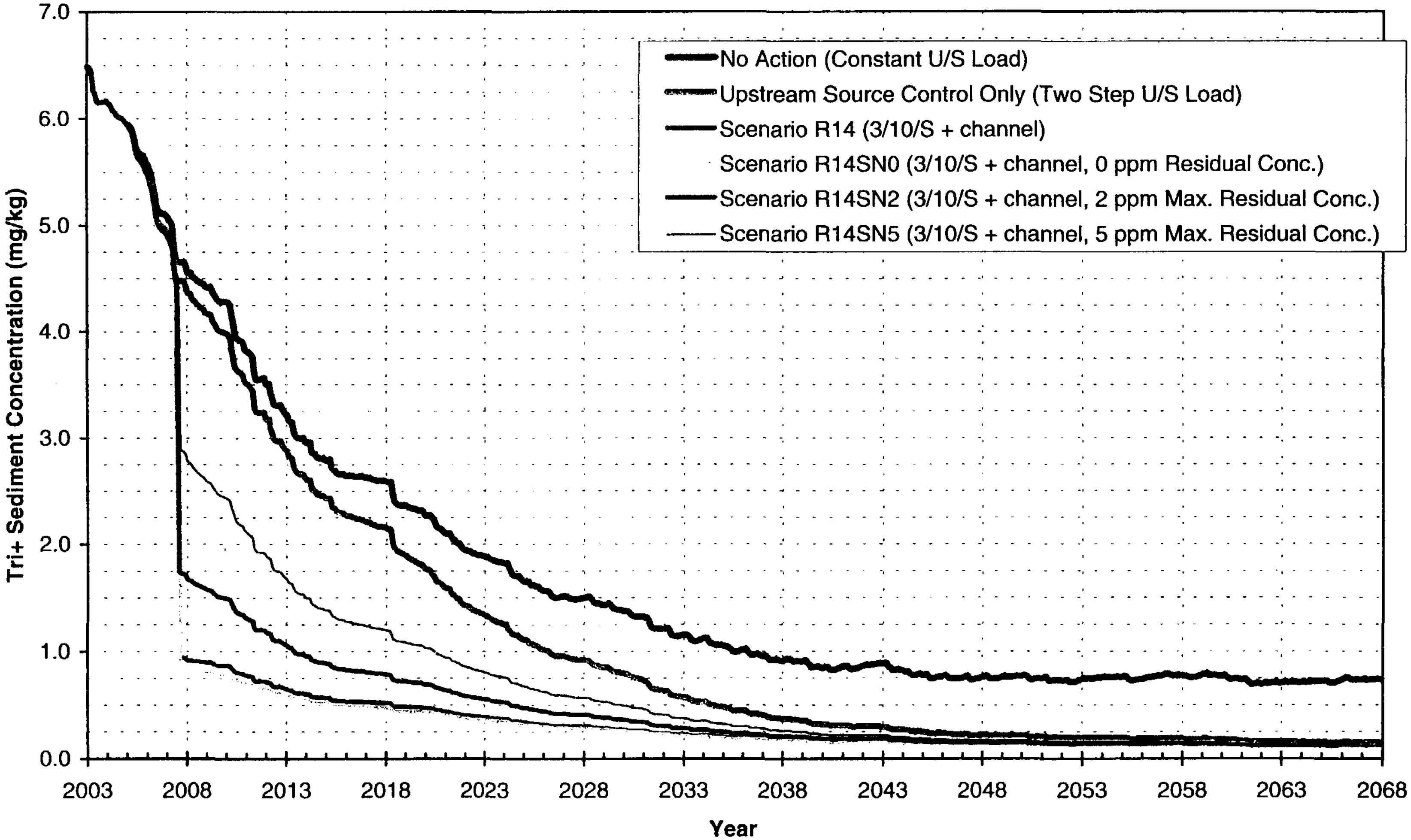
Figure RE86. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401752

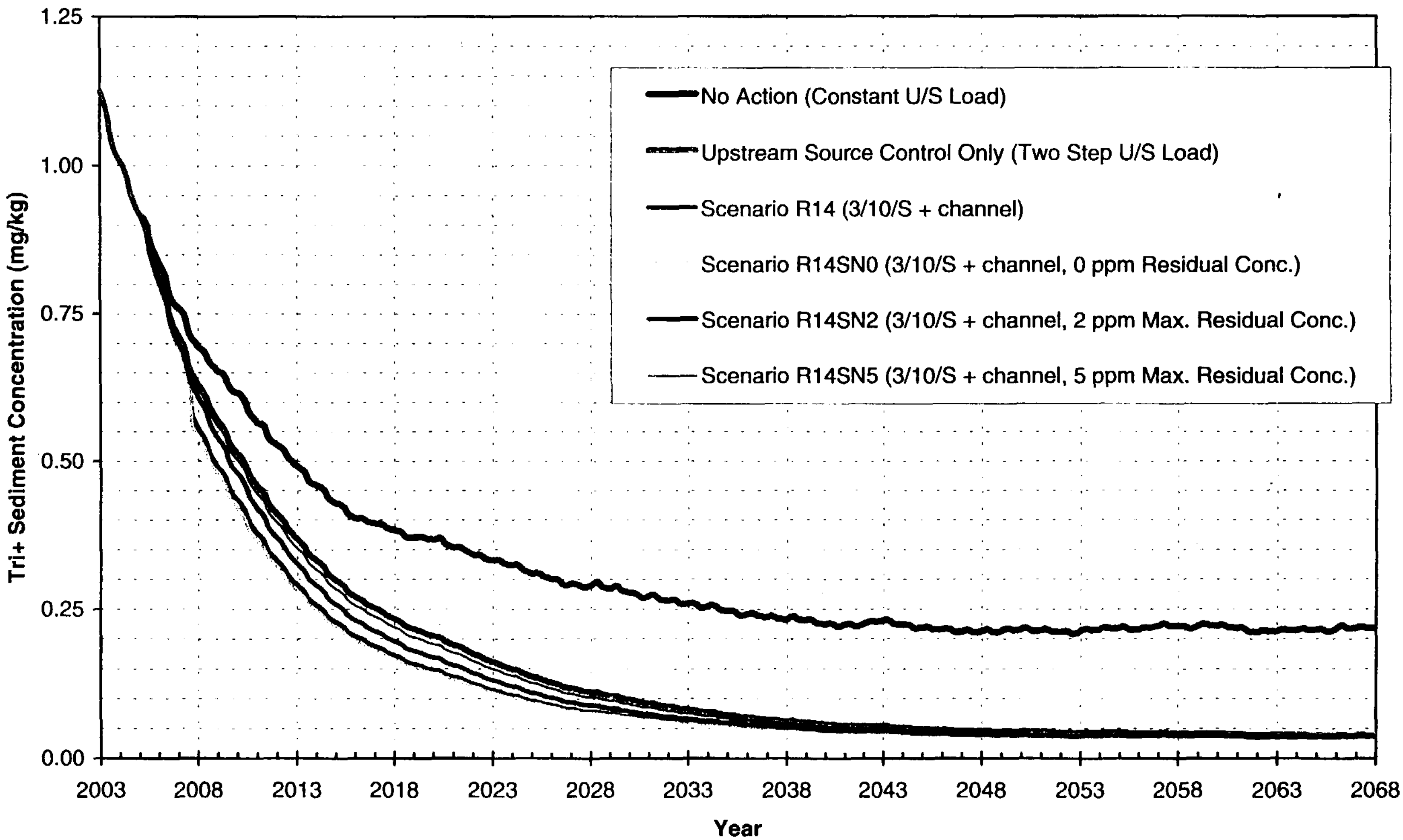
re85_re98_2 11/16/00

Figure RE87. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



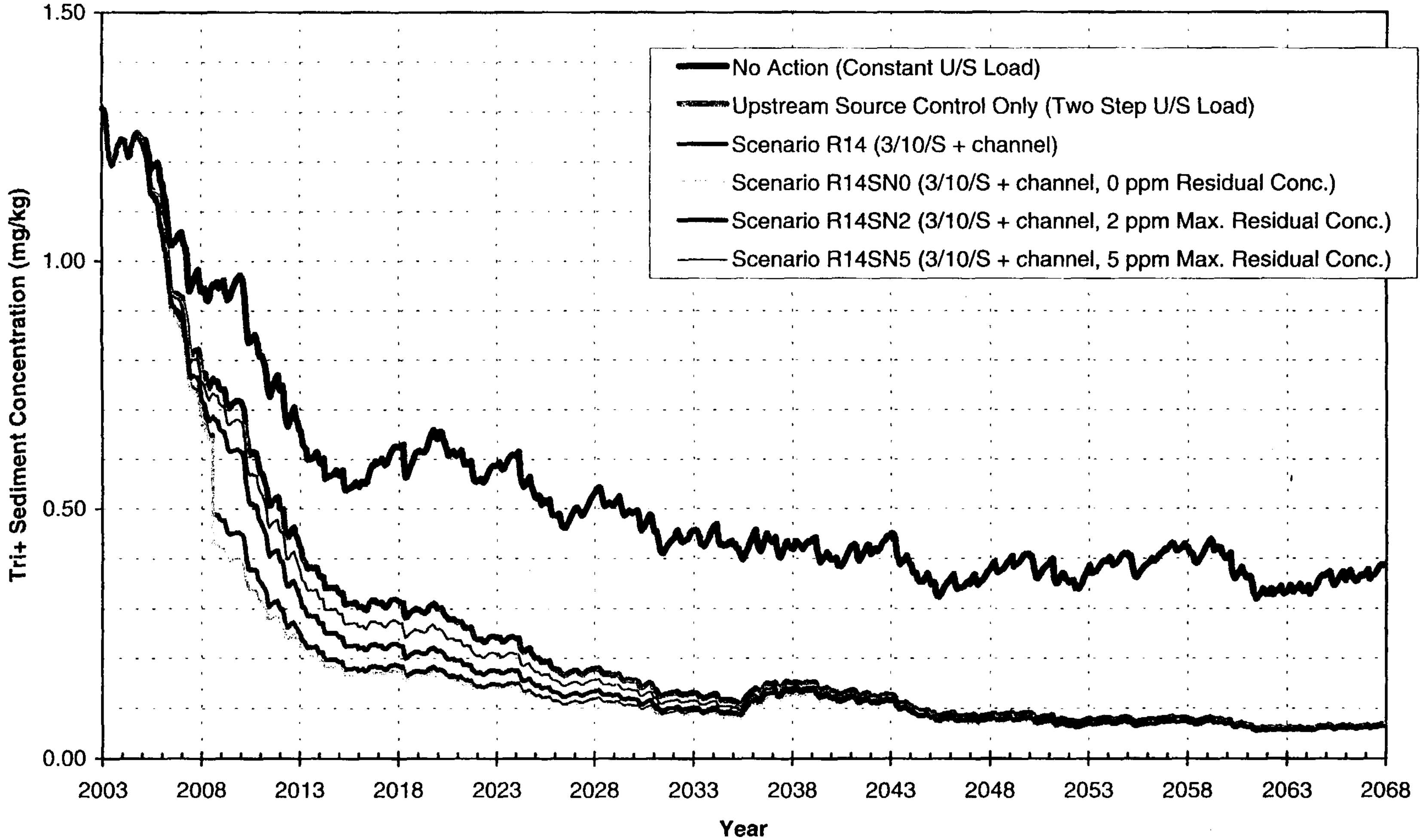
401753

Figure RE88. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401754

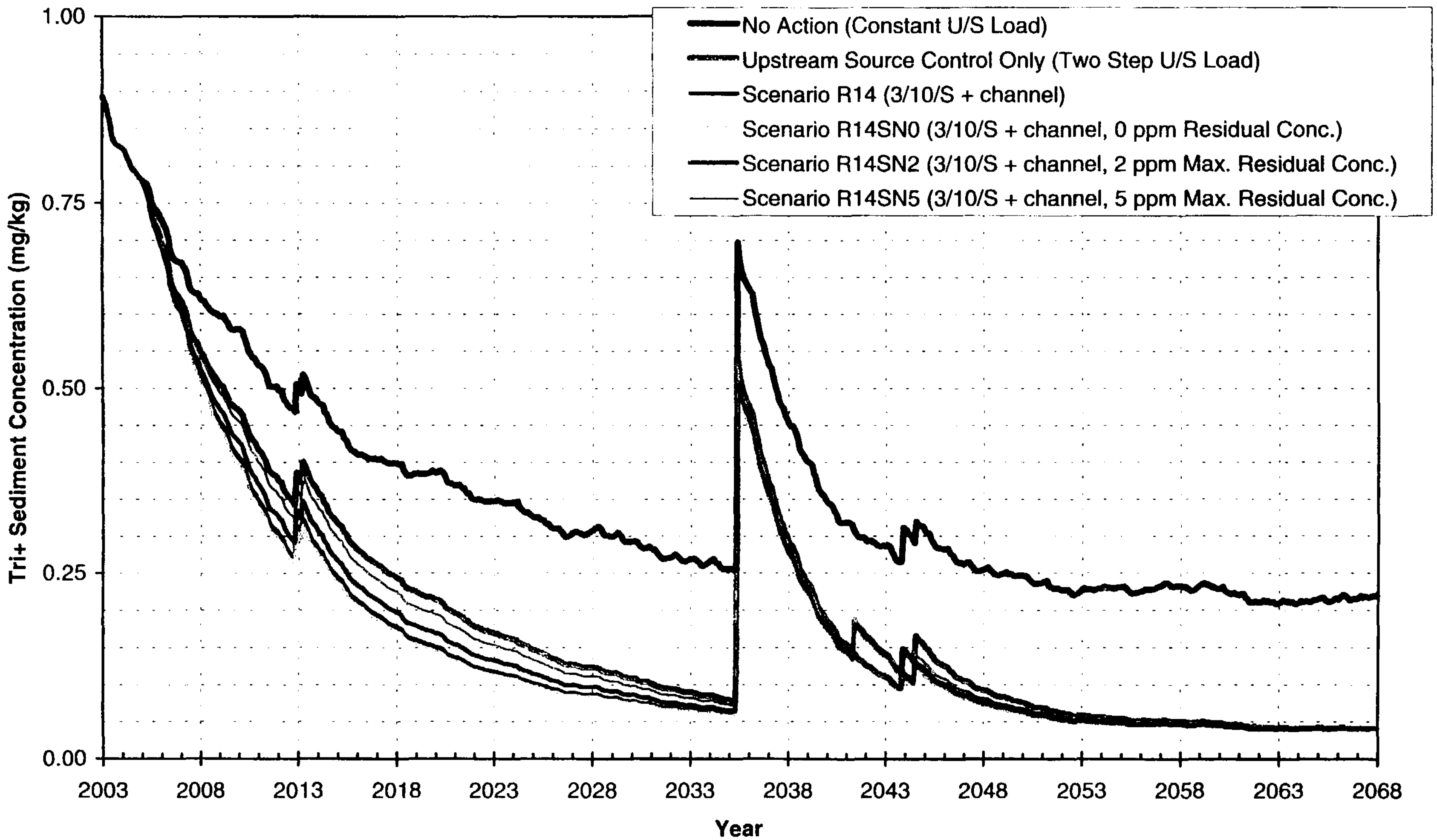
Figure RE89. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401755

re85_re98_2 11/16/00

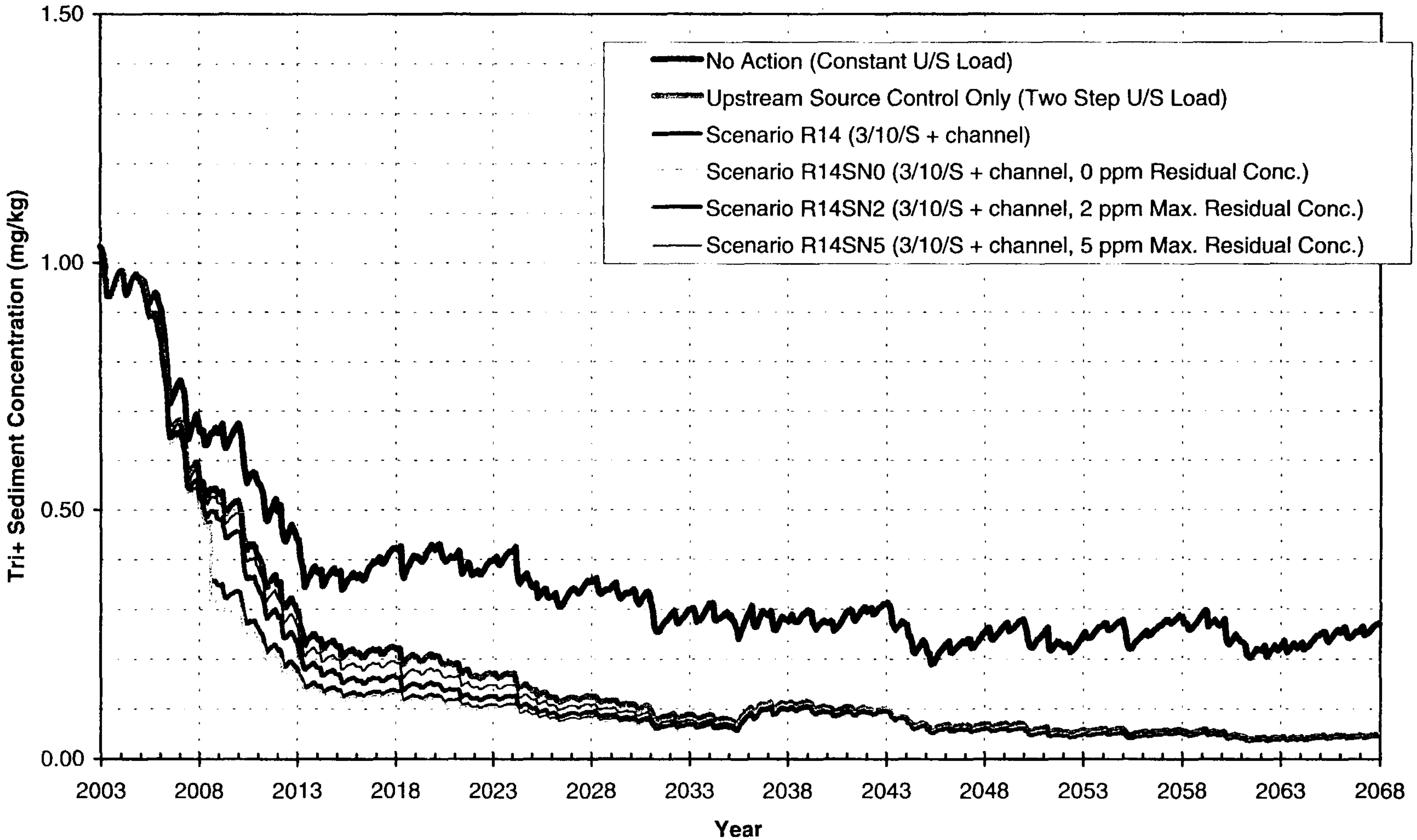
Figure RE90. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401756

re85_re98_2 11/16/00

Figure RE91. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



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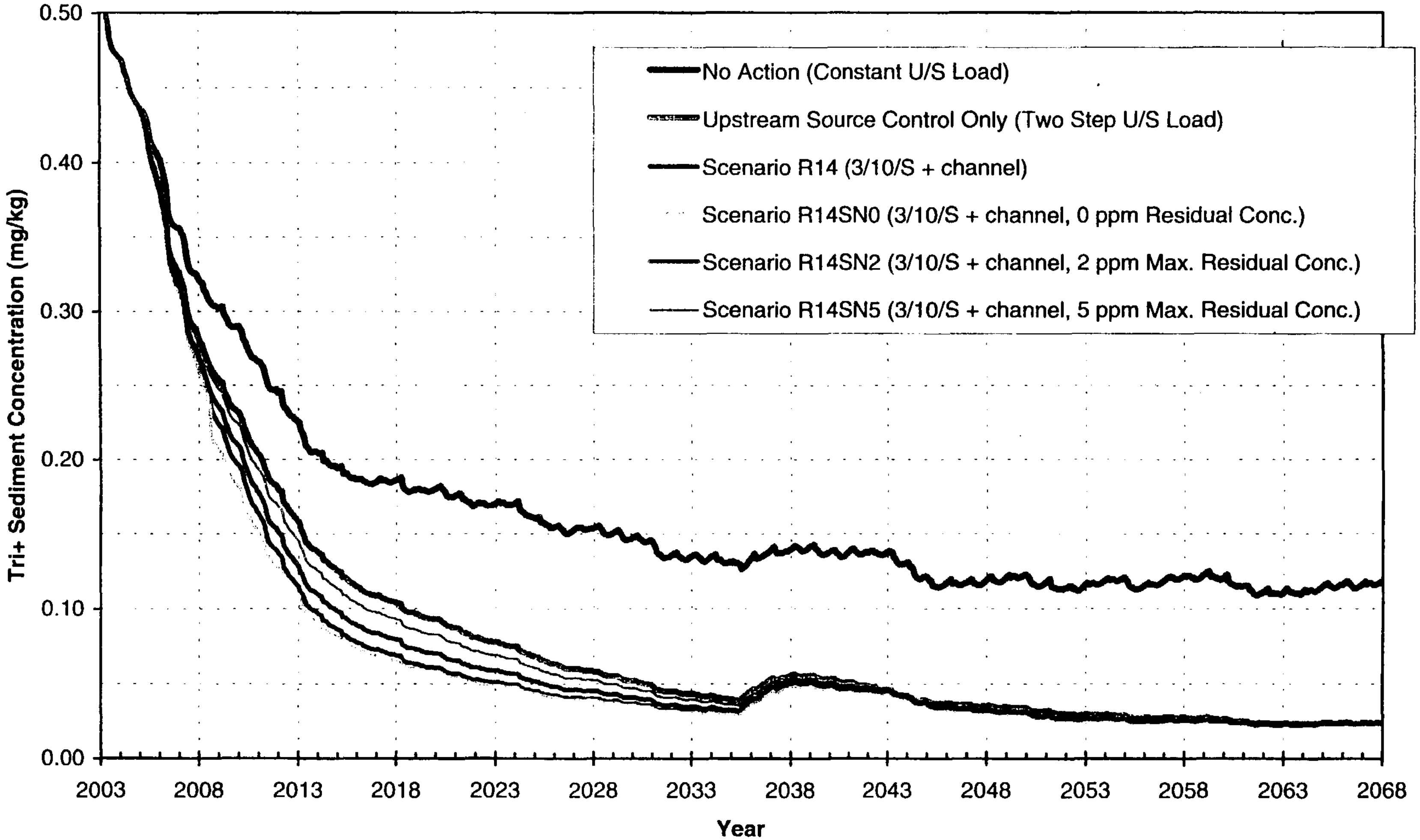
re85_re98_2 11/16/00

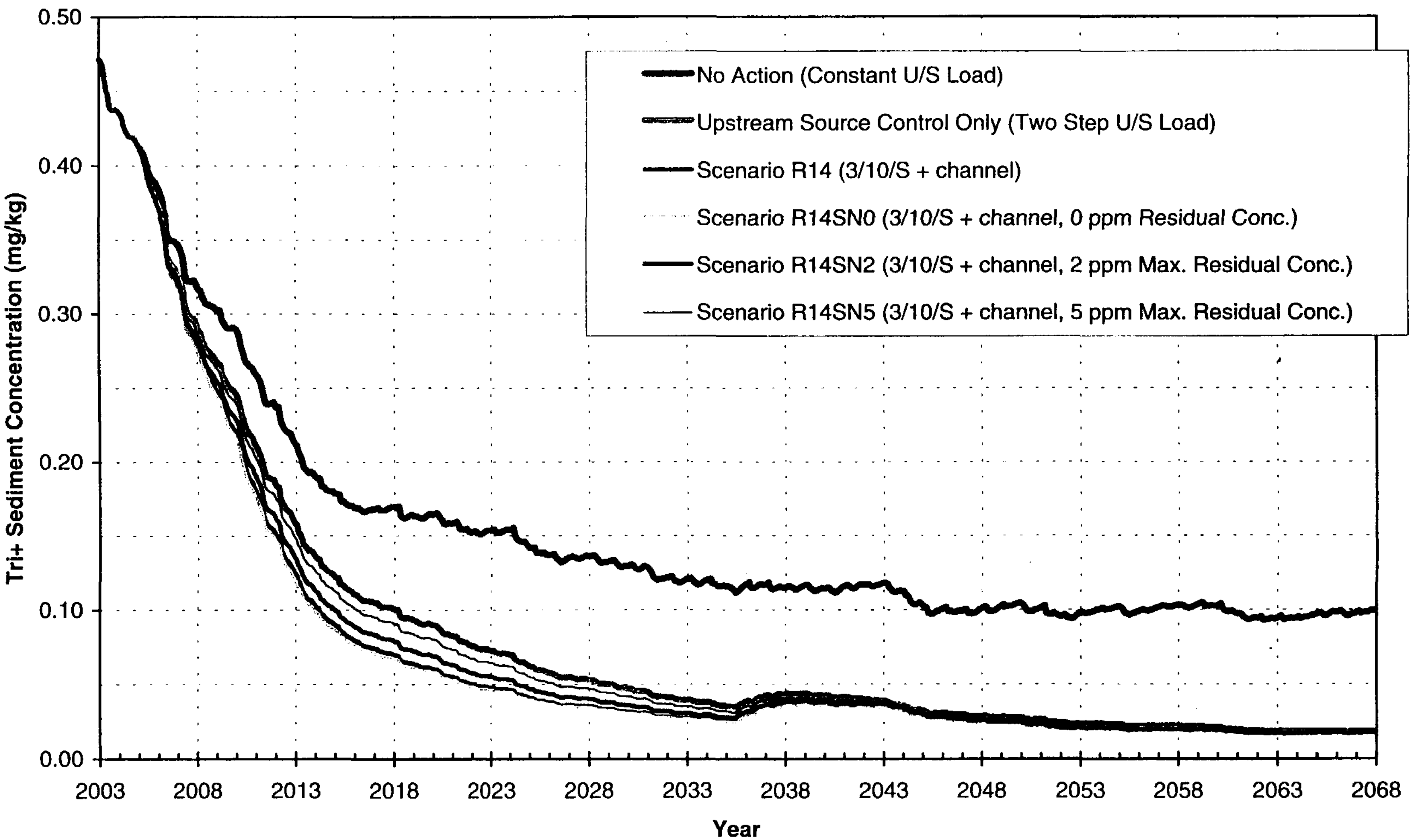
Figure RE92. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401758

re85_re98_2 11/16/00

Figure RE93. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Removal Scenarios Sensitivity Analysis



401759

re85_re98_2 11/16/00

Figure RE94. Comparison Between Water Column Forecasts at Thompson Island Dam - Removal Scenarios Sensitivity Analysis

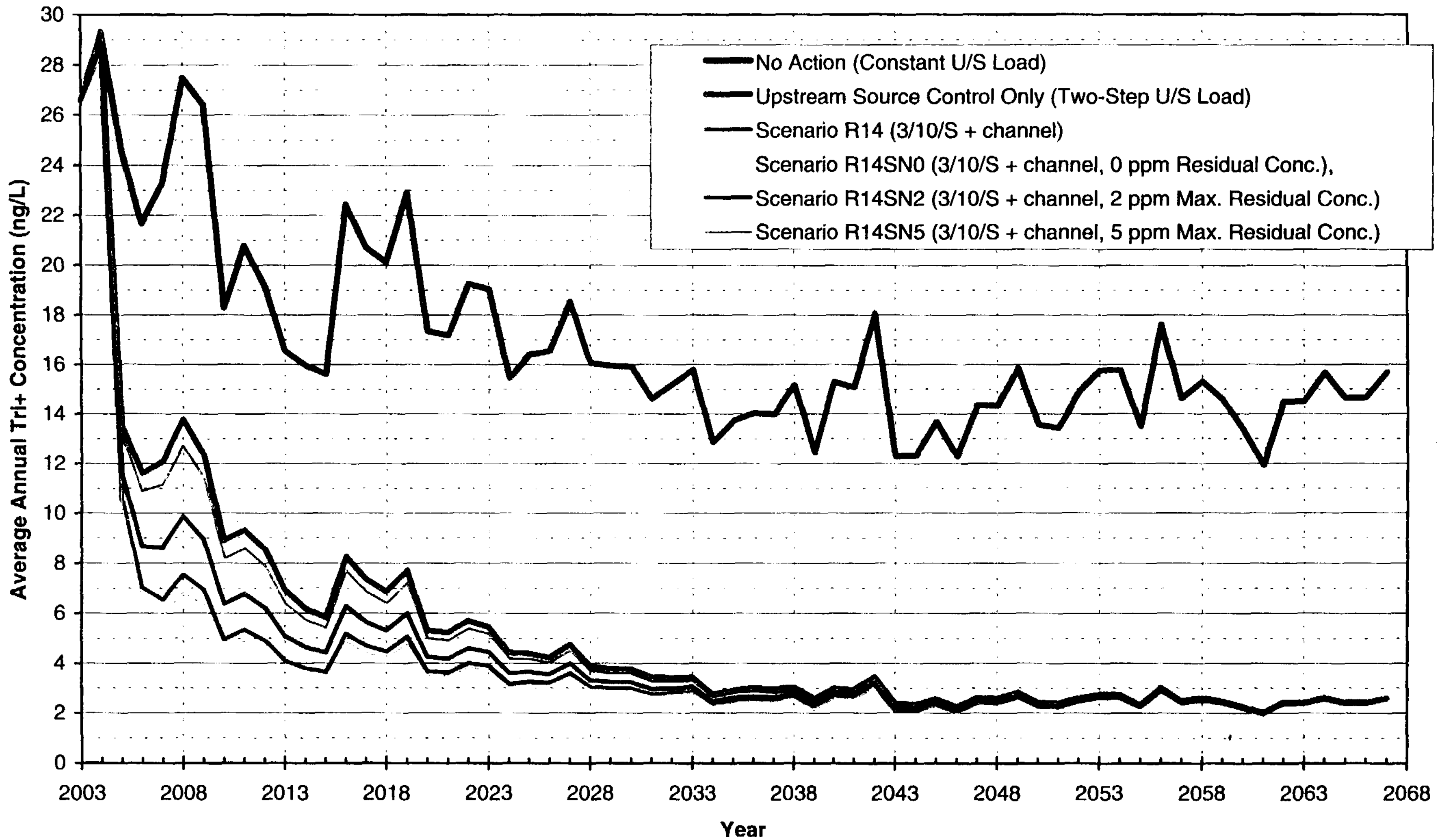


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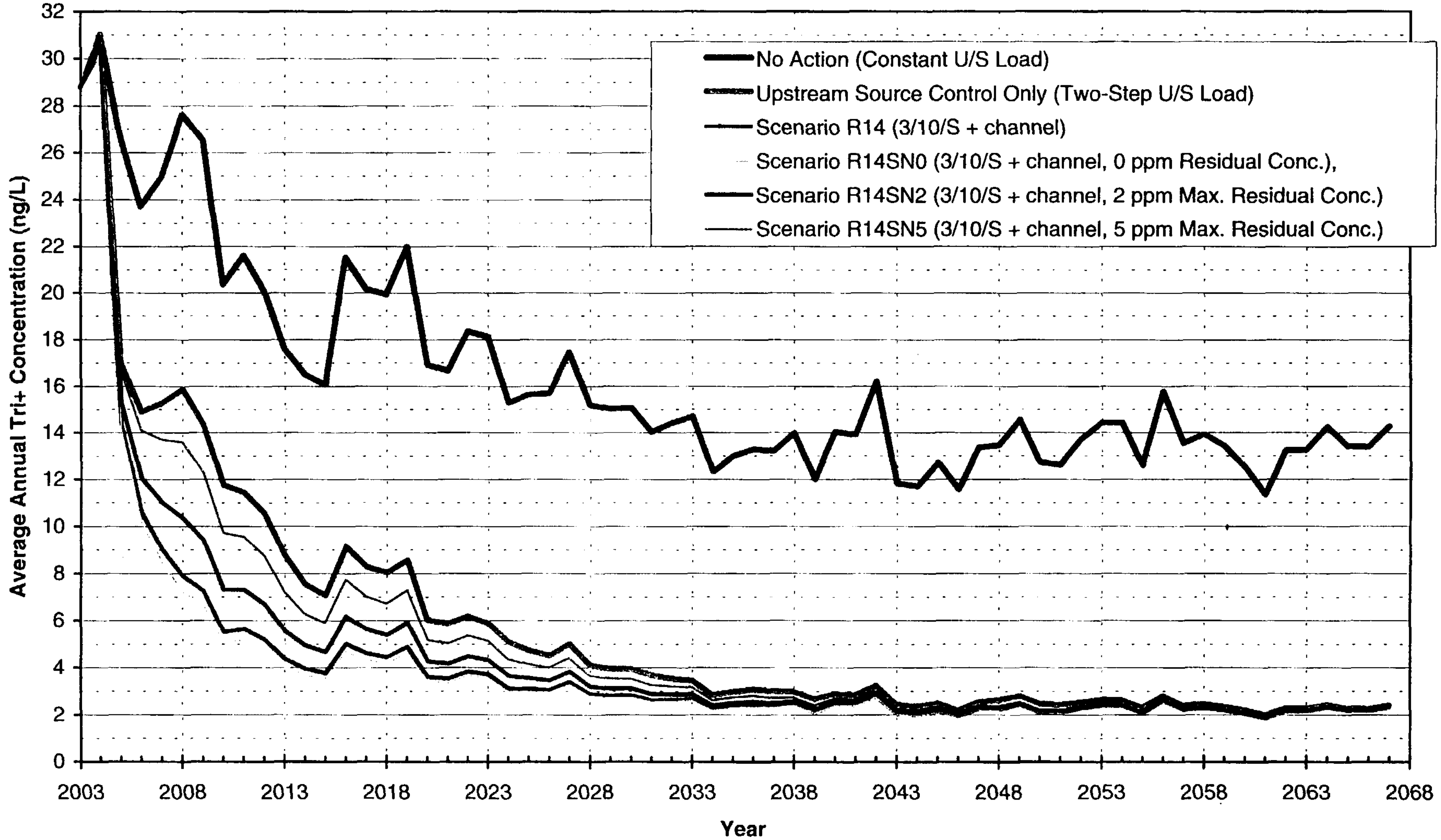
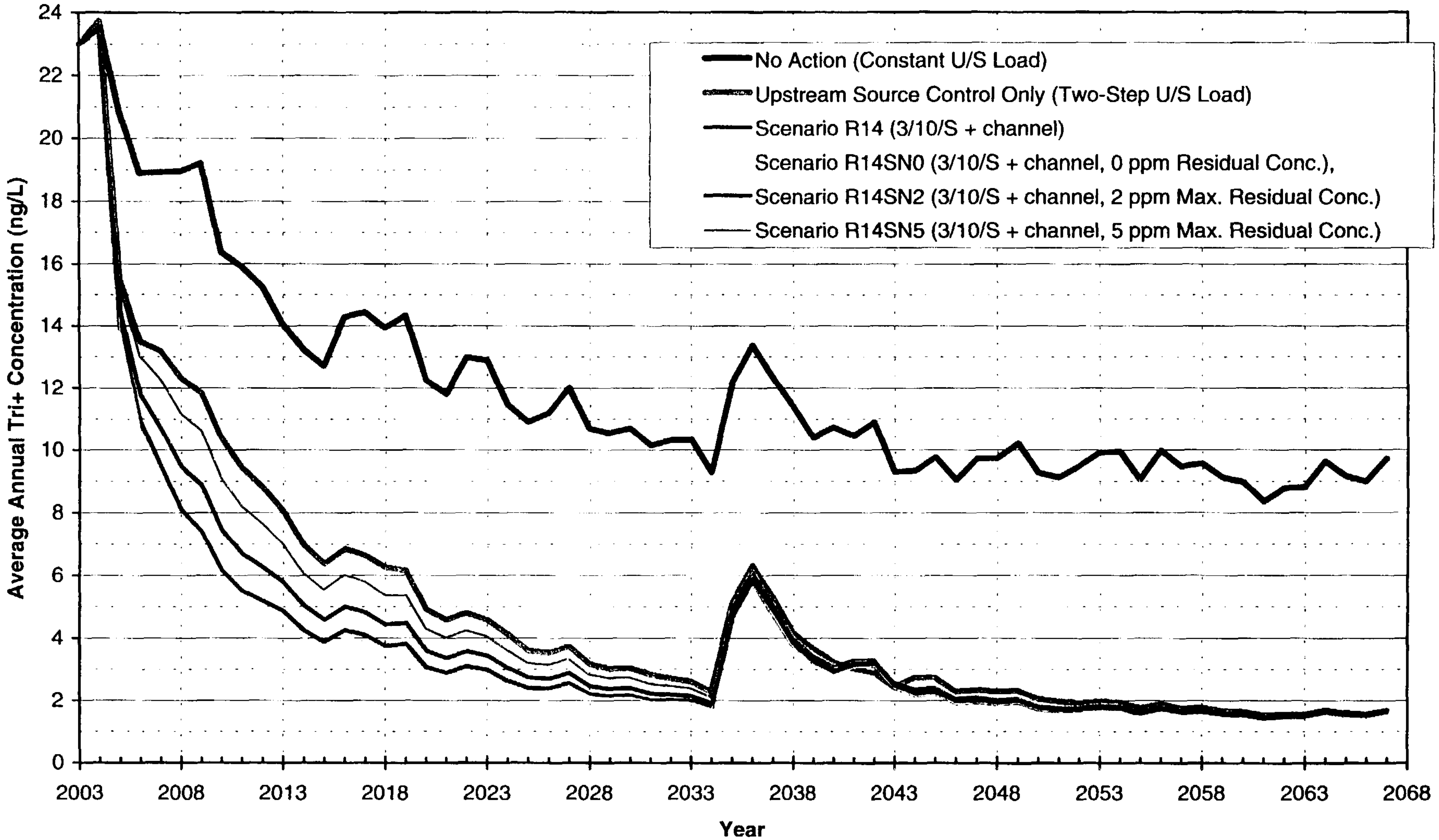
Figure RE95. Comparison Between Water Column Forecasts at Northumberland Dam - Removal Scenarios Sensitivity Analysis



401761

re85_re98_2 11/16/00

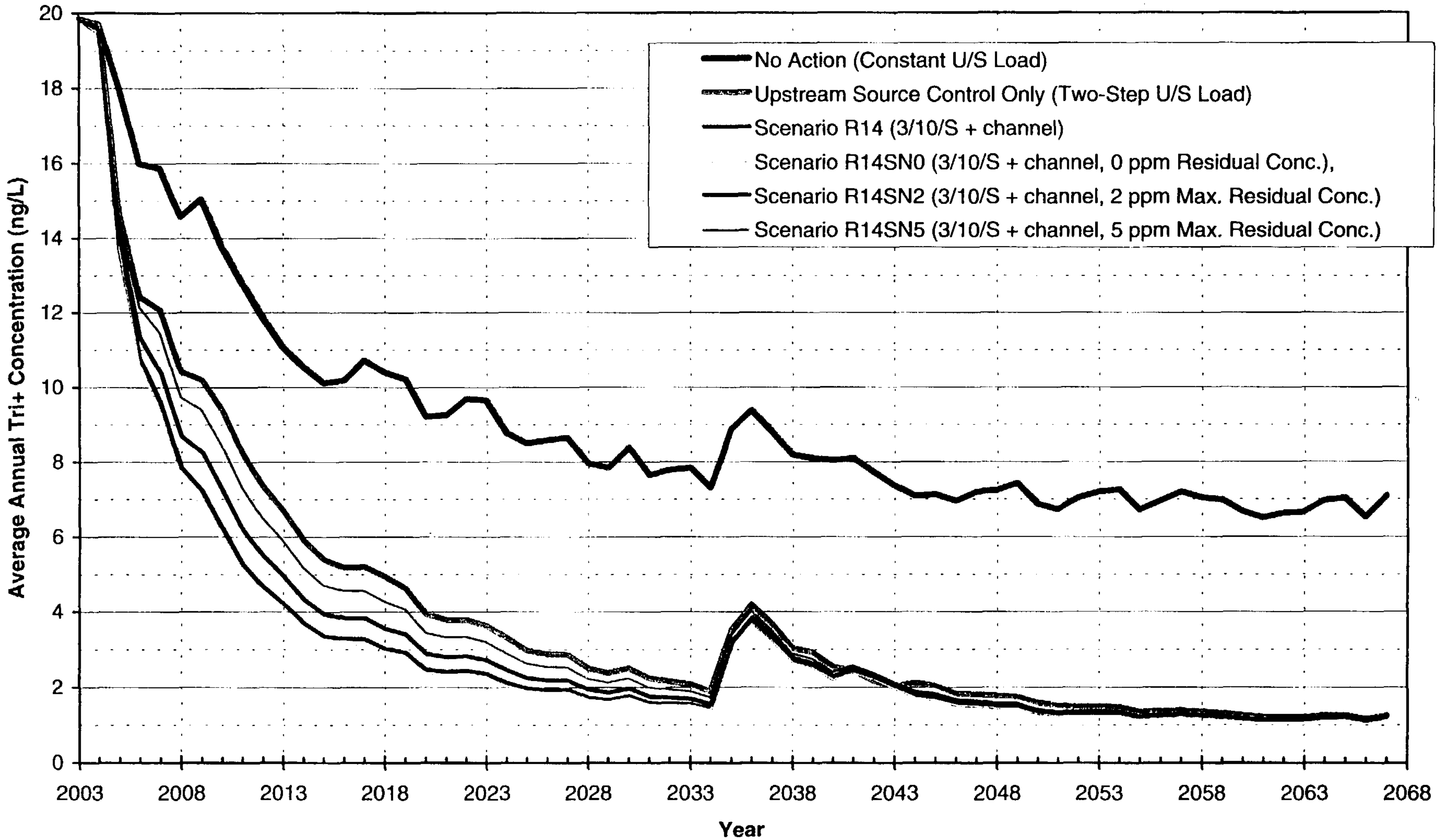
Figure RE96. Comparison Between Water Column Forecasts at Stillwater - Removal Scenarios Sensitivity Analysis



401762

re98_2 11/16/00

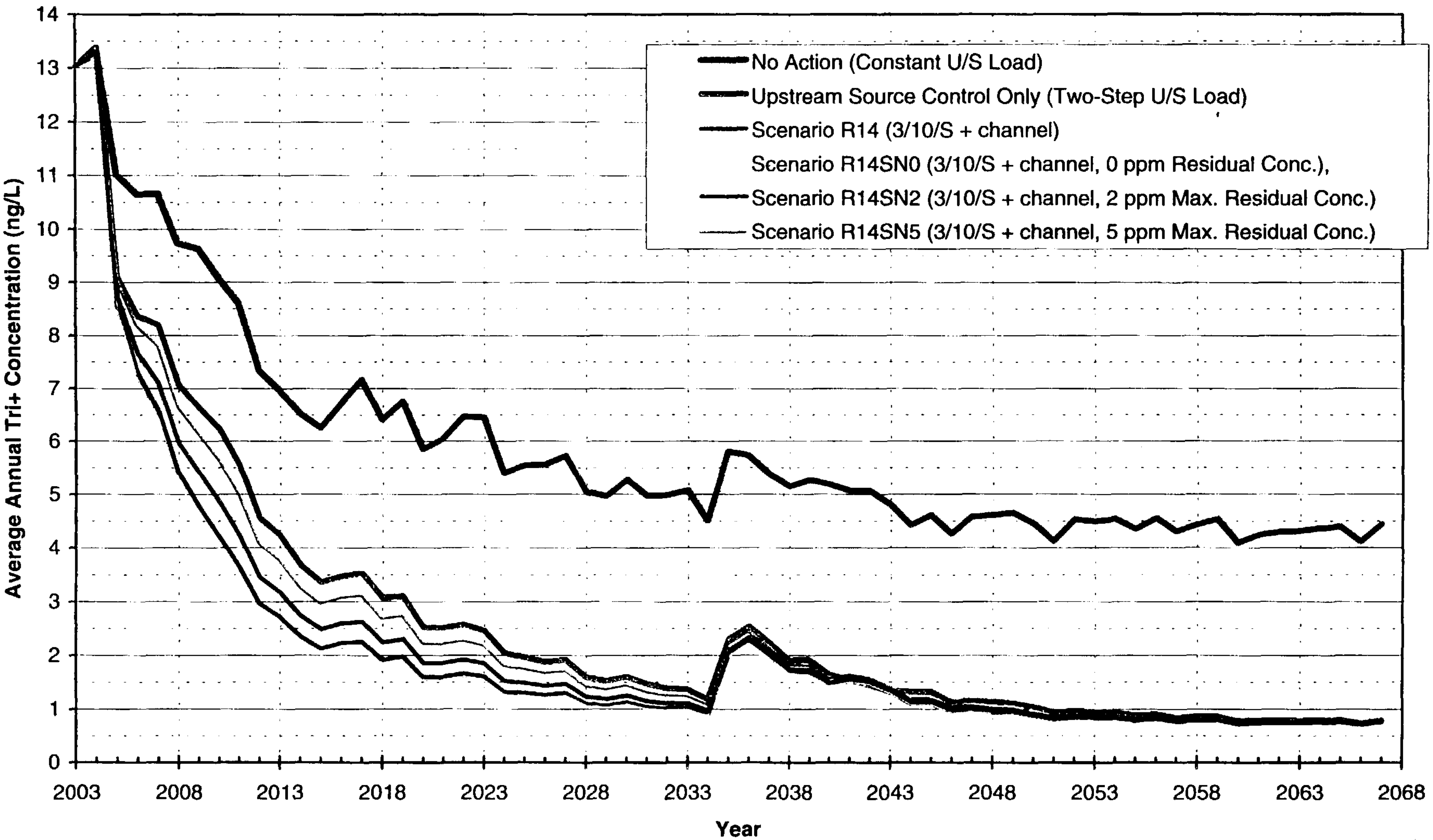
Figure RE97. Comparison Between Water Column Forecasts at Waterford - Removal Scenarios Sensitivity Analysis



re85_re98_2 11/16/00

401763

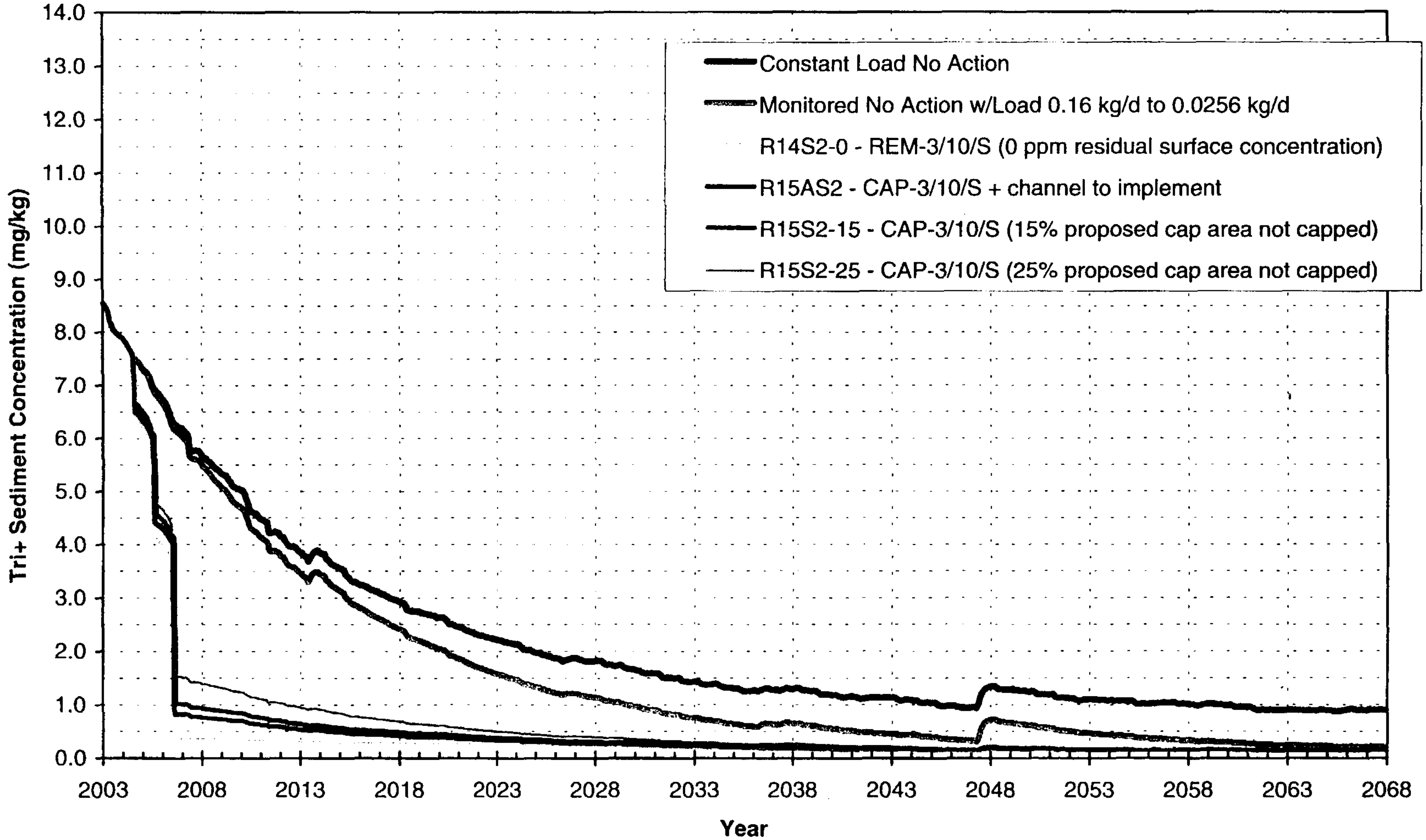
Figure RE98. Comparison Between Water Column Forecasts at Federal Dam - Removal Scenarios Sensitivity Analysis



401764

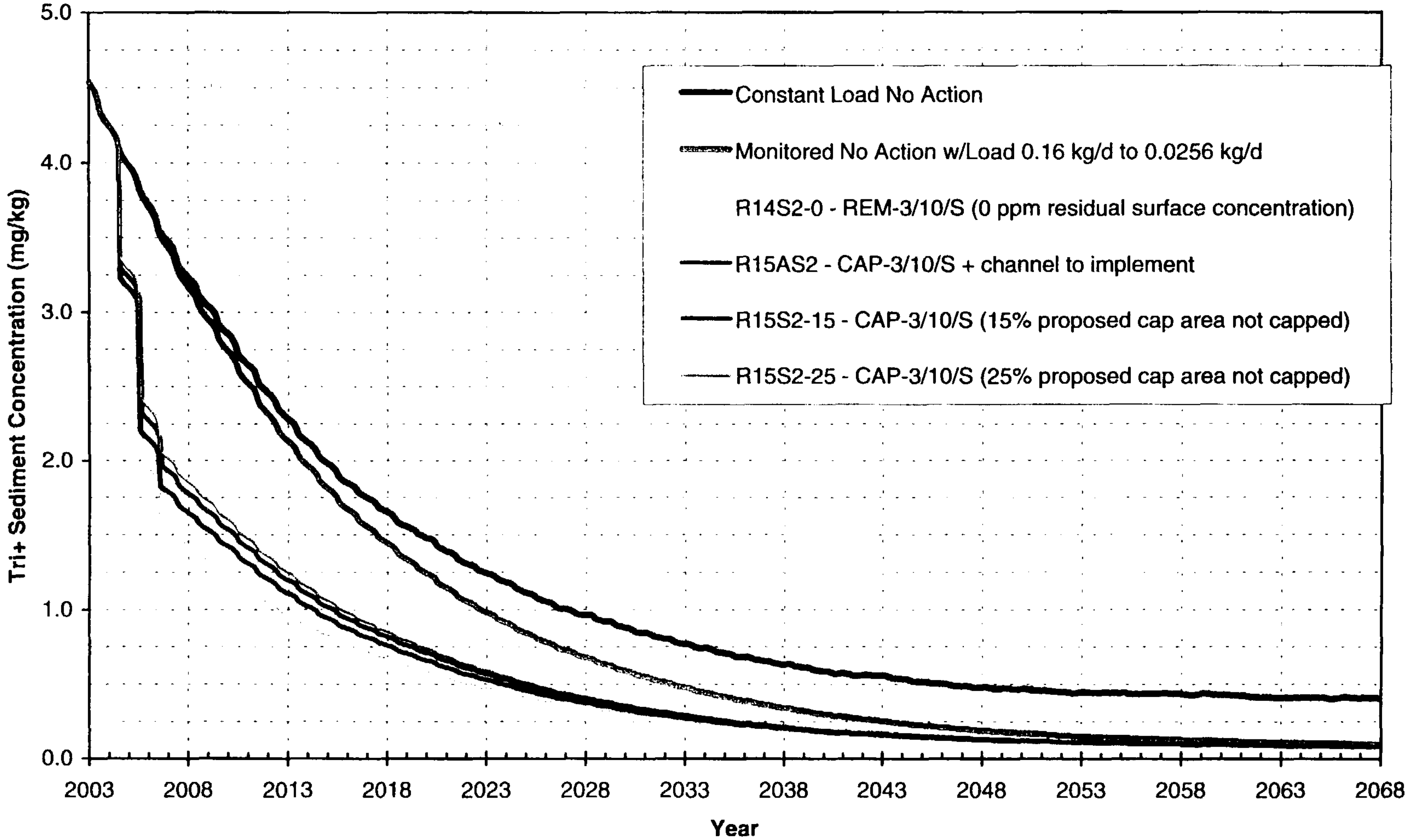
re85_re98_2 11/16/00

Figure RE99. Comparison Between Forecasts for Thompson Island Pool Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



401765

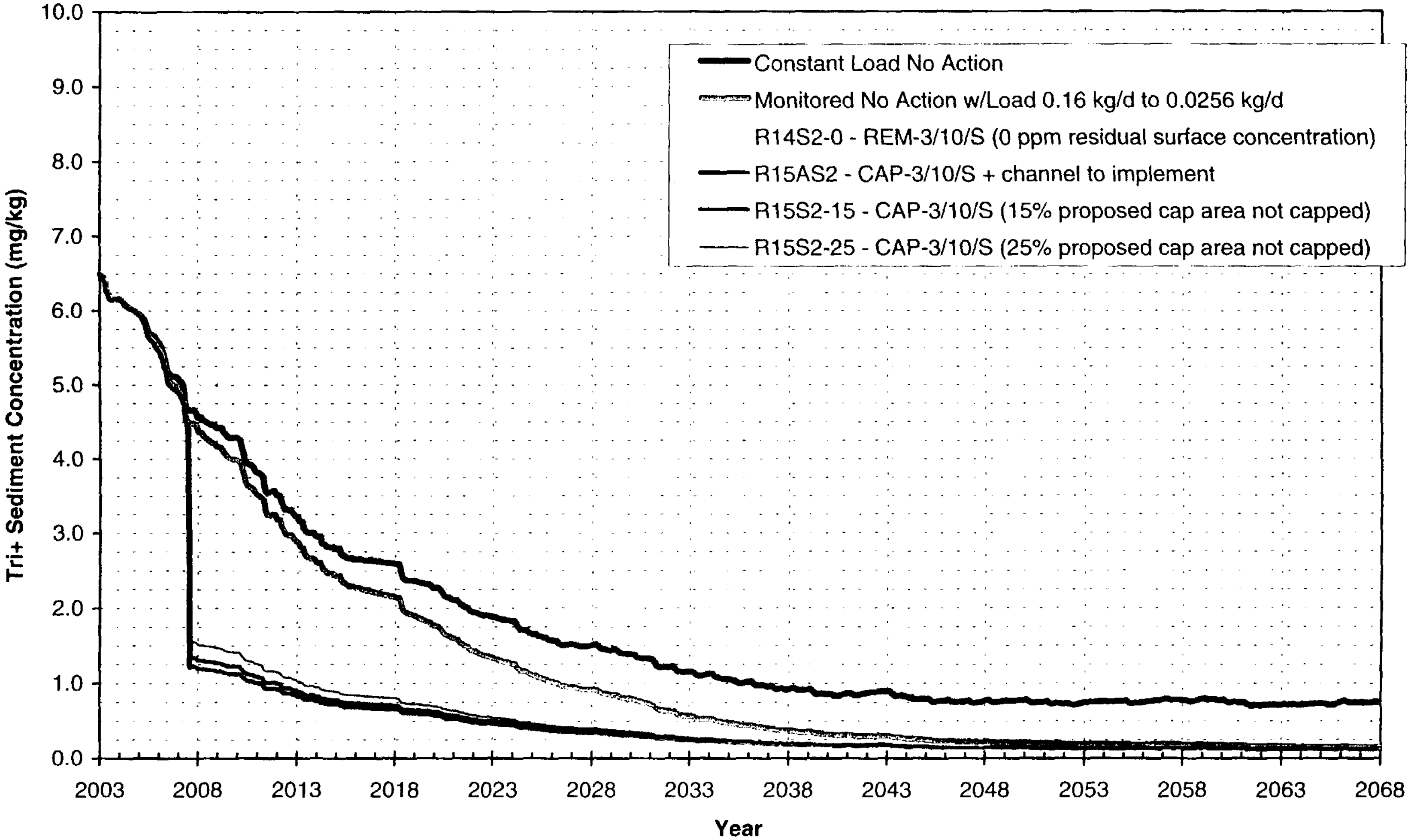
Figure RE100. Comparison Between Forecasts for Thompson Island Pool Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



401766

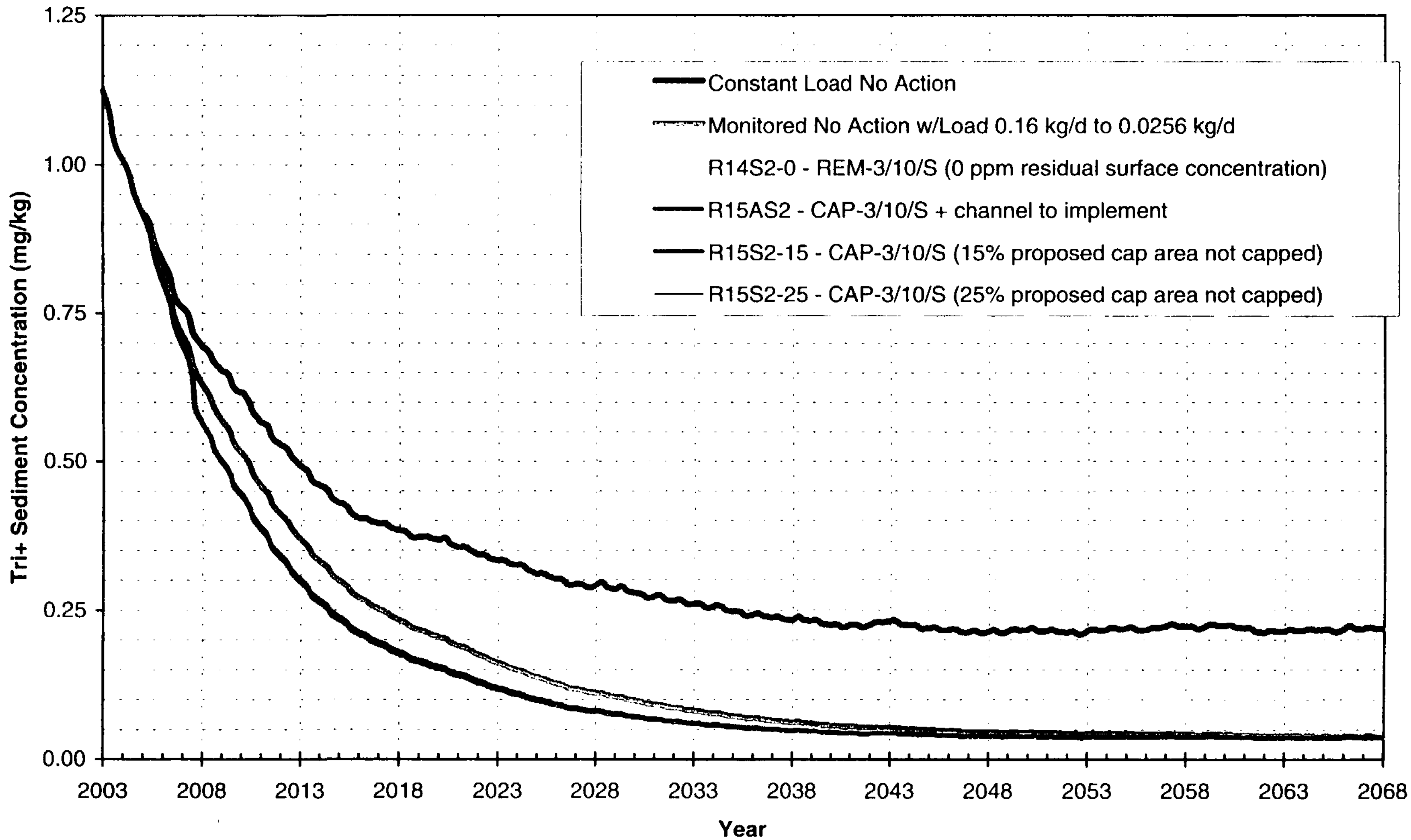
Fig_RE99_thru_RE112 11/16/00

Figure RE101. Comparison Between Forecasts for Schuylerville Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



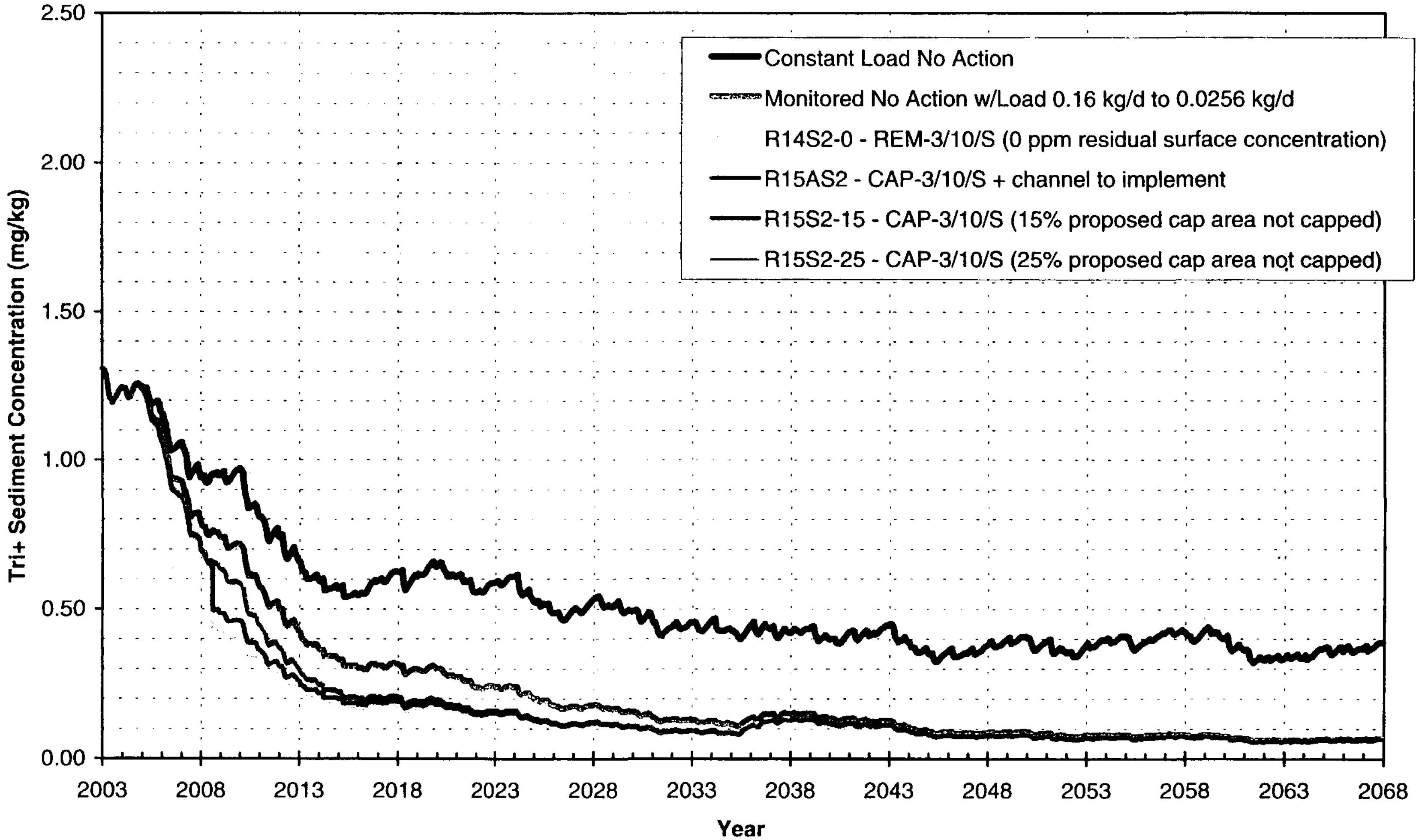
401767

Figure RE102. Comparison Between Forecasts for Schuylerville Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



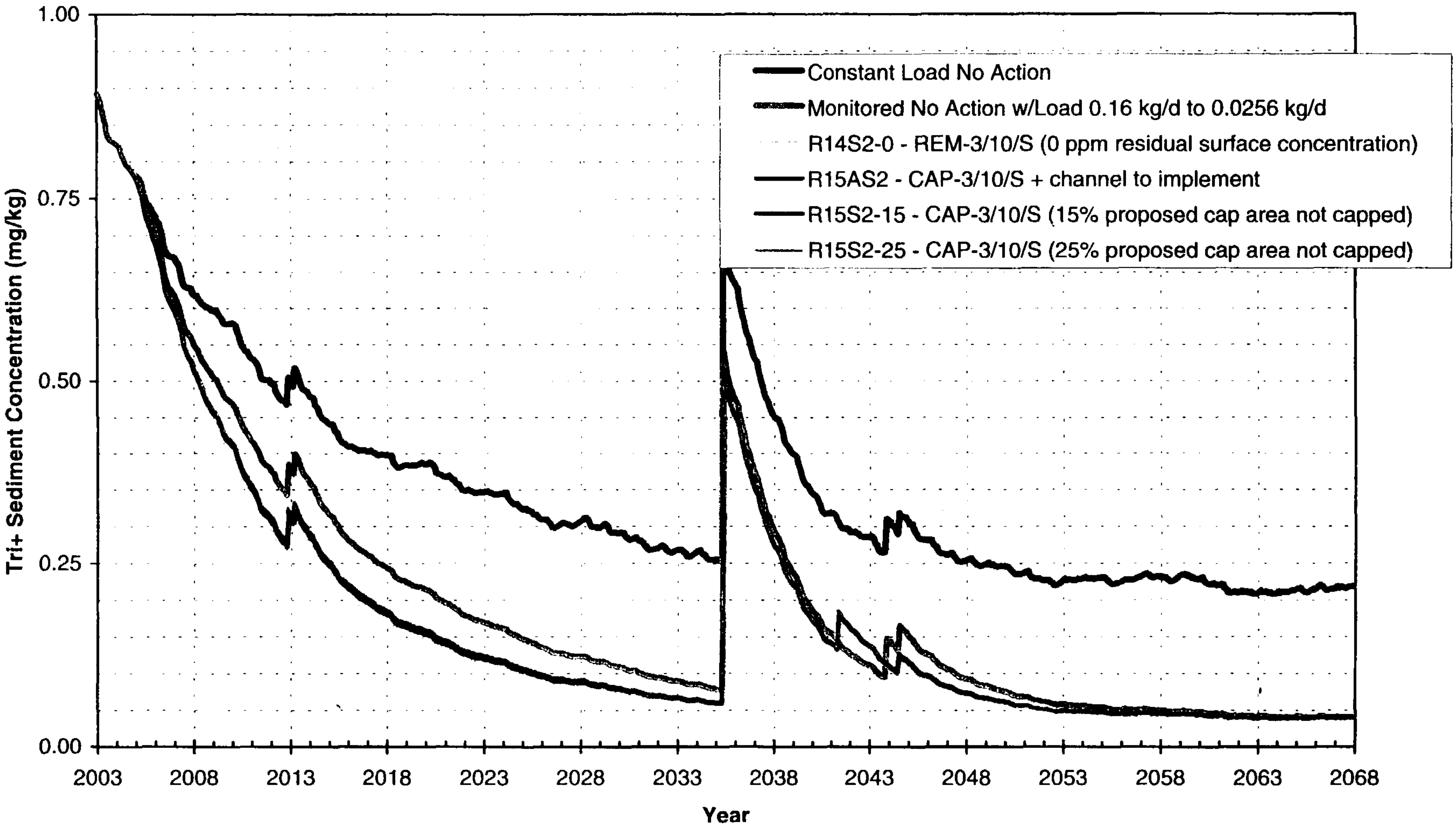
401768

Figure RE103. Comparison Between Forecasts for Stillwater Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



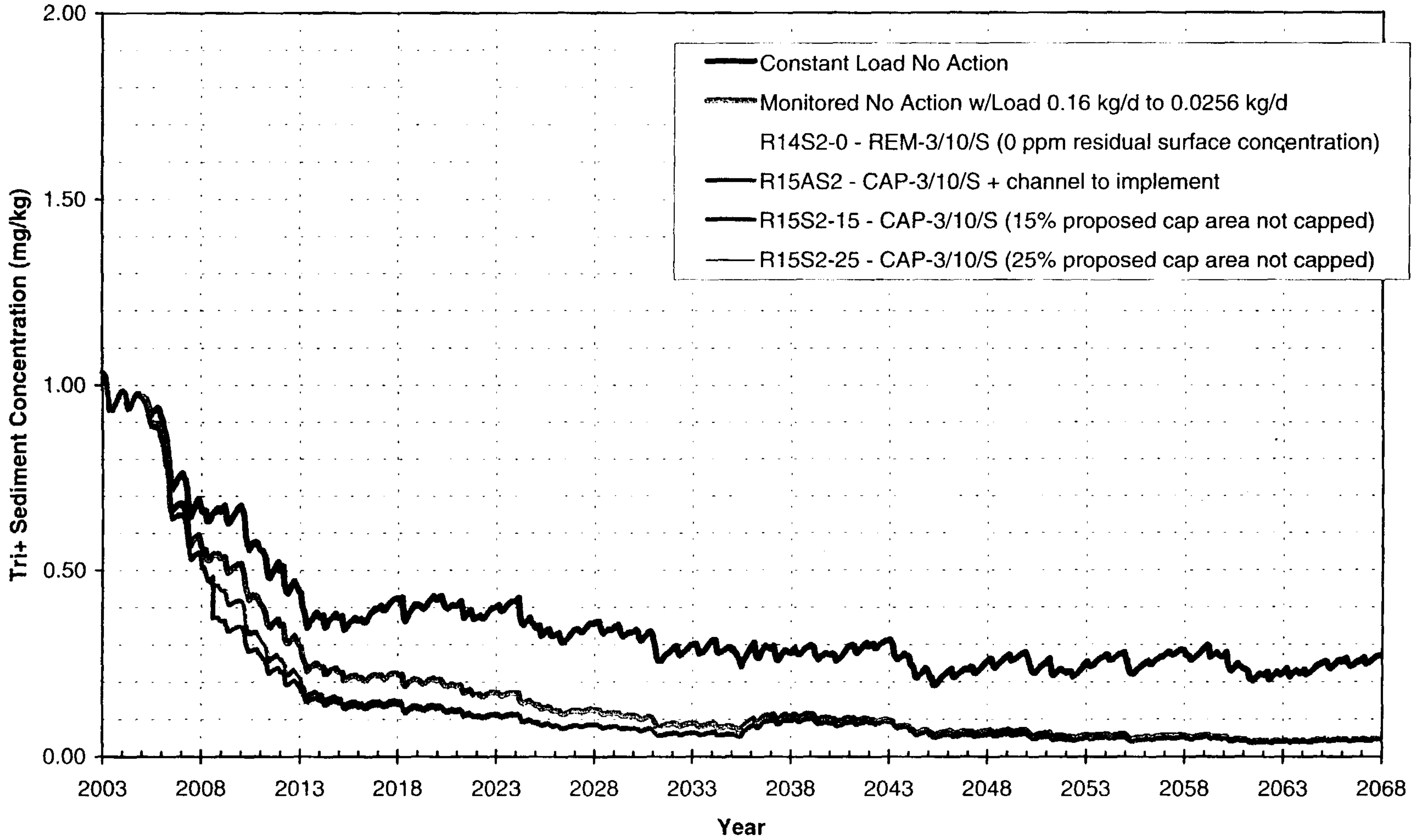
Fig_RE99_thru_RE112 11/16/00

Figure RE104. Comparison Between Forecasts for Stillwater Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



401770

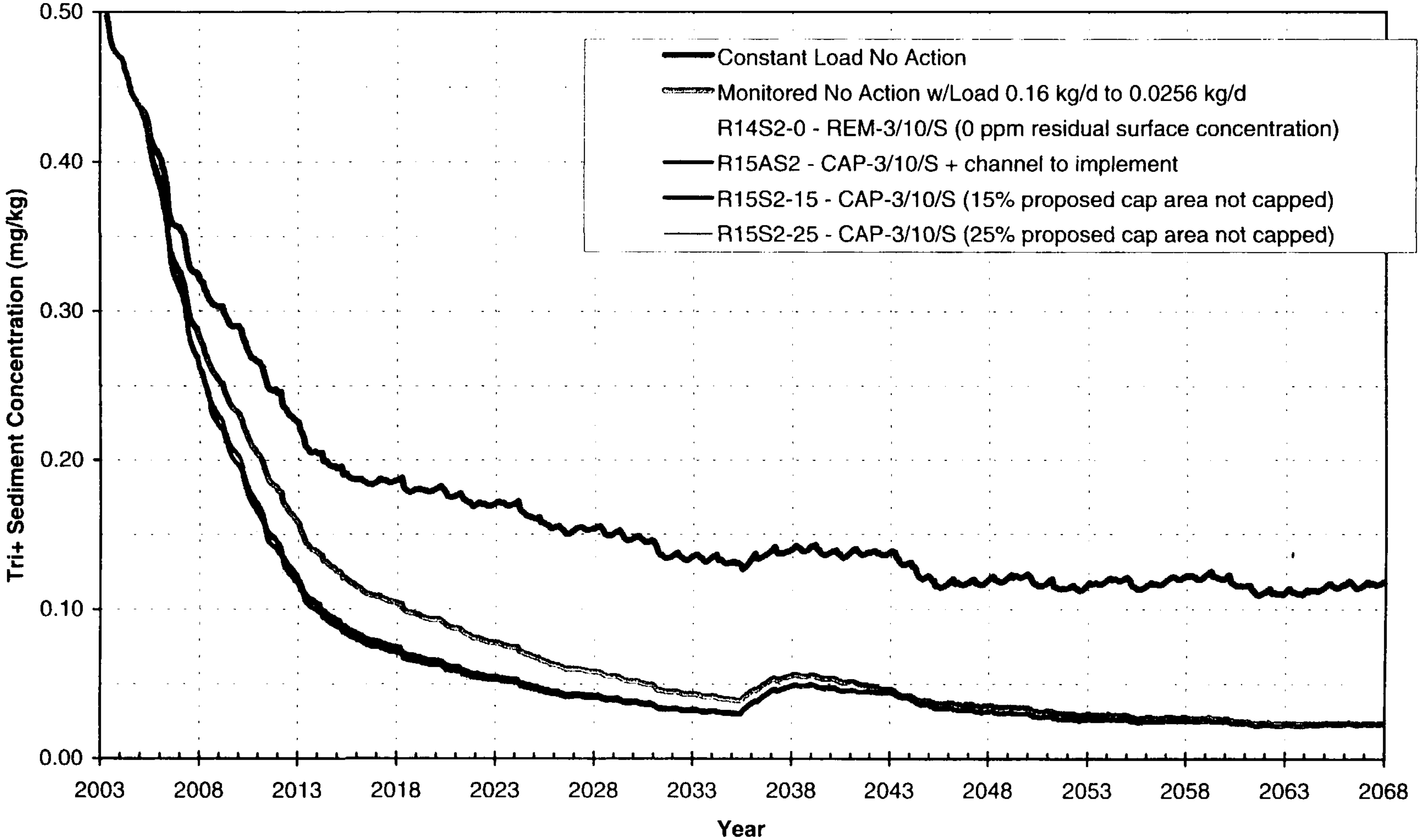
Figure RE105. Comparison Between Forecasts for Waterford Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



401771

Fig_RE99_thru_RE112 11/16/00

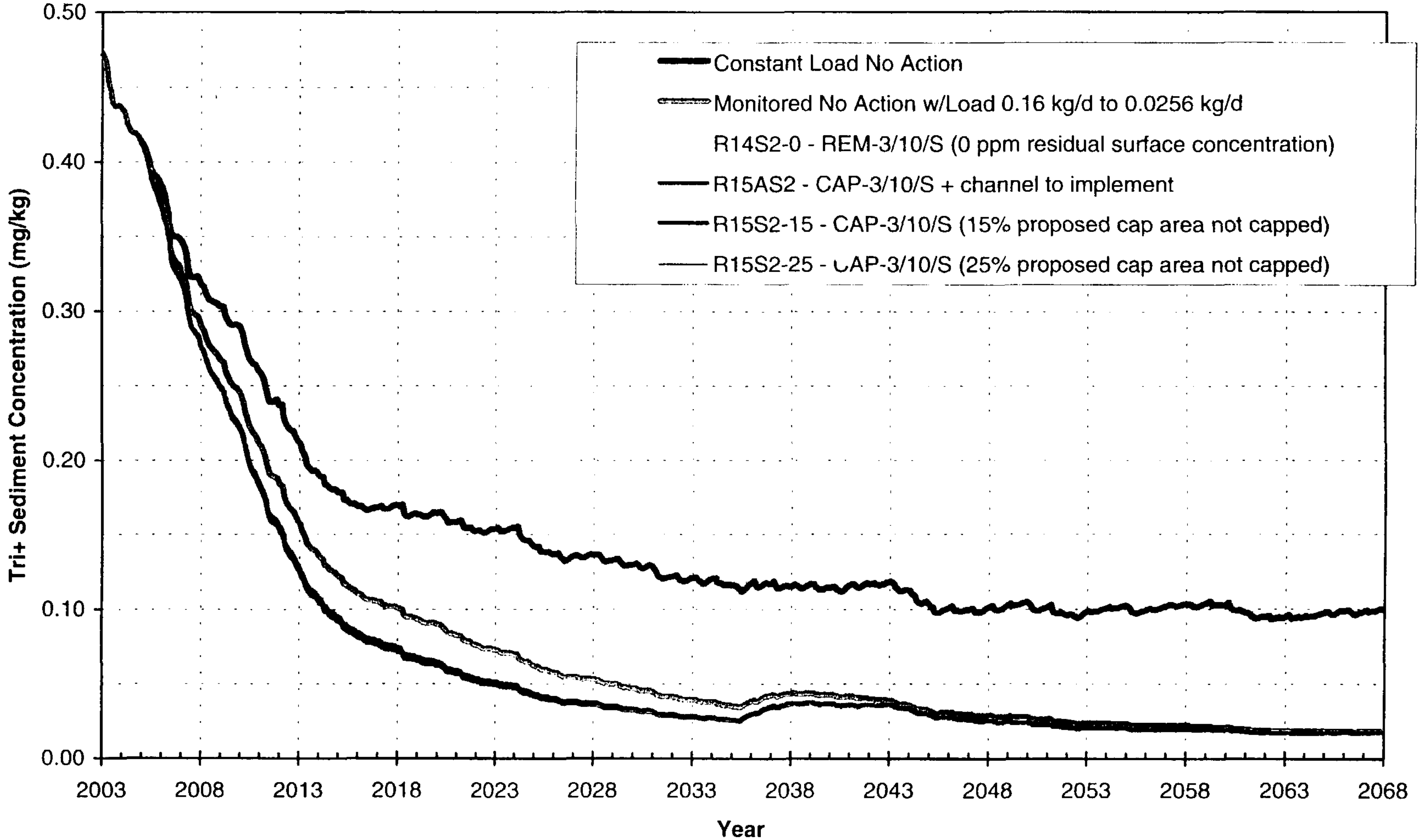
Figure RE106. Comparison Between Forecasts for Waterford Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



401772

Fig_RE99_thru_RE112 11/16/00

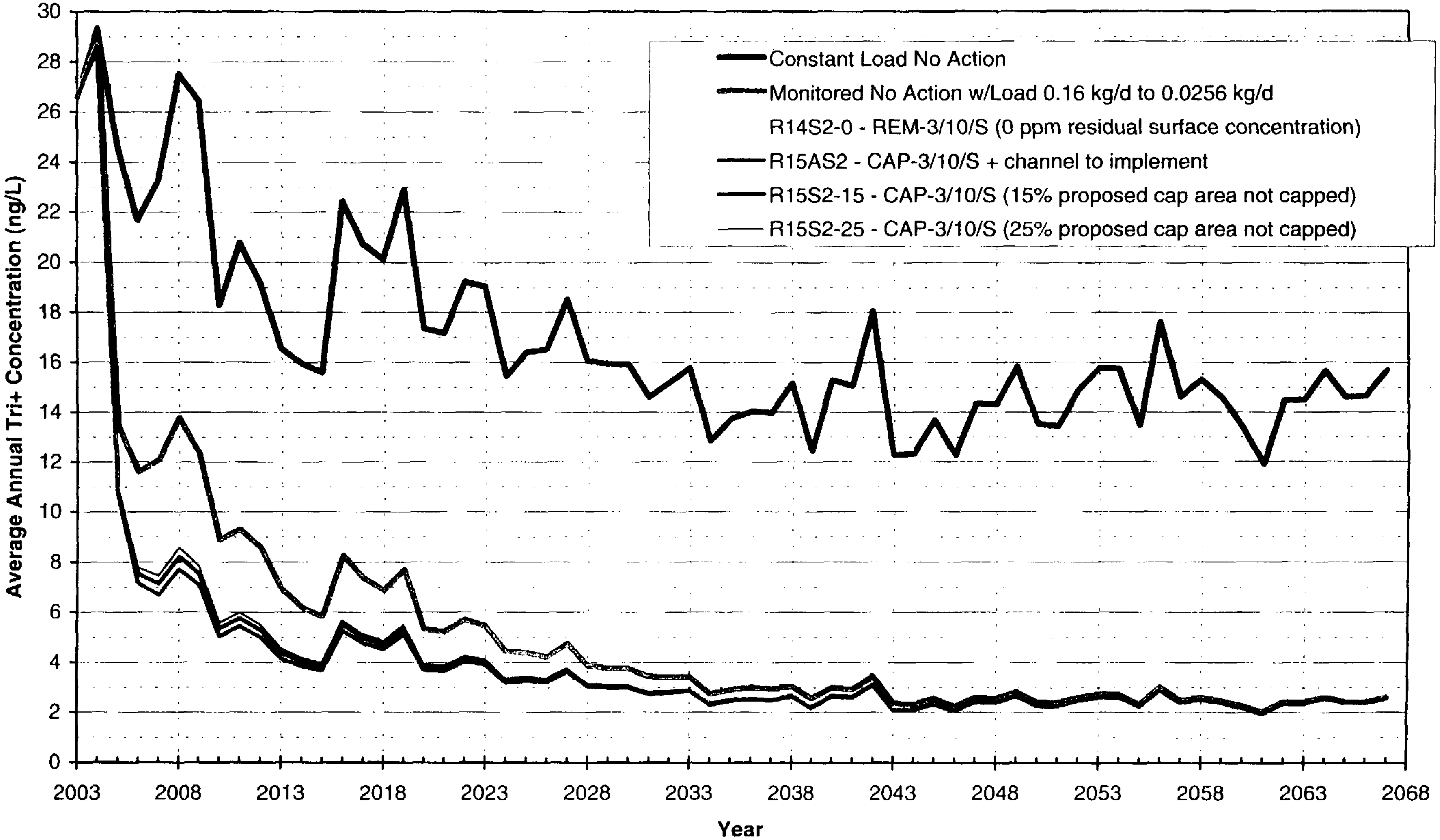
Figure RE107. Comparison Between Forecasts for Federal Dam Non-Cohesive Surficial Sediments - Cap Scenarios Sensitivity Analysis



401773

Fig_RE99_thru_RE112 11/16/00

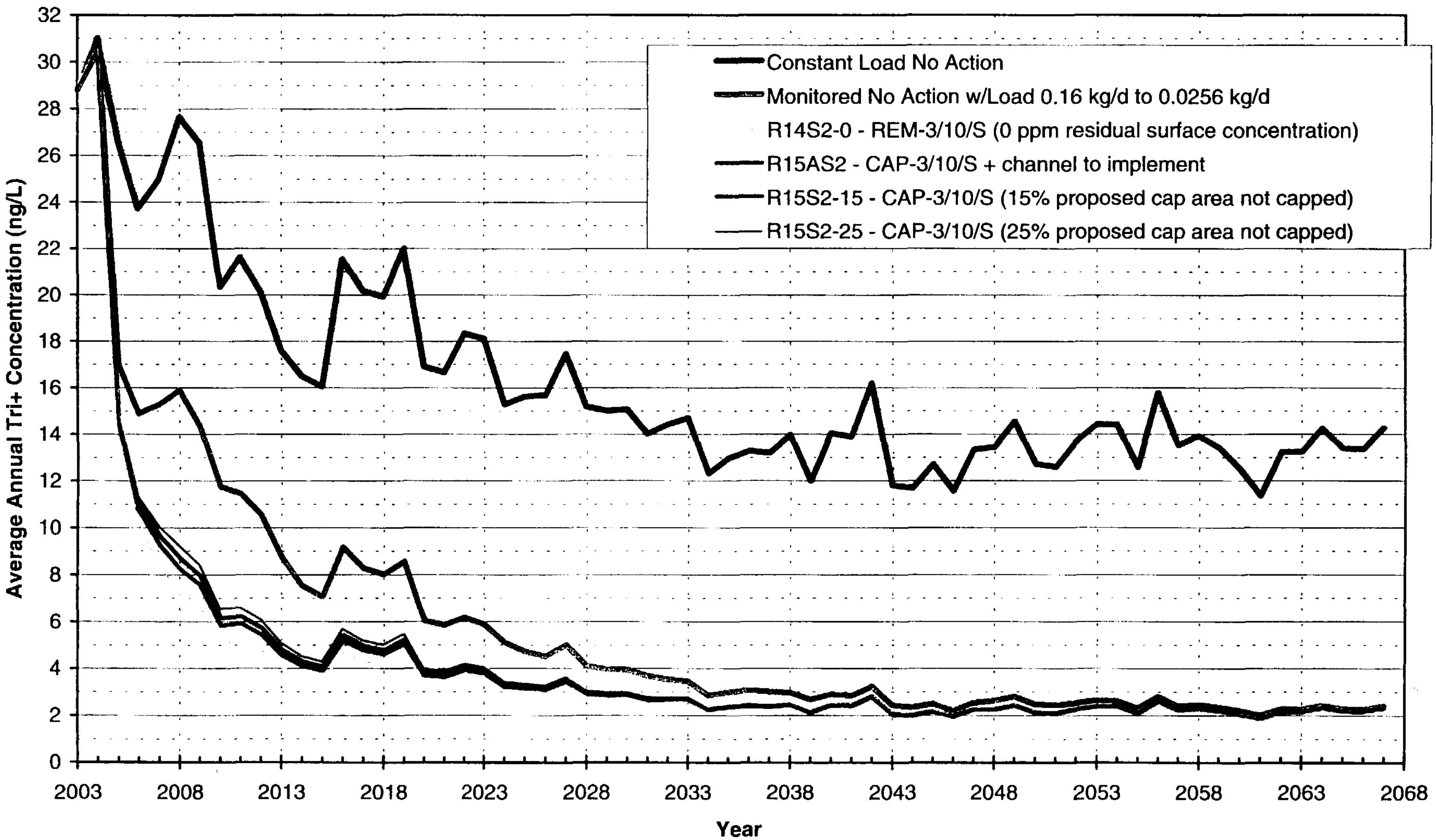
Figure RE108. Comparison Between Water Column Forecasts at Thompson Island Dam - Cap Scenarios Sensitivity Analysis



401774

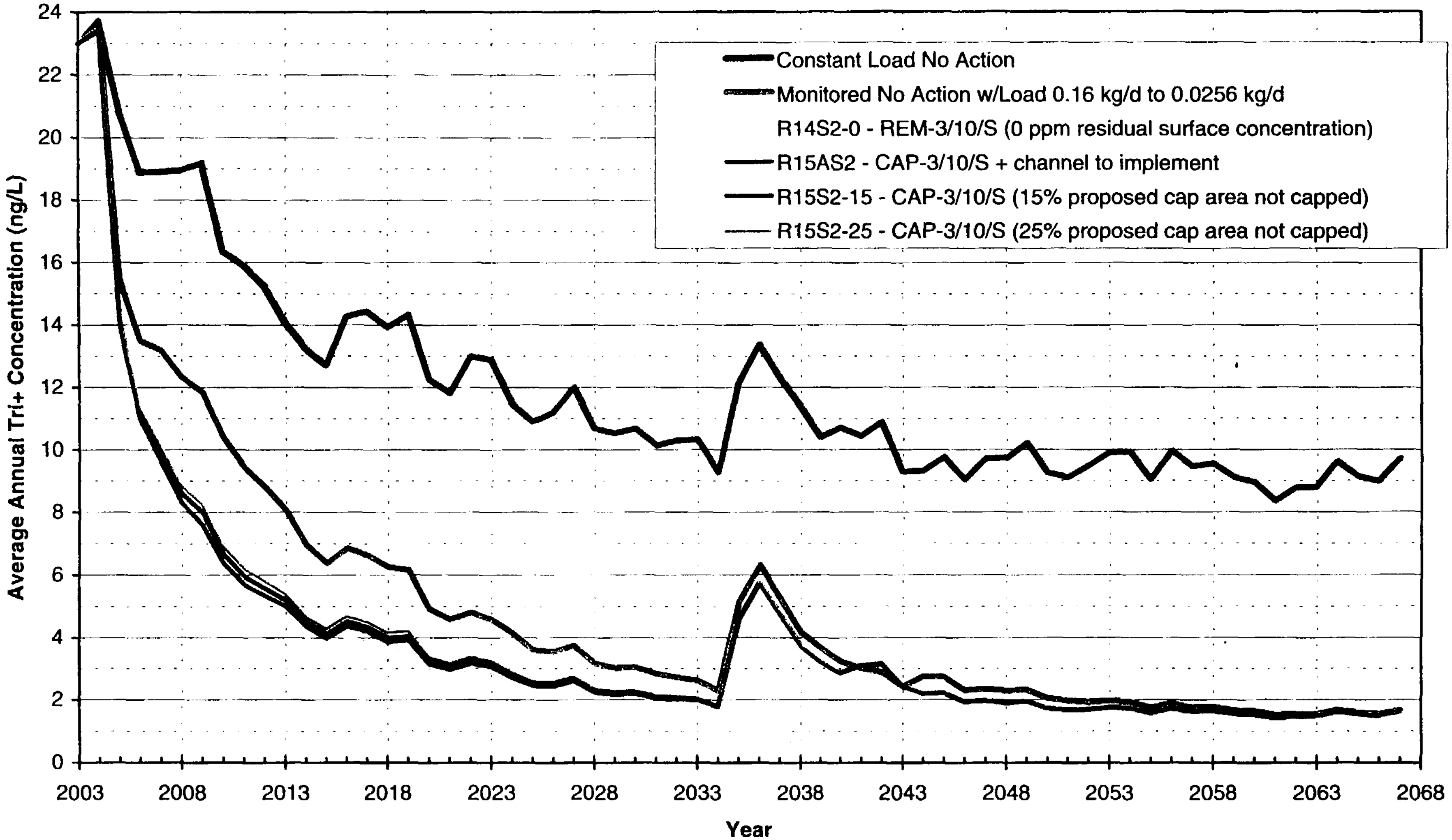
Fig_RE99_thru_RE112 11/16/00

Figure RE109. Comparison Between Water Column Forecasts at Northumberland Dam - Cap Scenarios Sensitivity Analysis



401775

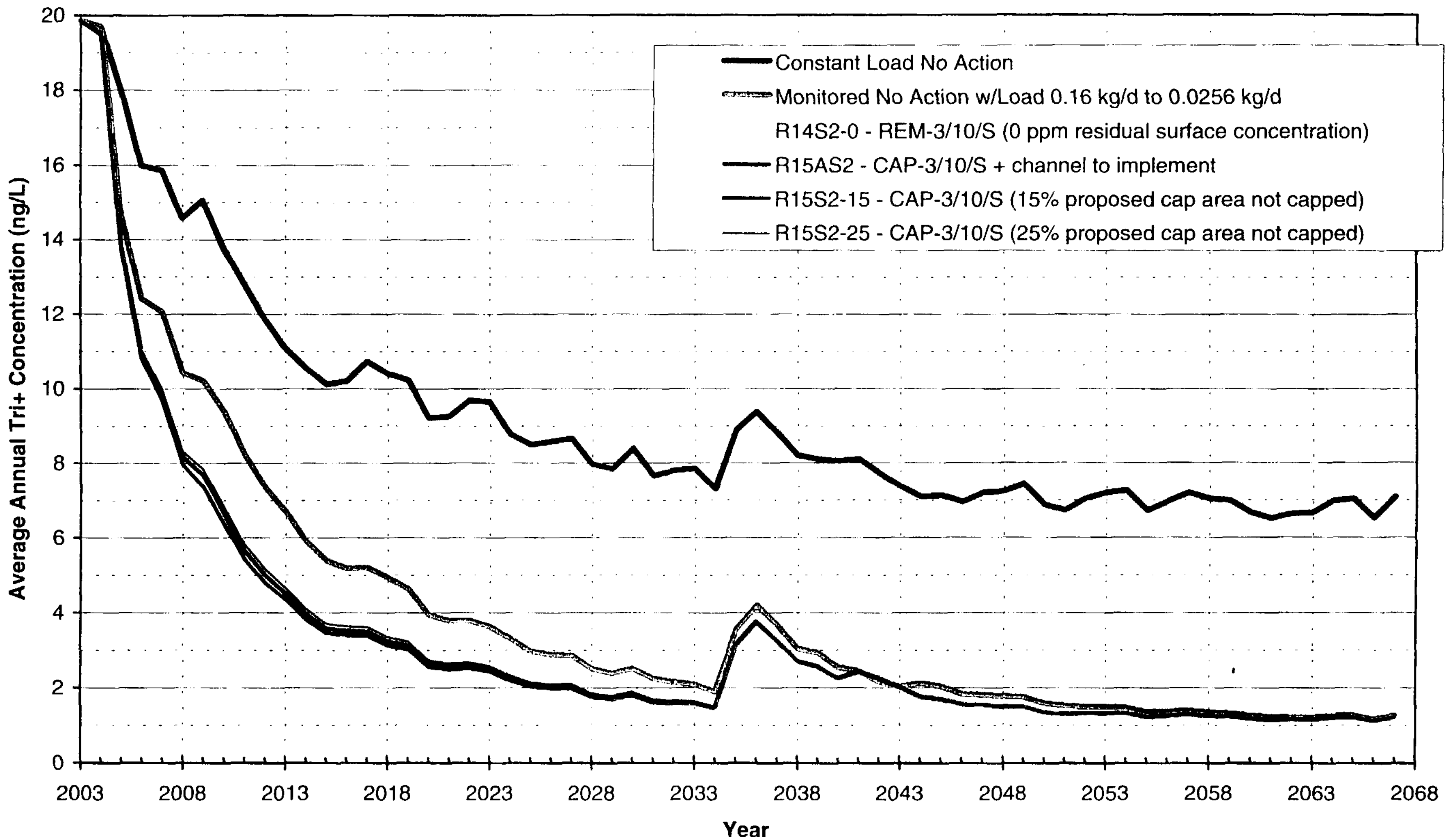
Figure RE110. Comparison Between Water Column Forecasts at Stillwater - Cap Scenarios Sensitivity Analysis



401776

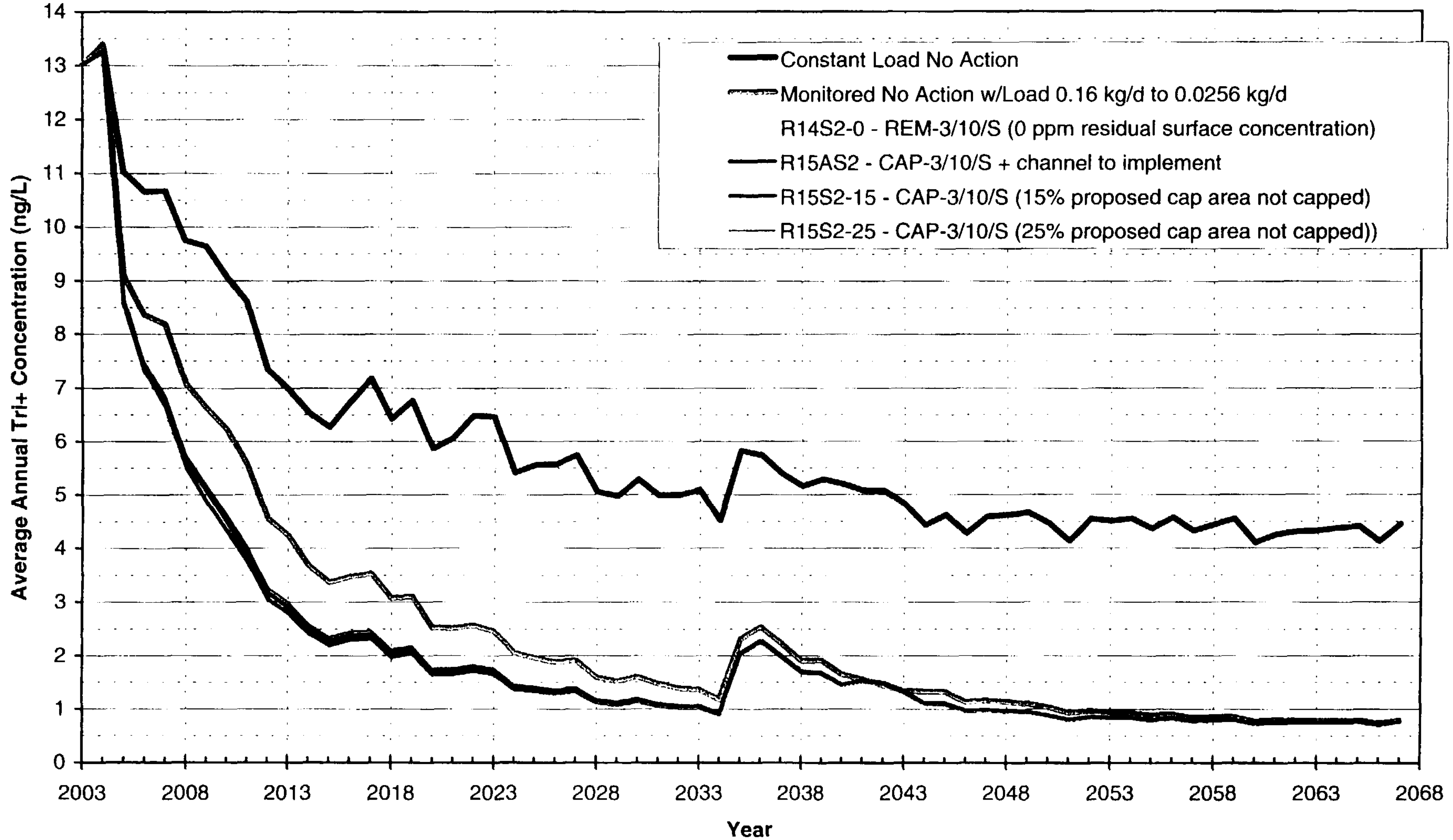
599_thru_RE112 11/16/00

Figure RE111. Comparison Between Water Column Forecasts at Waterford - Cap Scenarios Sensitivity Analysis



401777

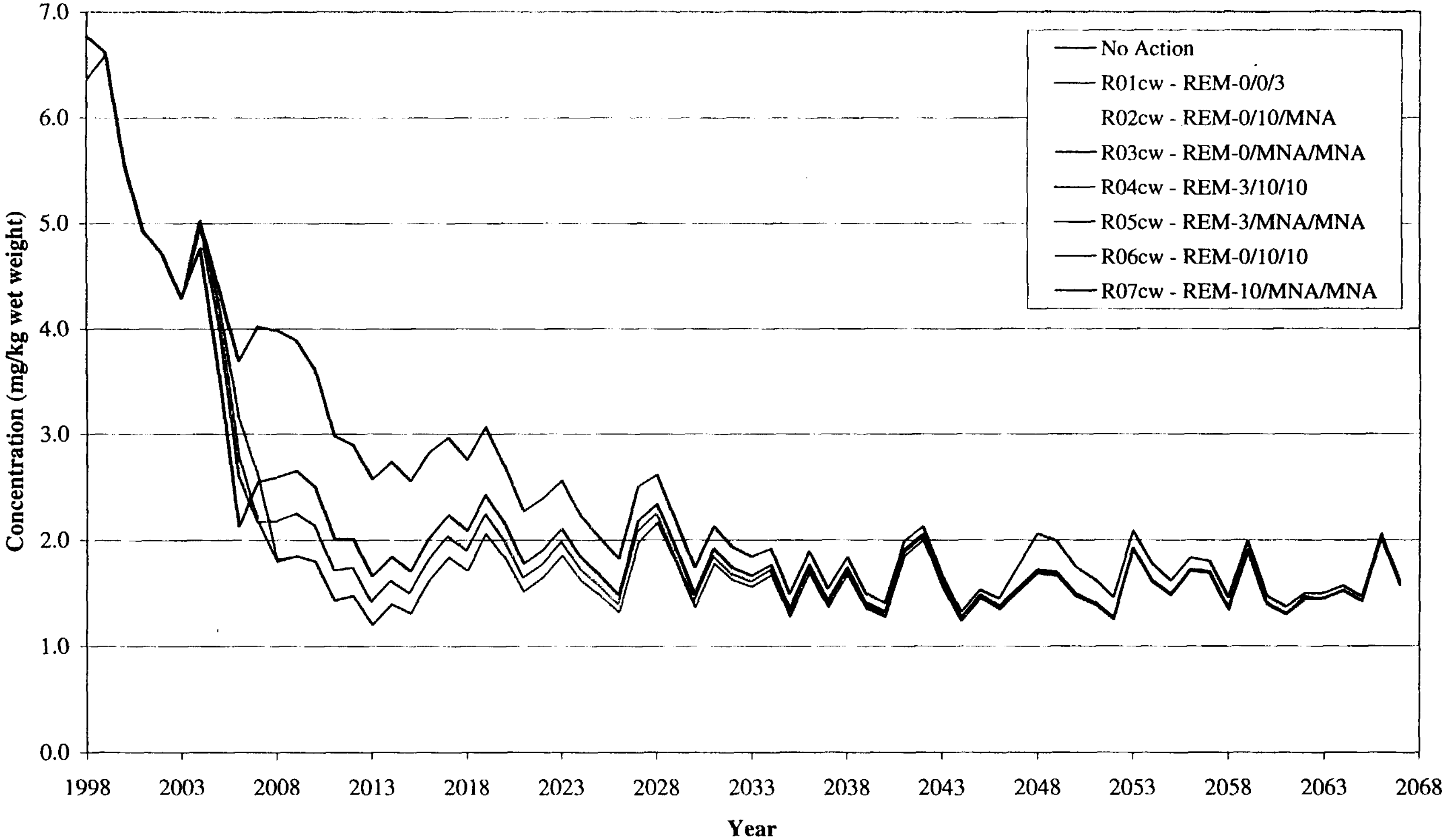
Figure RE112. Comparison Between Water Column Forecasts at Federal Dam - Cap Scenarios Sensitivity Analysis



401778

Fig_RE99_thru_RE112 11/16/00

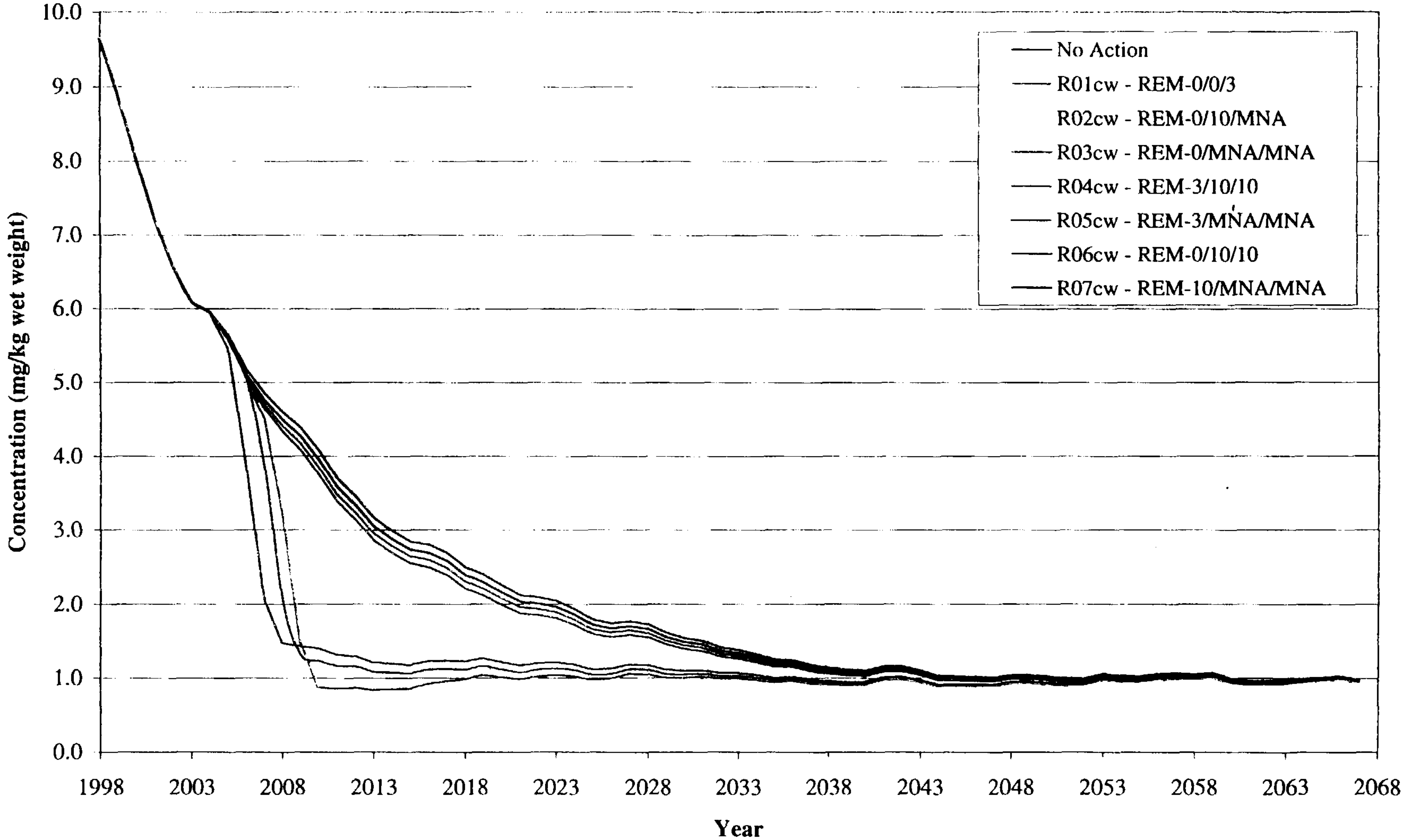
Figure RE113. Comparison Between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Constant Upstream Load Conditions



401779

Fig_RE113_thru_RE115 11/20/00

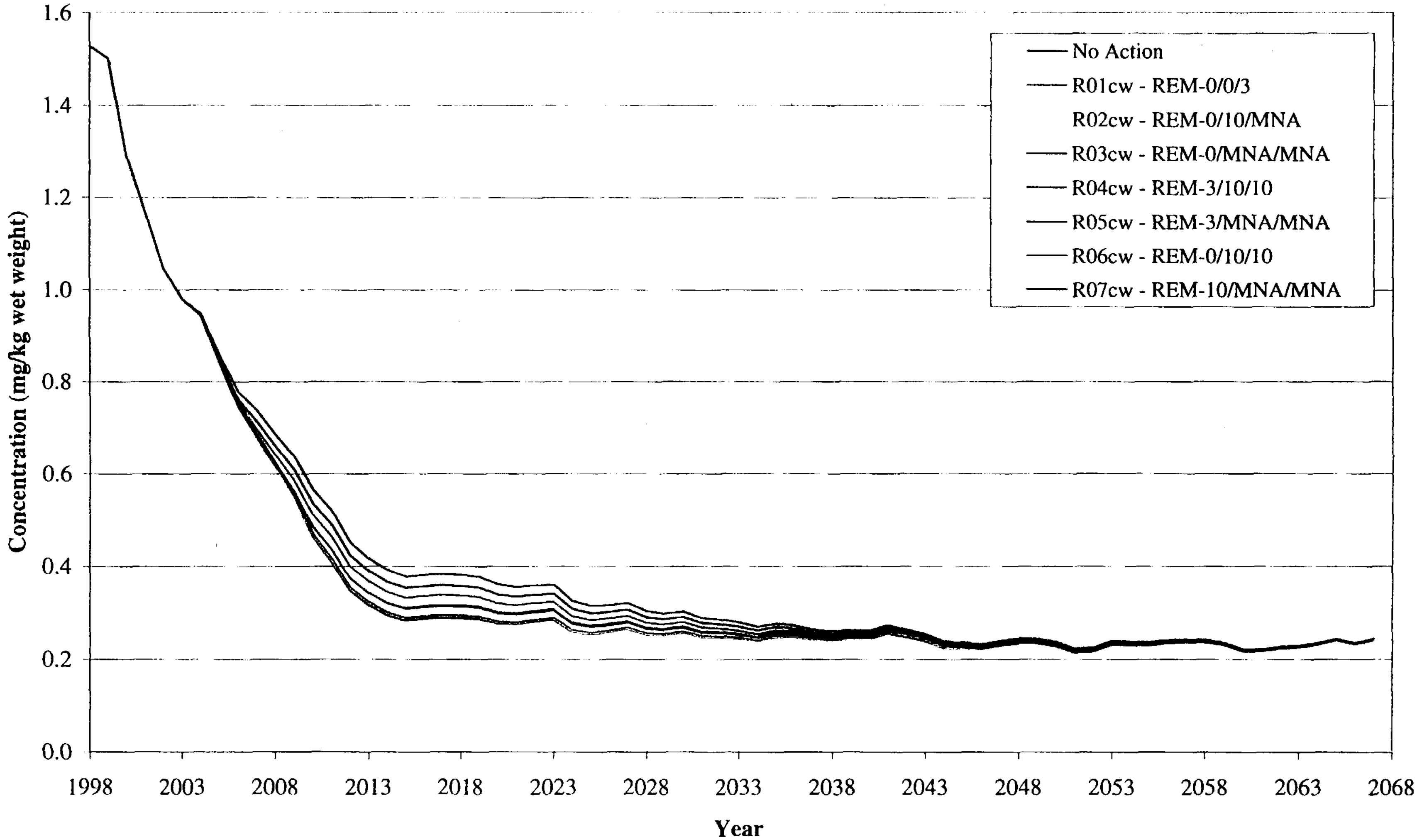
Figure RE114. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Constant Upstream Load Conditions



401780

Fig_RE113_thru_RE115 11/20/00

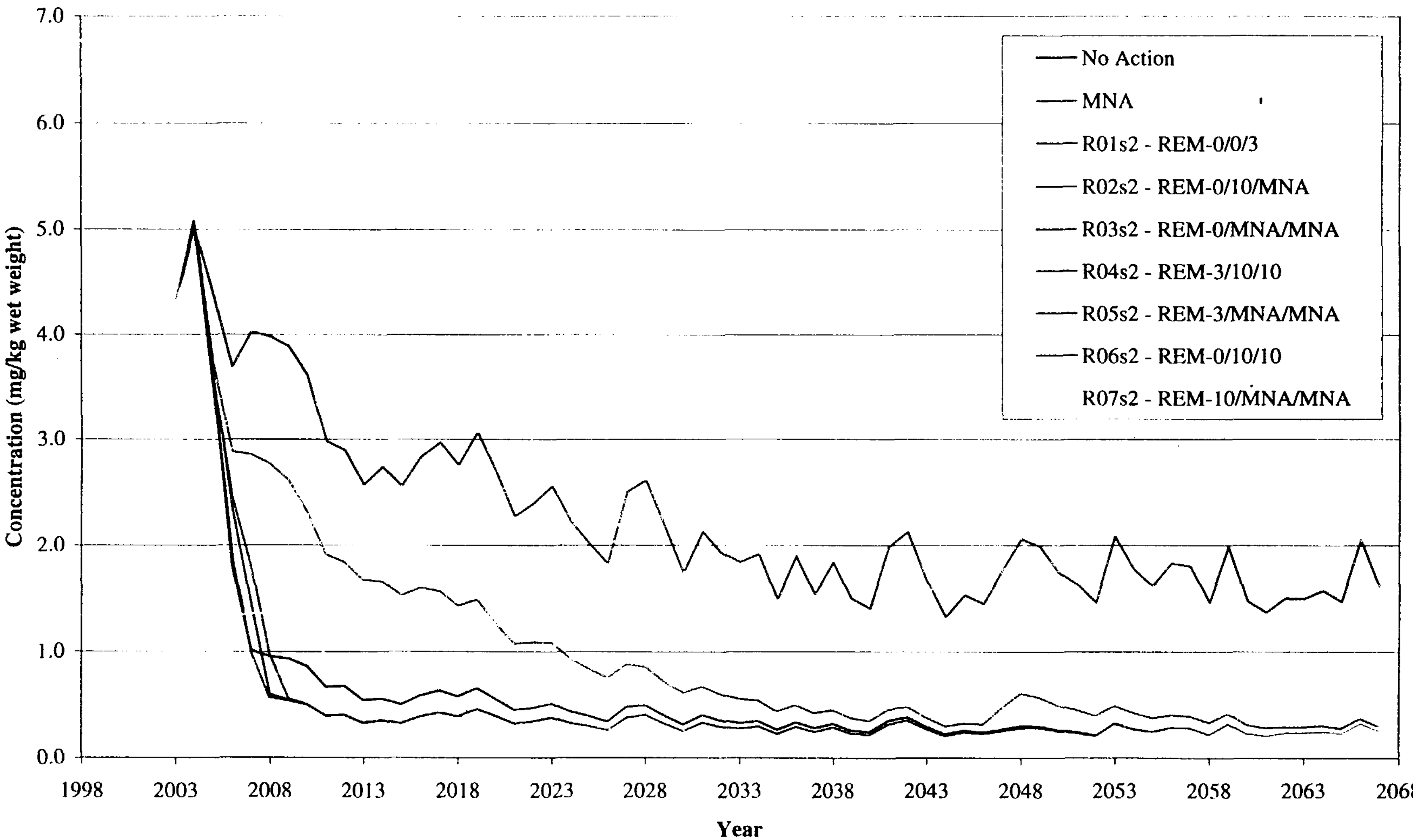
Figure RE115. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Constant Upstream Load Conditions



401781

Fig_RE113_thru_RE115 11/20/00

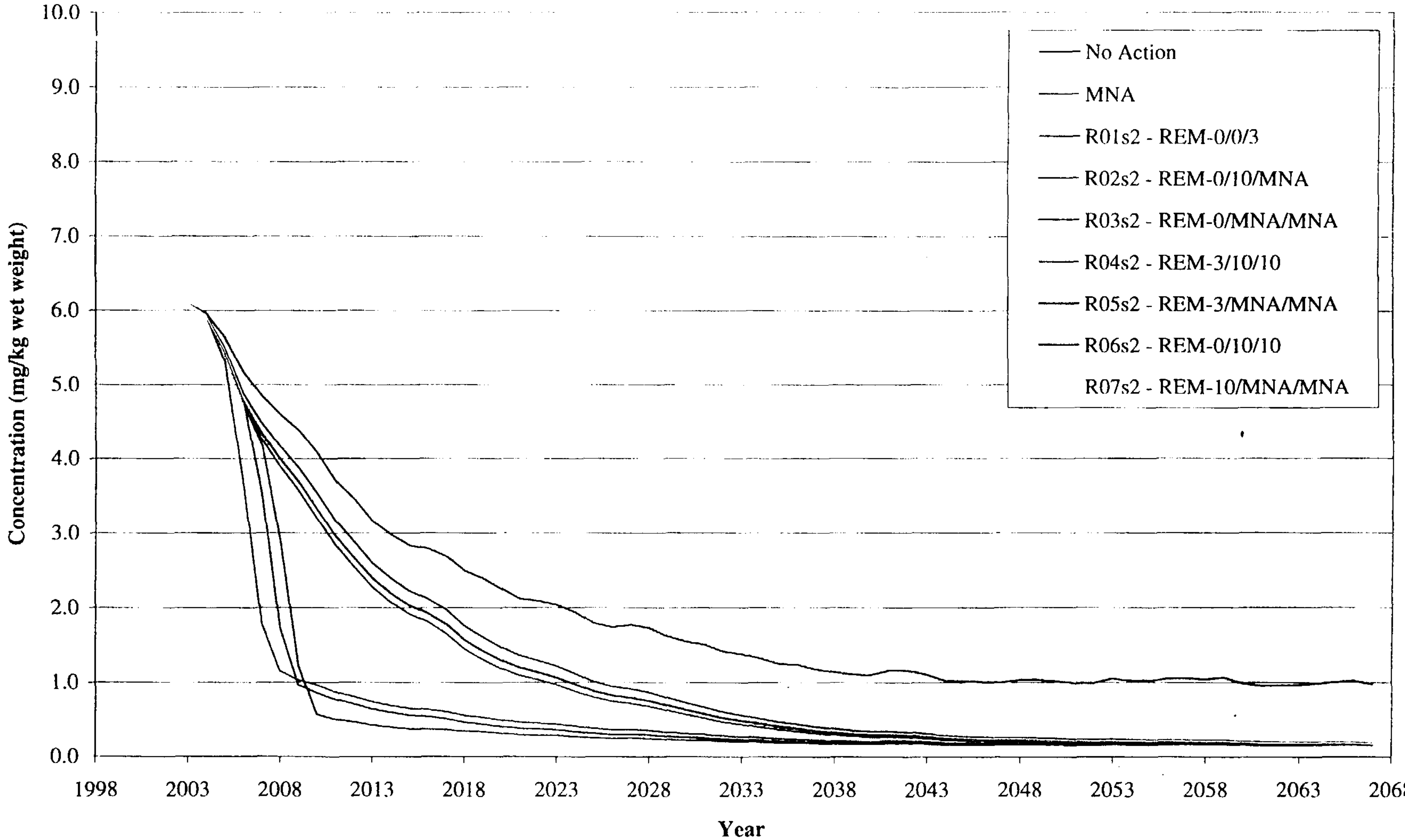
Figure RE116. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Step Down Upstream Load Conditions



401782

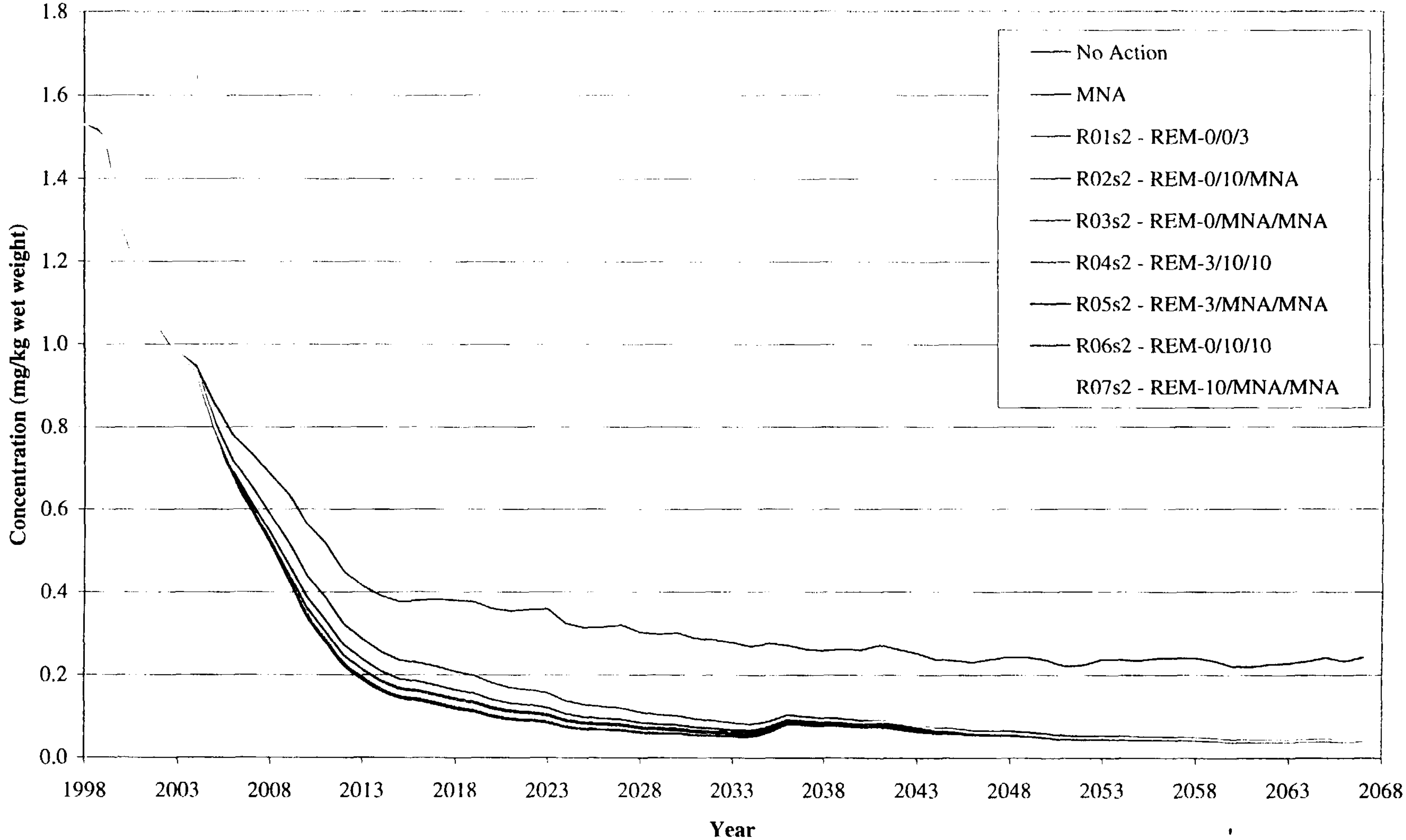
Fig RE116_thru_RE118 11/20/00

Figure RE117. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Step Down Upstream Load Conditions



401783

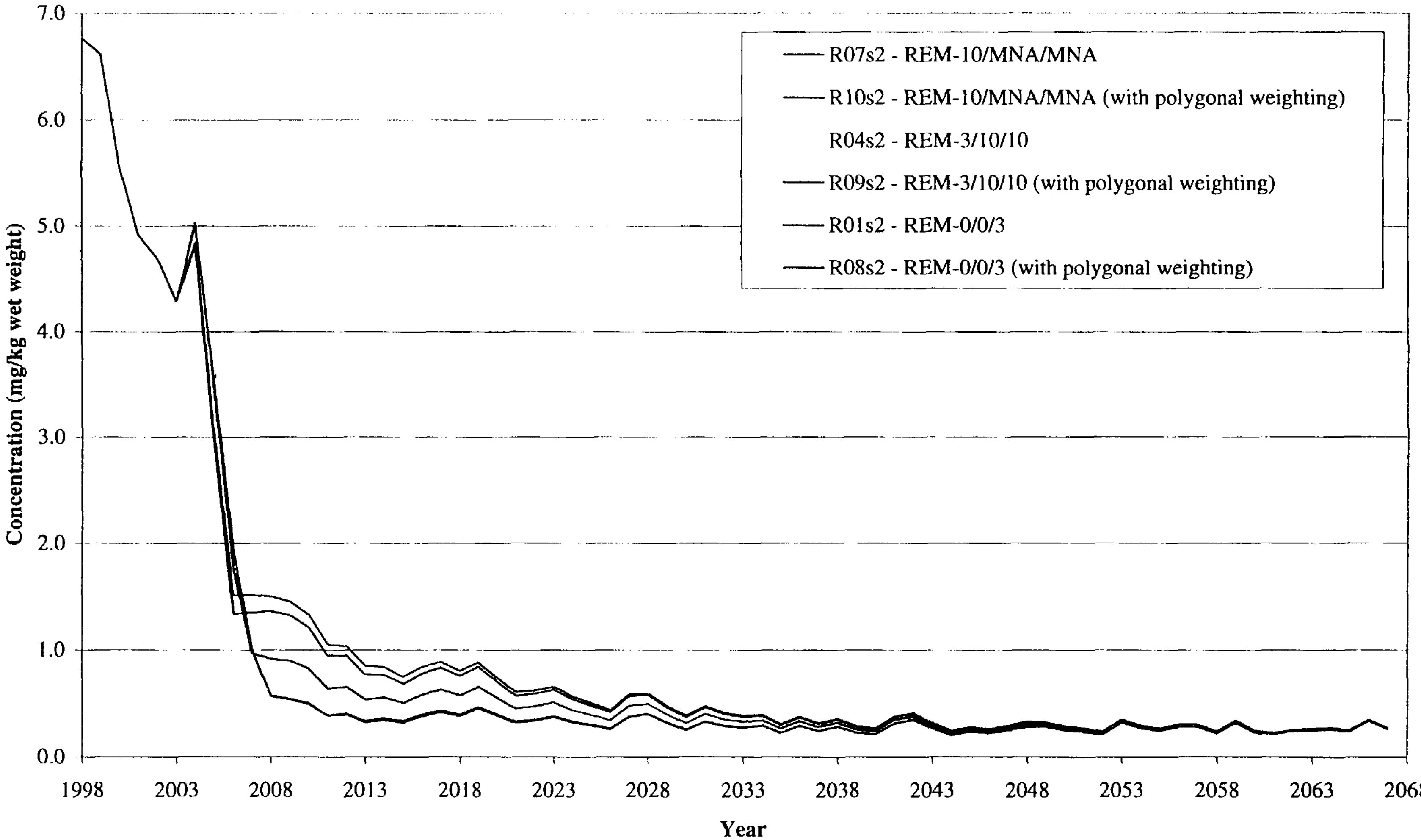
Figure RE118. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Step Down Upsteam Load Conditions



401784

Fig RE116_thru_RE118 11/20/00

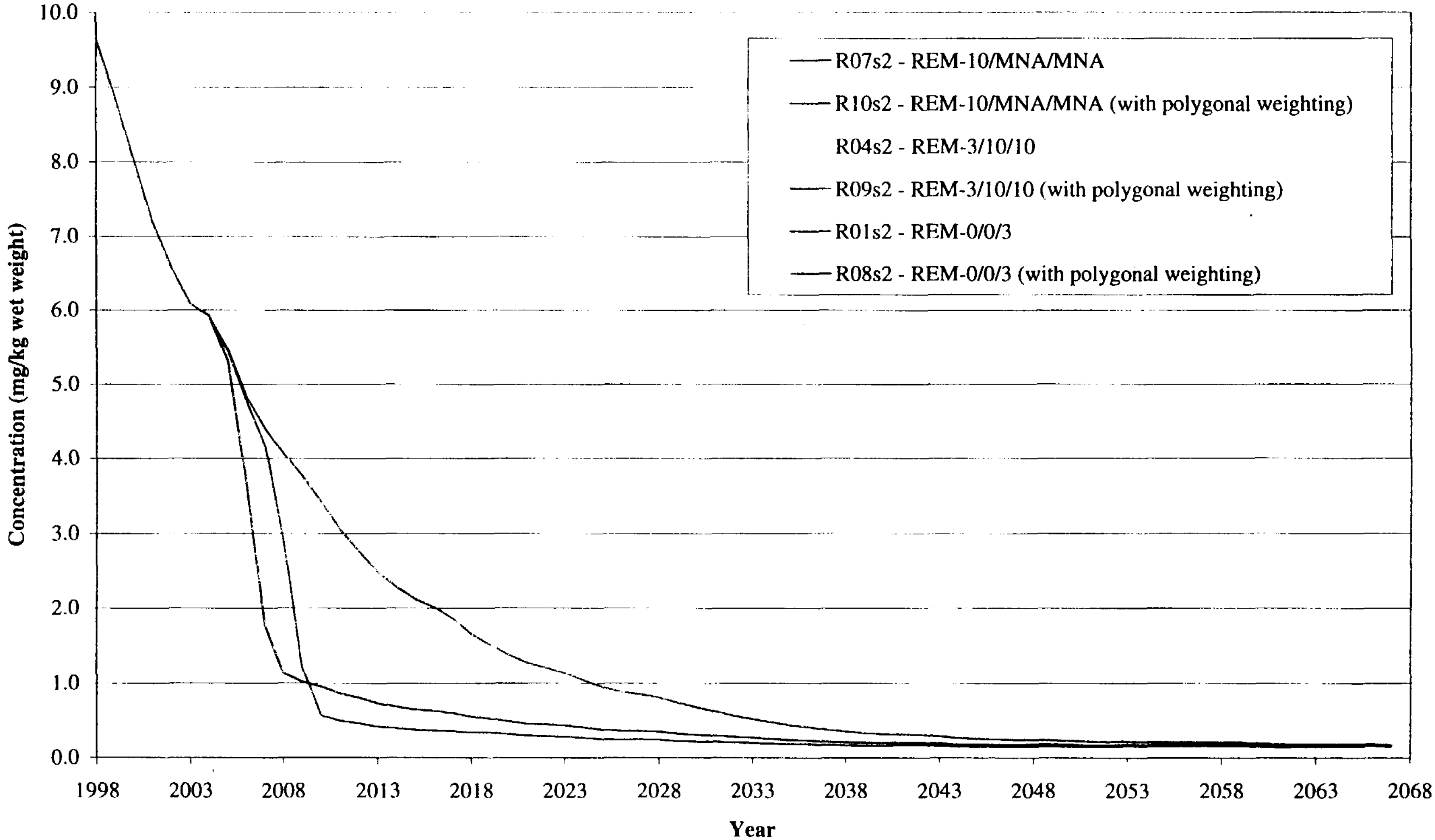
Figure RE119. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



401785

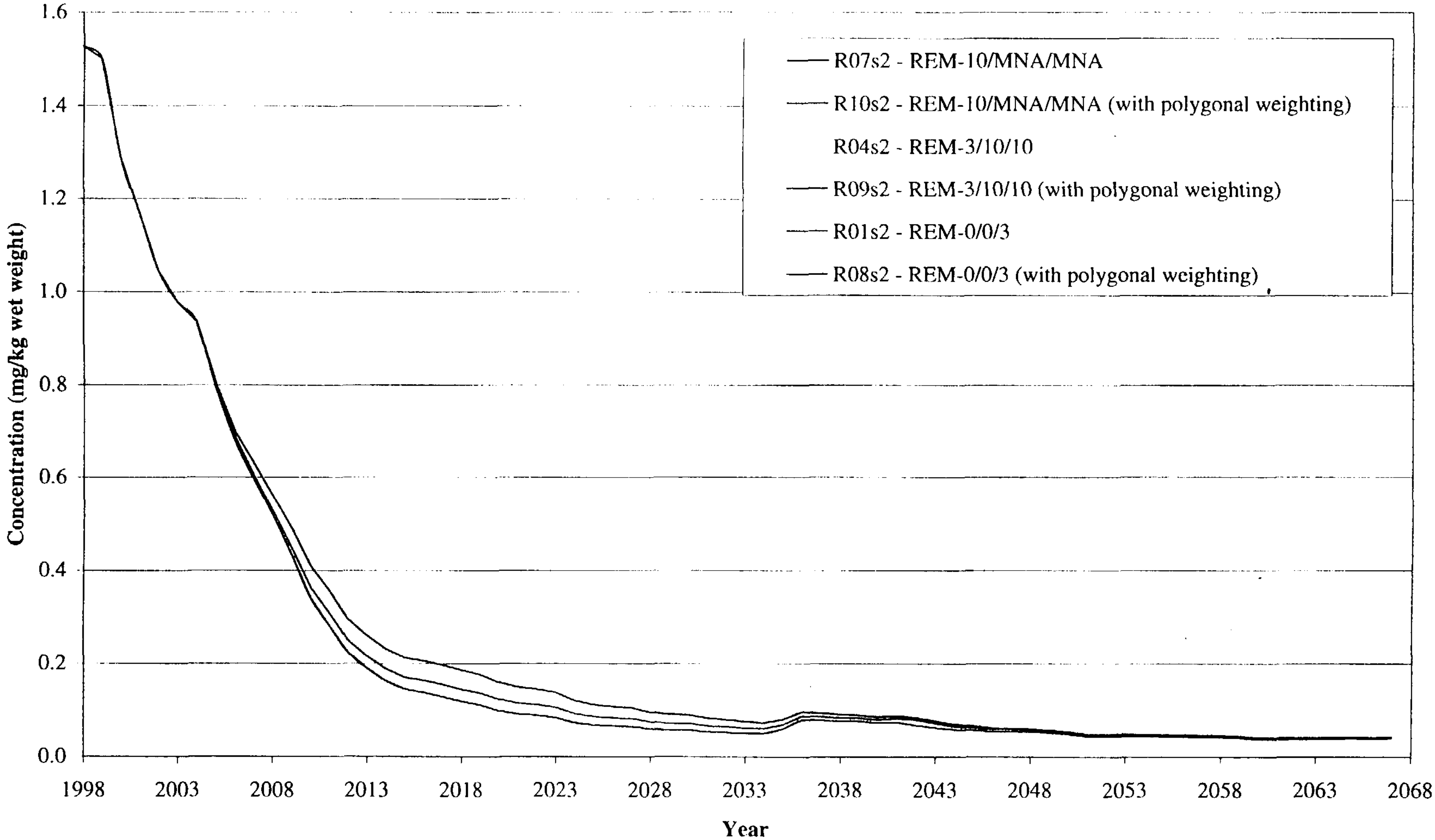
Fig_RE119_thru_RE121 11/20/00

Figure RE120. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



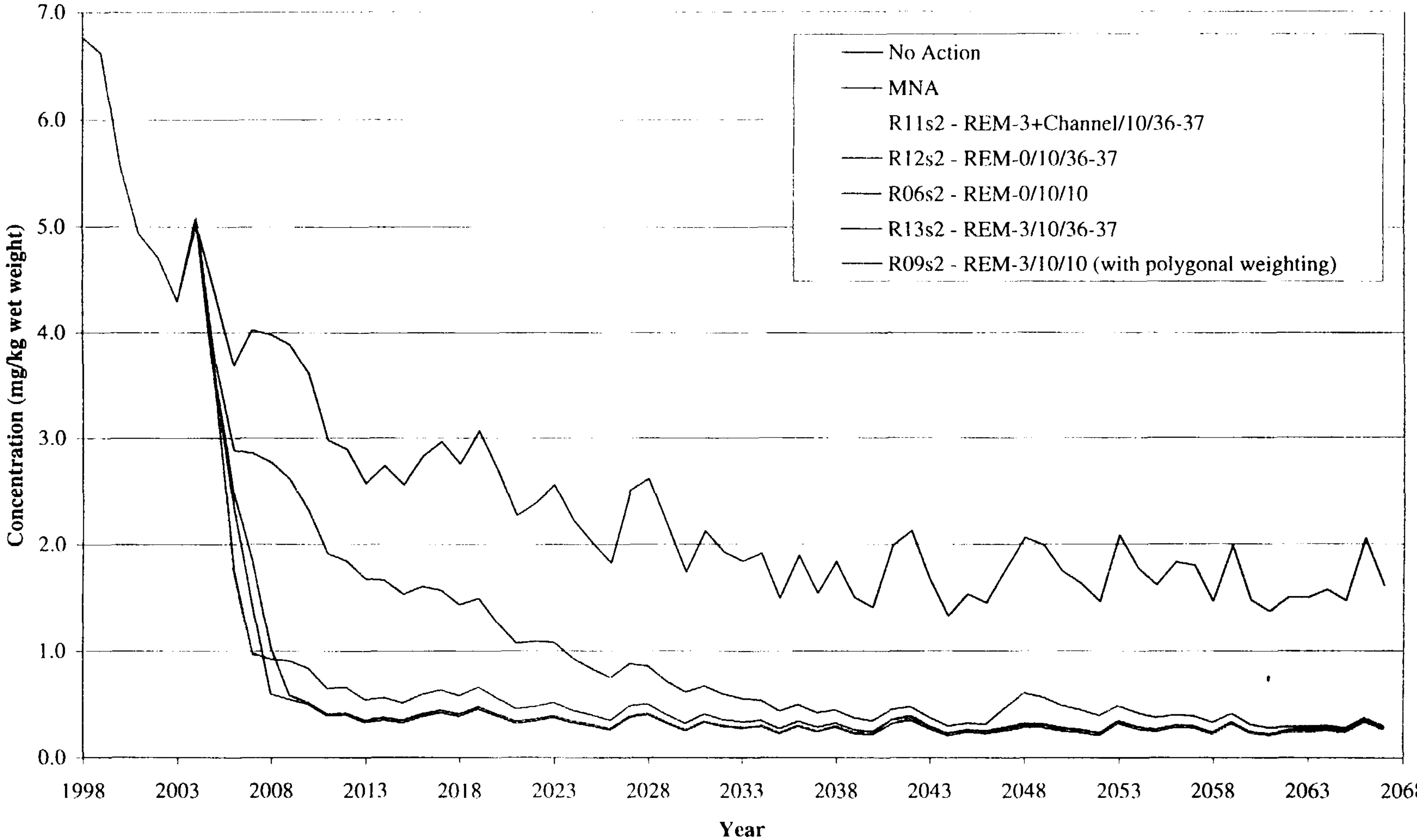
401786

Figure RE121. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Polygonal Weighting vs. Point Averaged Method for Calculating PCB Percent Removal



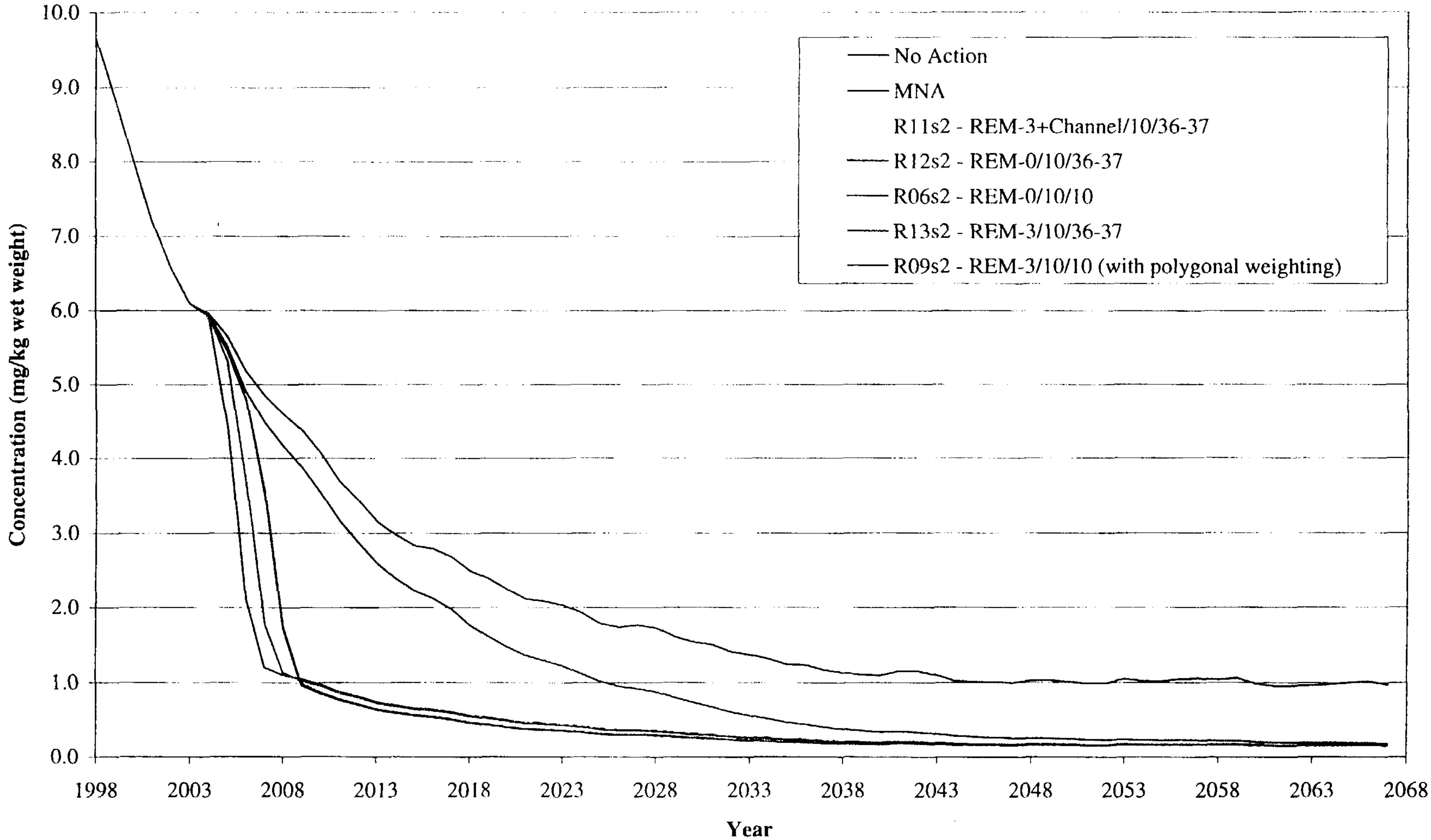
401787

Figure RE122. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Channel Dredging in River Section 1/Removal in River Section 2



401788

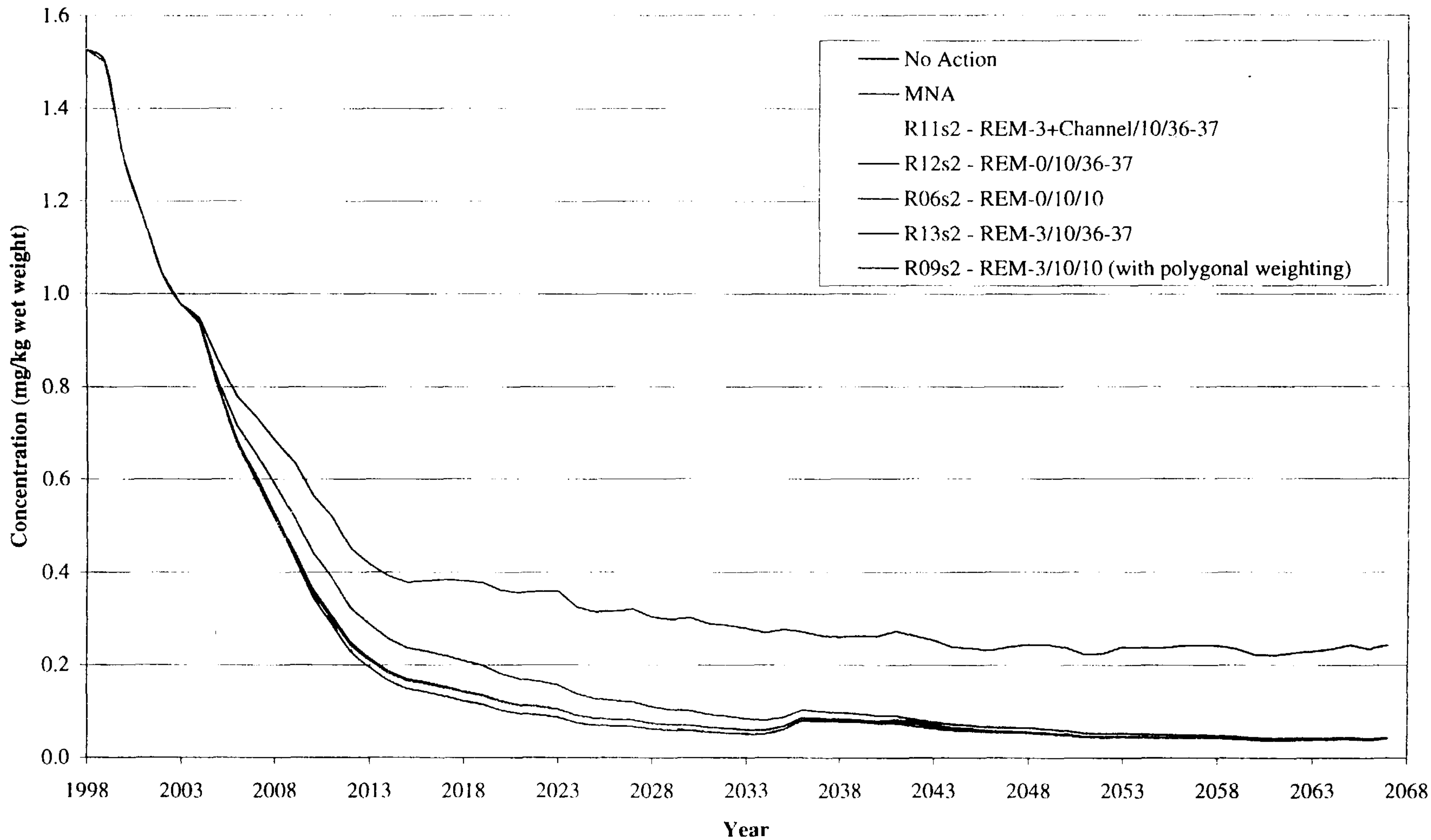
Figure RE123. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Channel Dredging in River Section 1/Removal in River Section 2



401789

Fig_RE122_thru_RE124 11/20/00

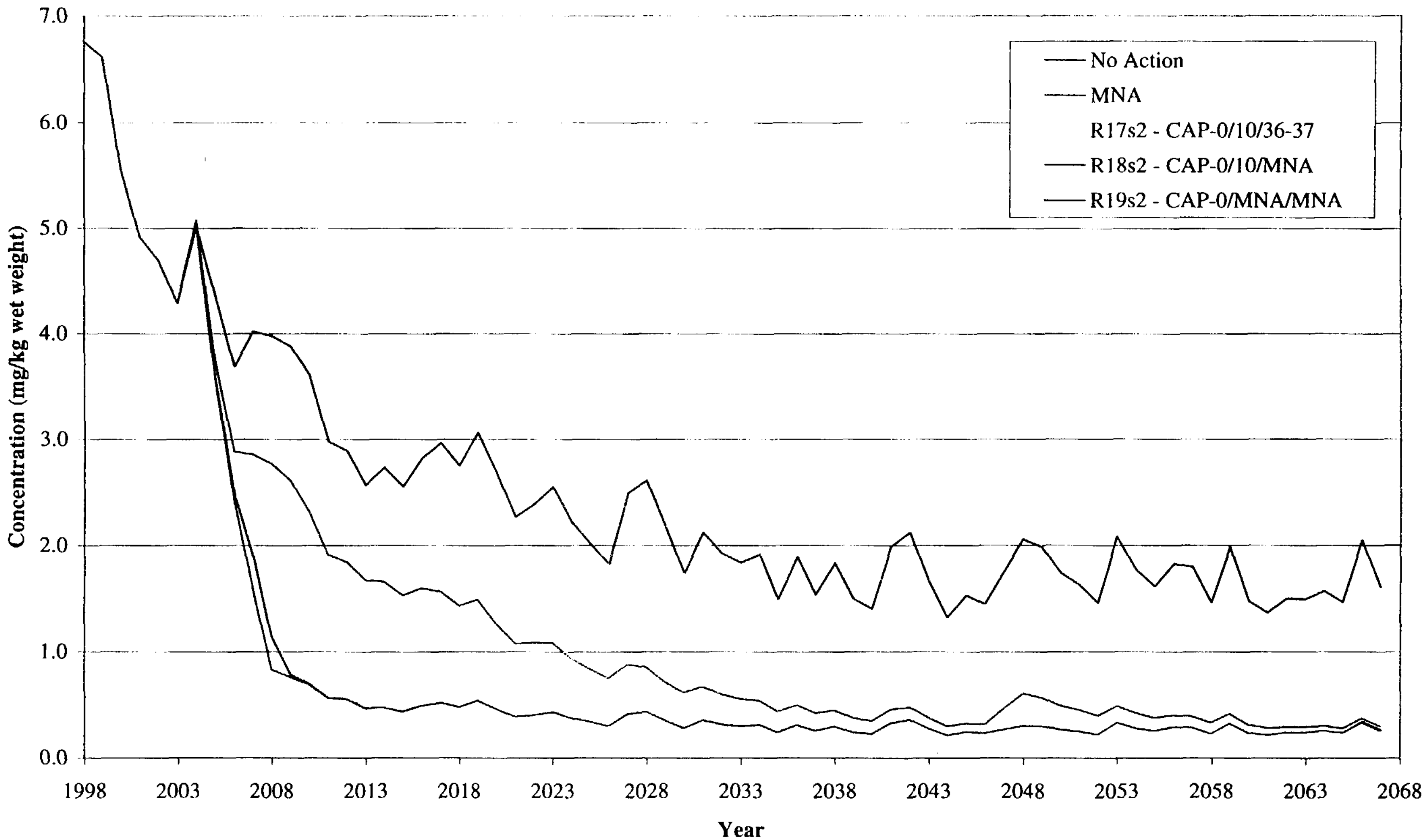
Figure RE124. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Channel Dredging in River Section 1/Removal in River Section 2



401790

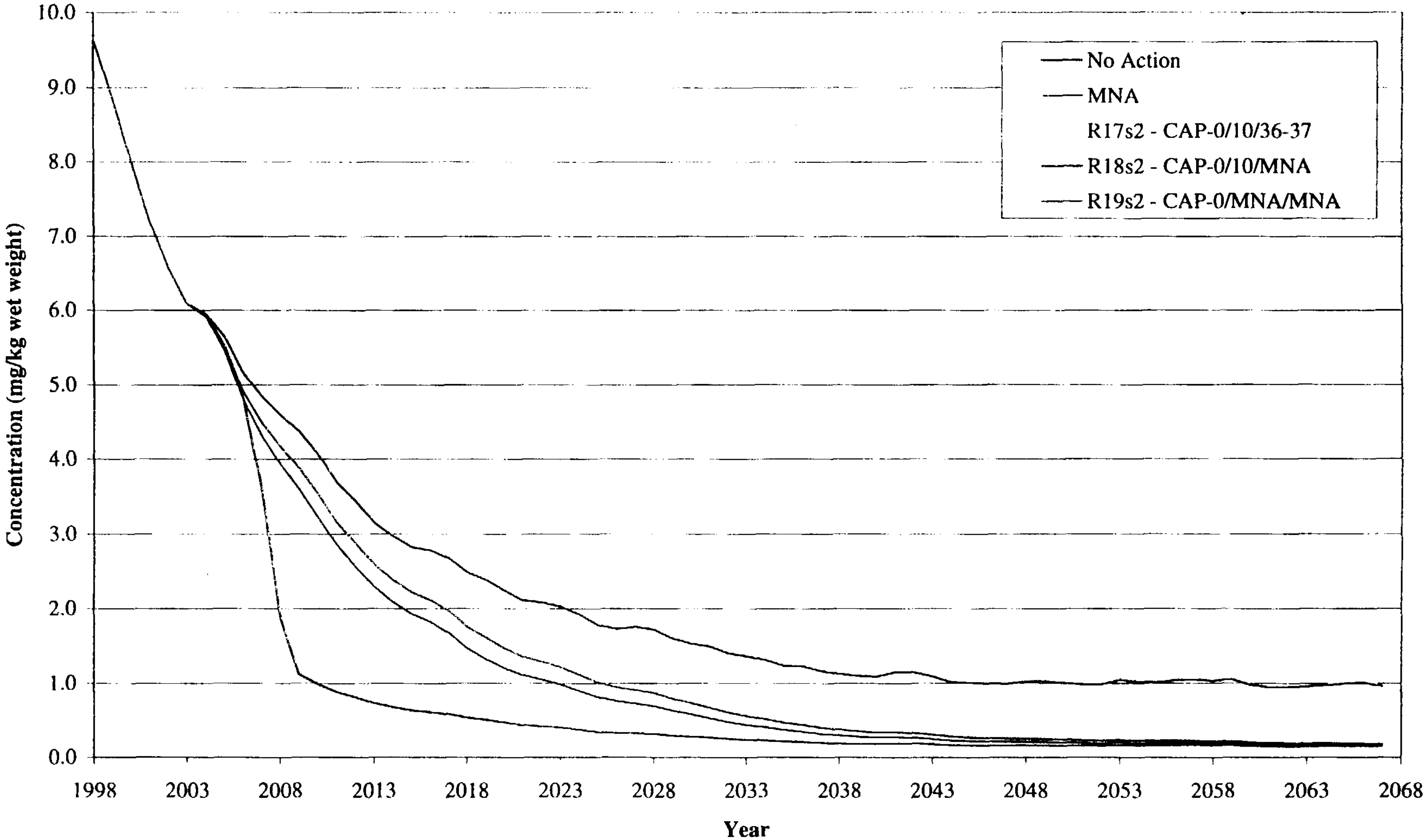
Fig RE122_thru RE124 11/20/00

Figure RE125. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Cap Scenarios



401791

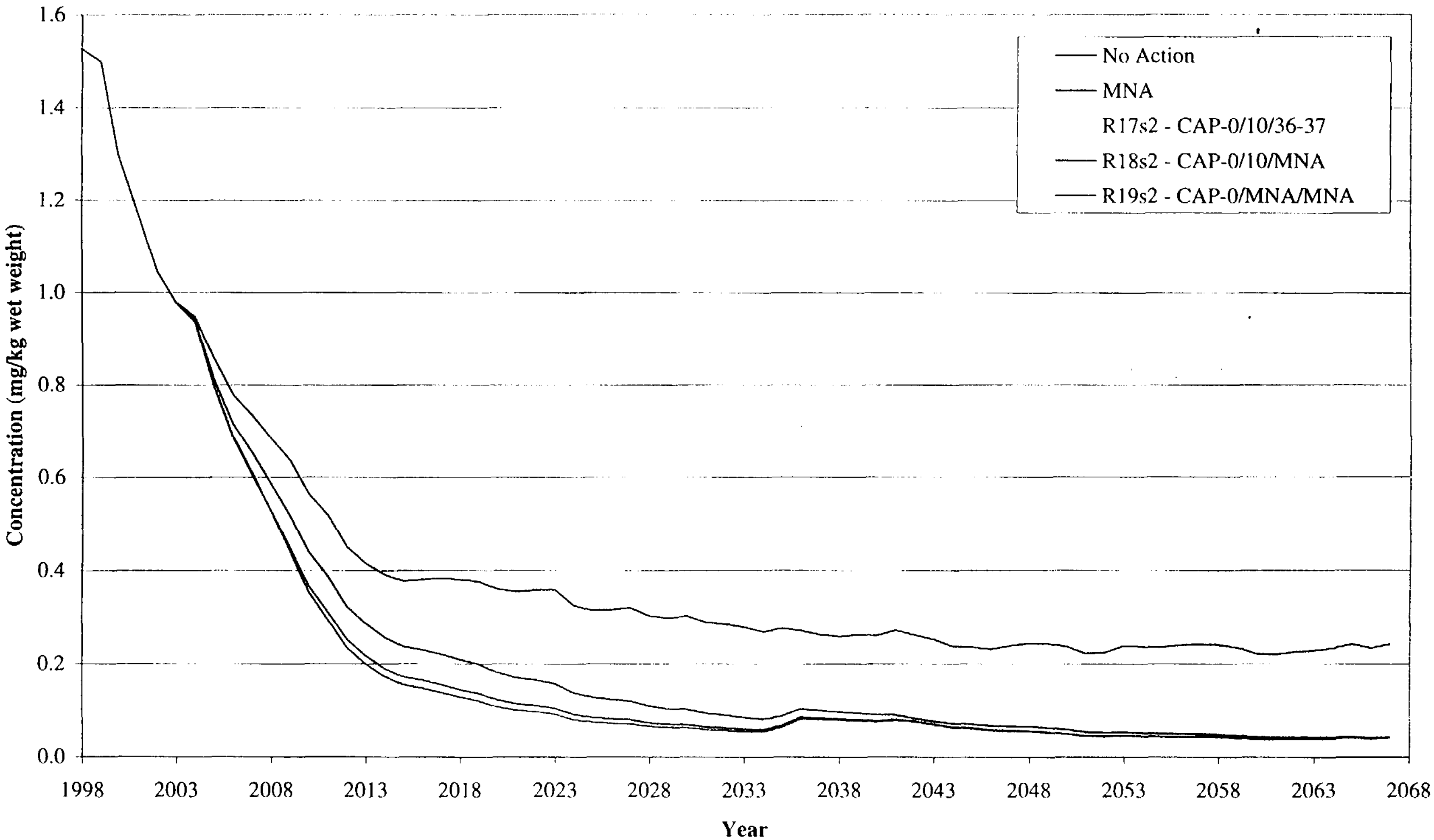
Figure RE126. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Cap Scenarios



401792

Fig RE125_thru_RE127 11/20/00

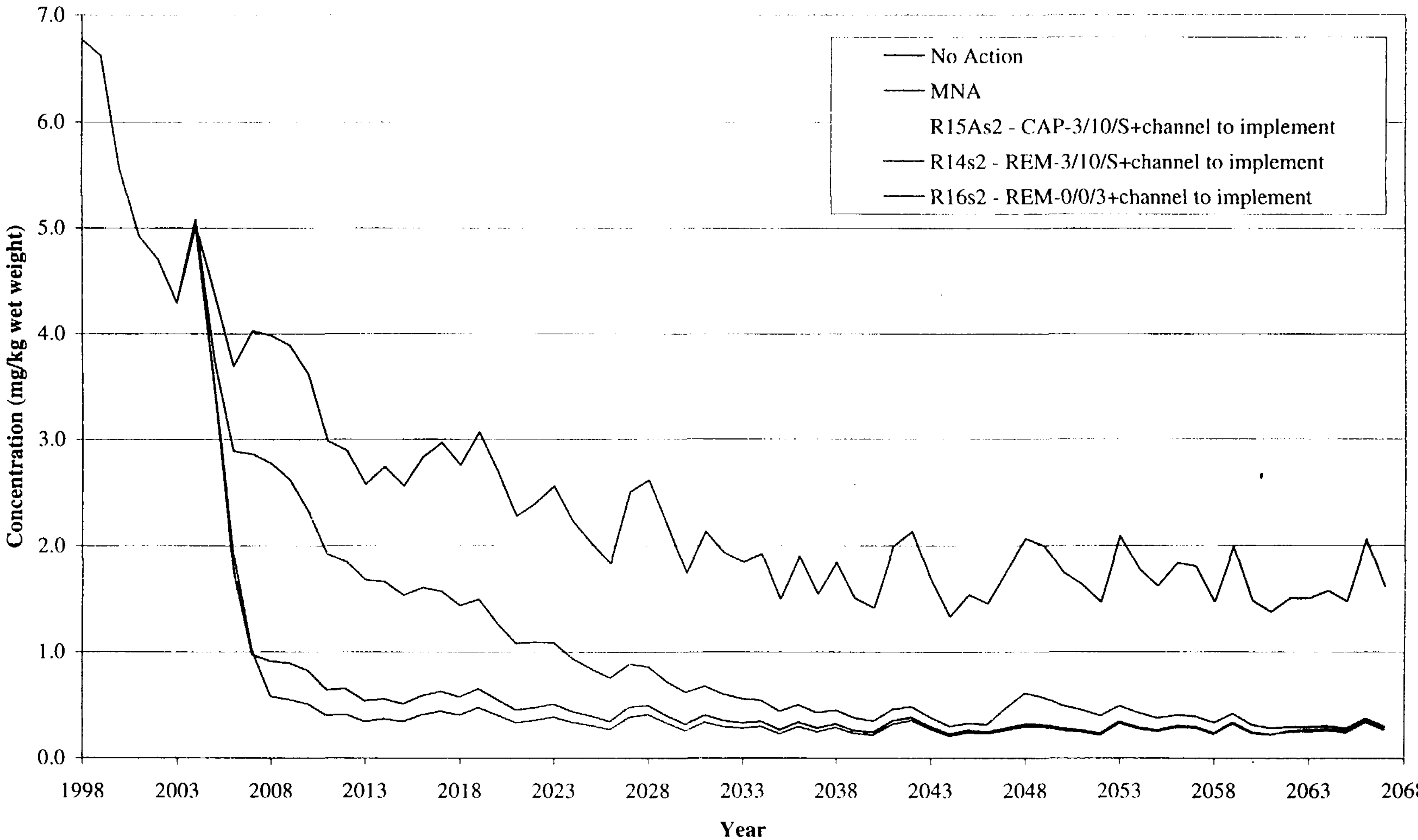
Figure RE127. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Cap Scenarios



401793

Fig RE125_thru_RE127 11/20/00

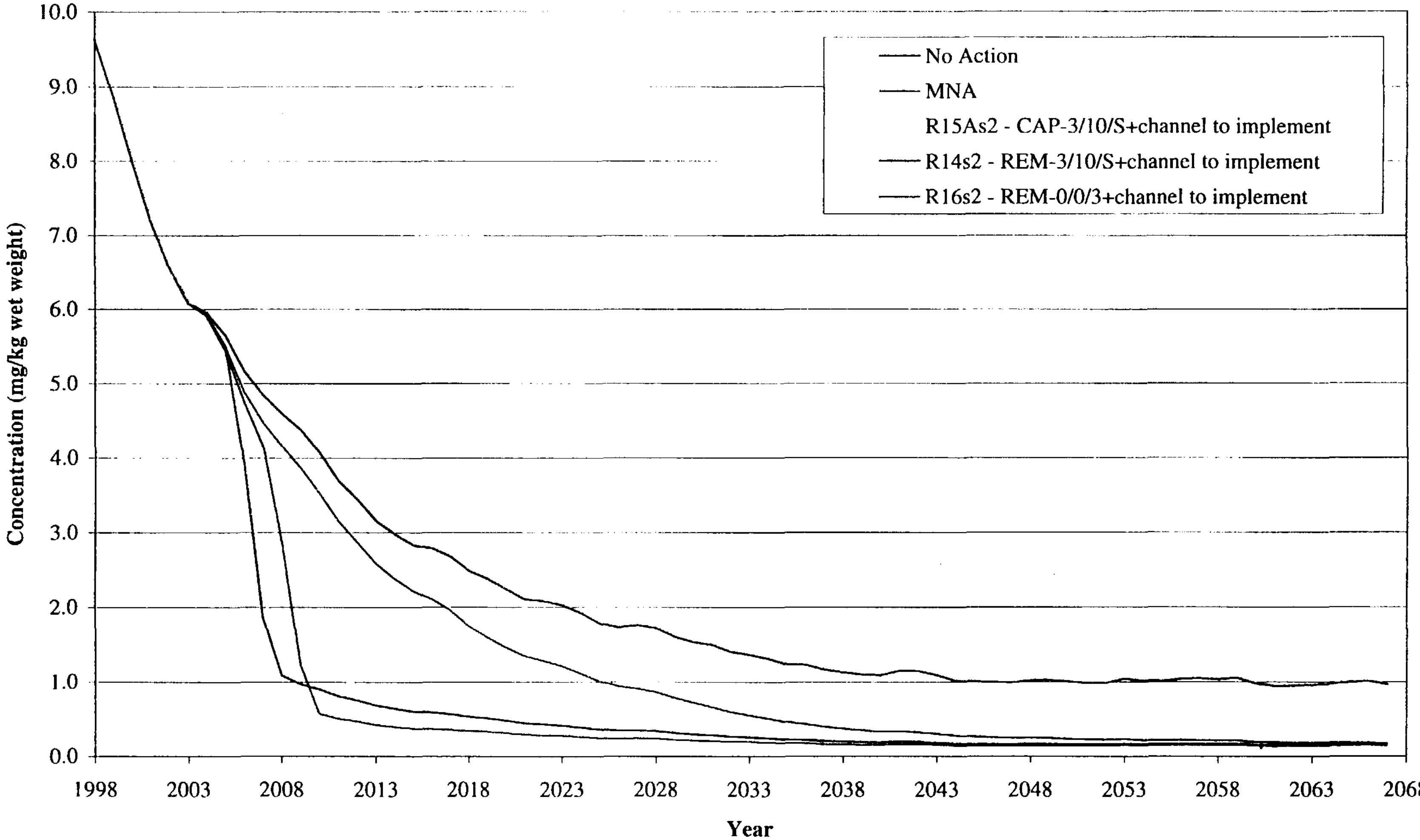
Figure RE128. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Alternatives Retained for Detailed Analysis



401794

Fig RE128 thru RE130 11/20/00

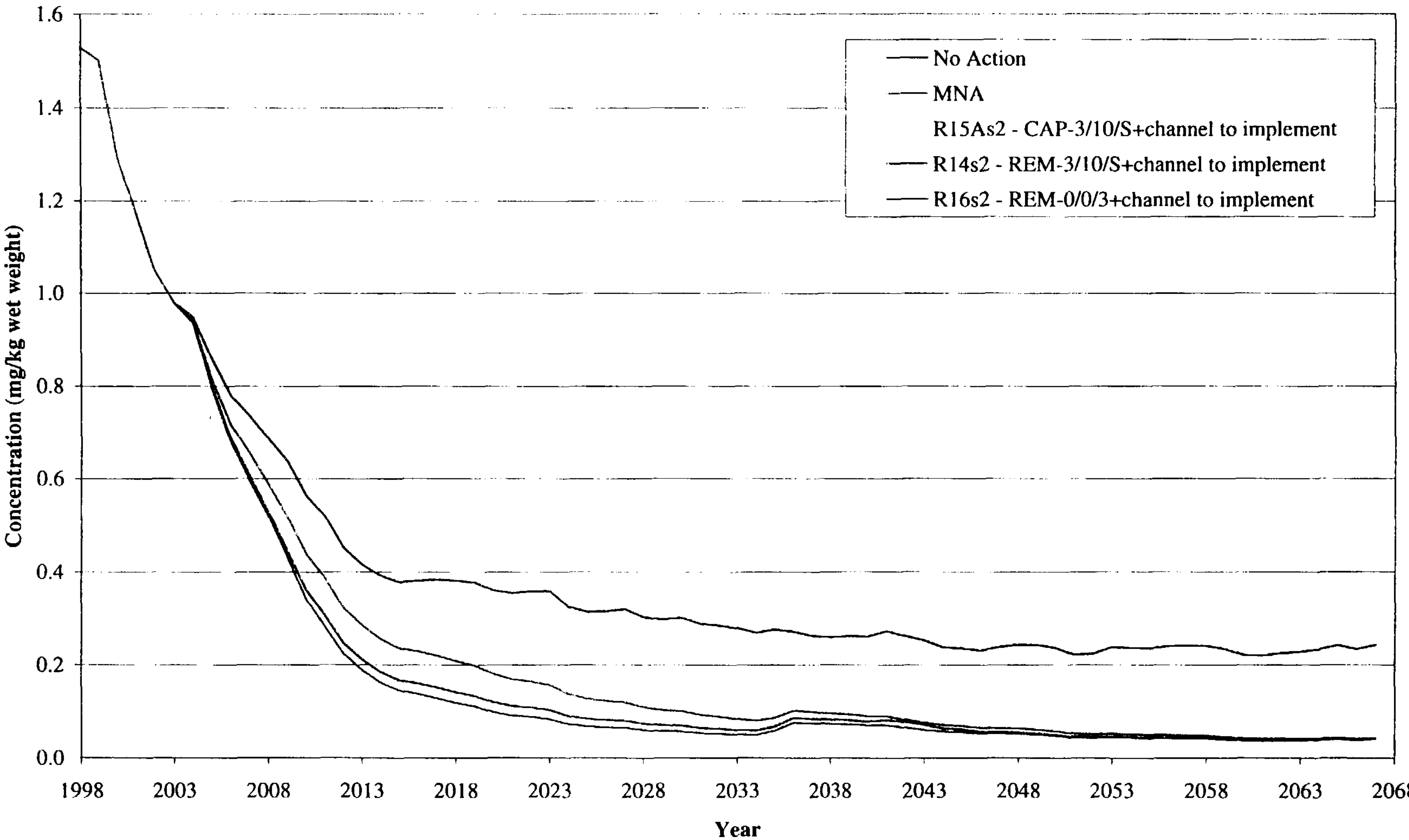
Figure RE129. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Alternatives Retained for Detailed Analysis



401795

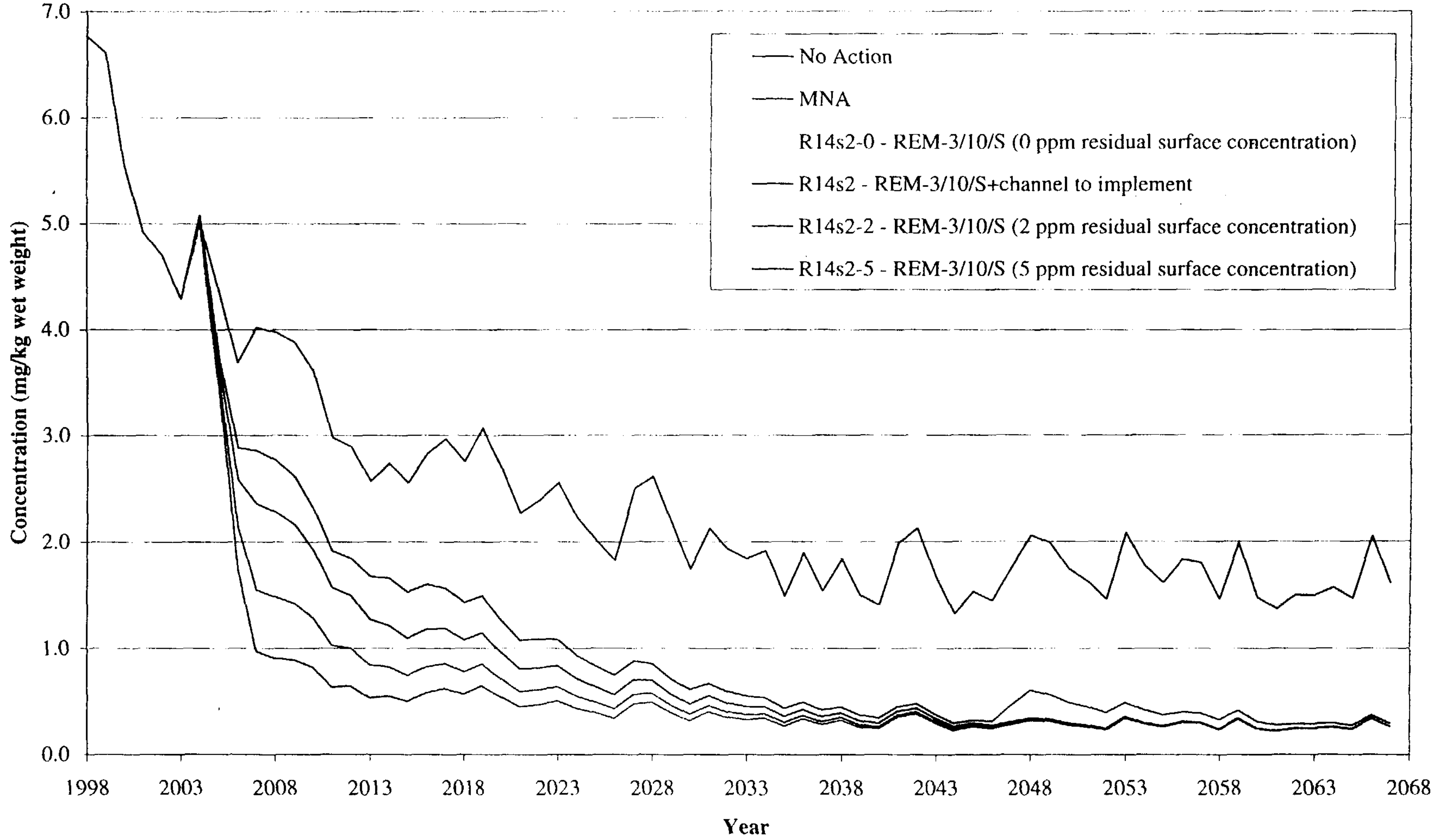
Fig_RE128_thru_RE130 11/20/00

Figure RE130. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Alternatives Retained for Detailed Analysis



401796

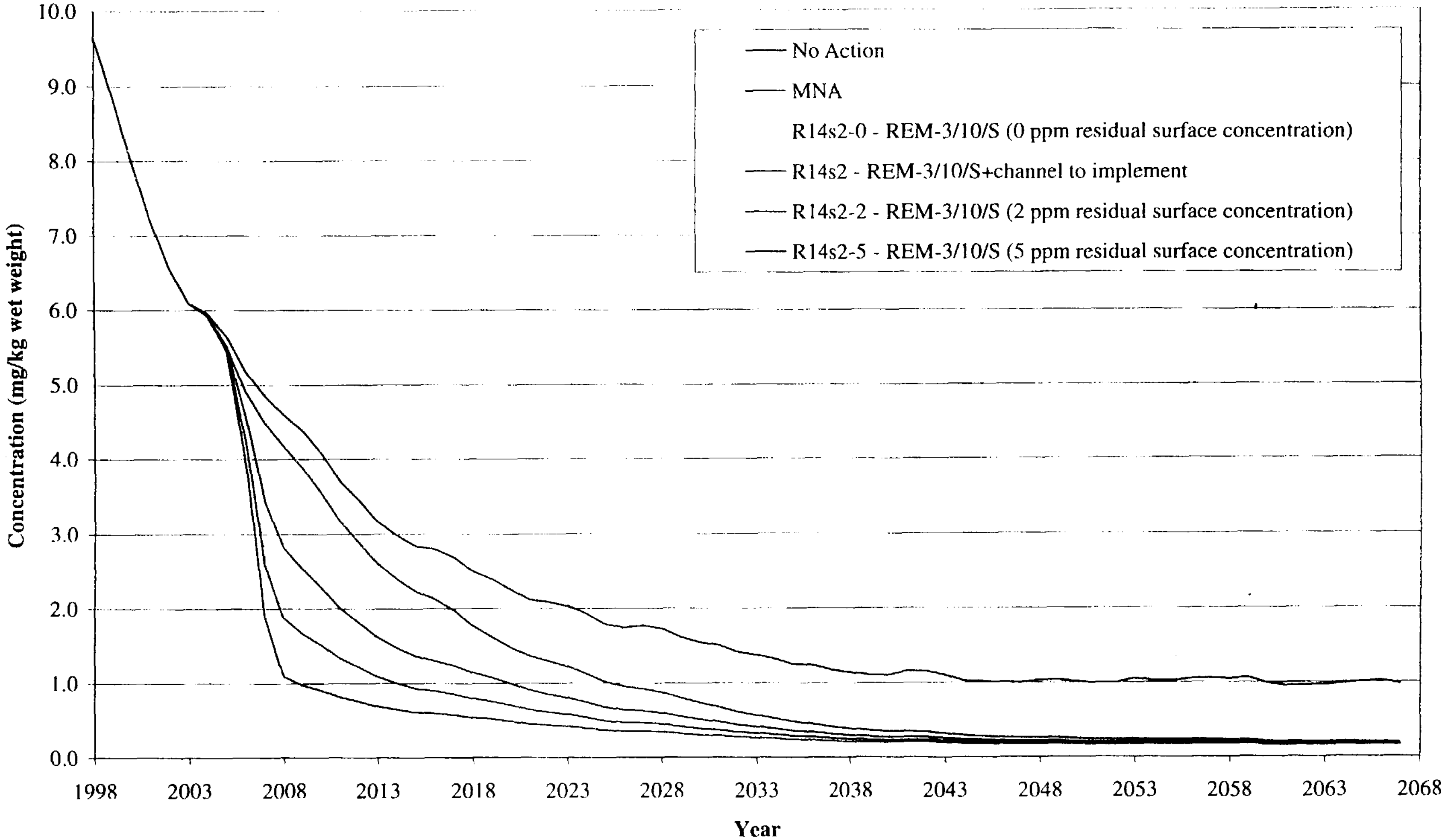
Figure RE131. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Removal Scenarios Sensitivity Analysis



401797

Fig_RE131_thru_RE133 11/20/00

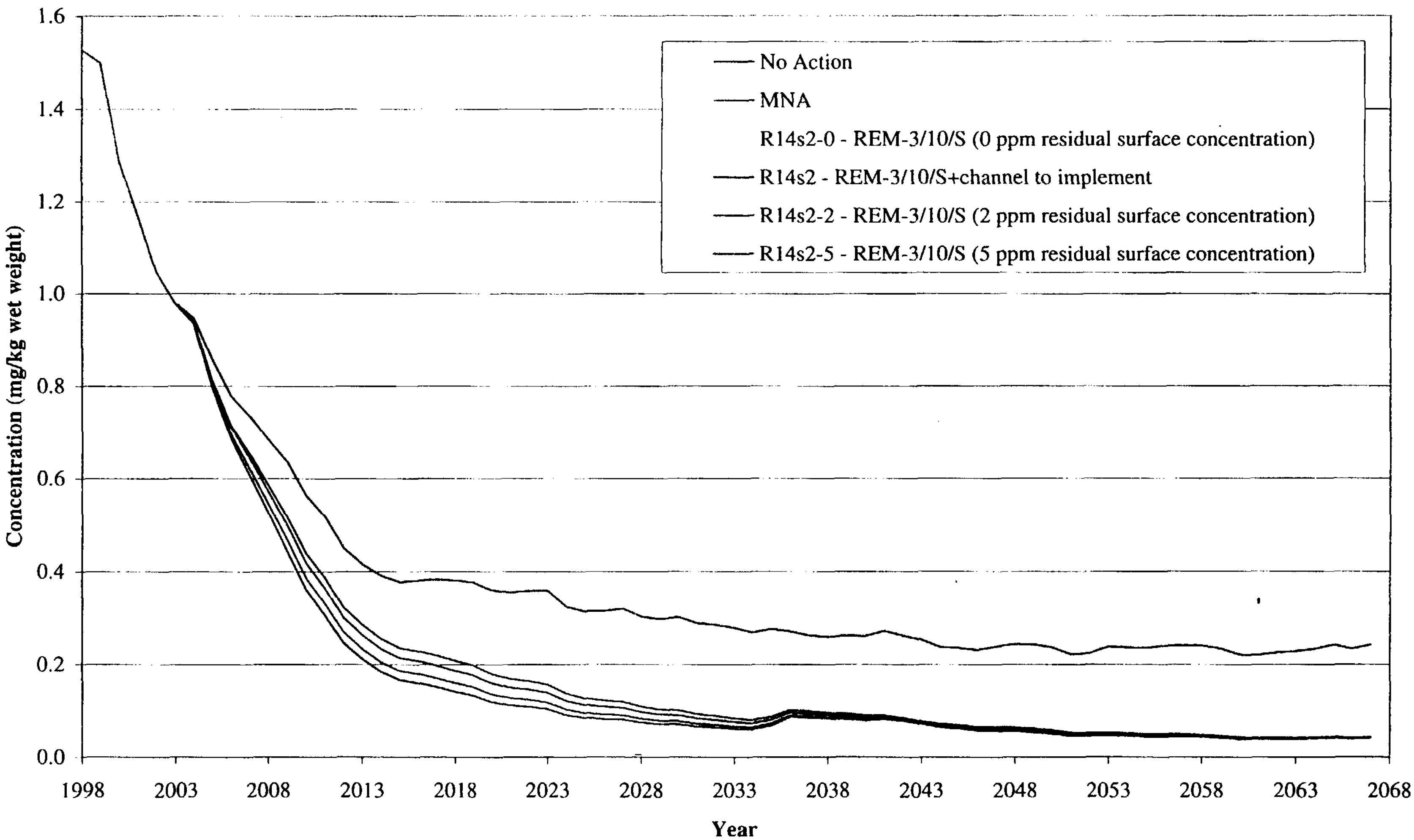
Figure RE132. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Removal Scenarios Sensitivity Analysis



401798

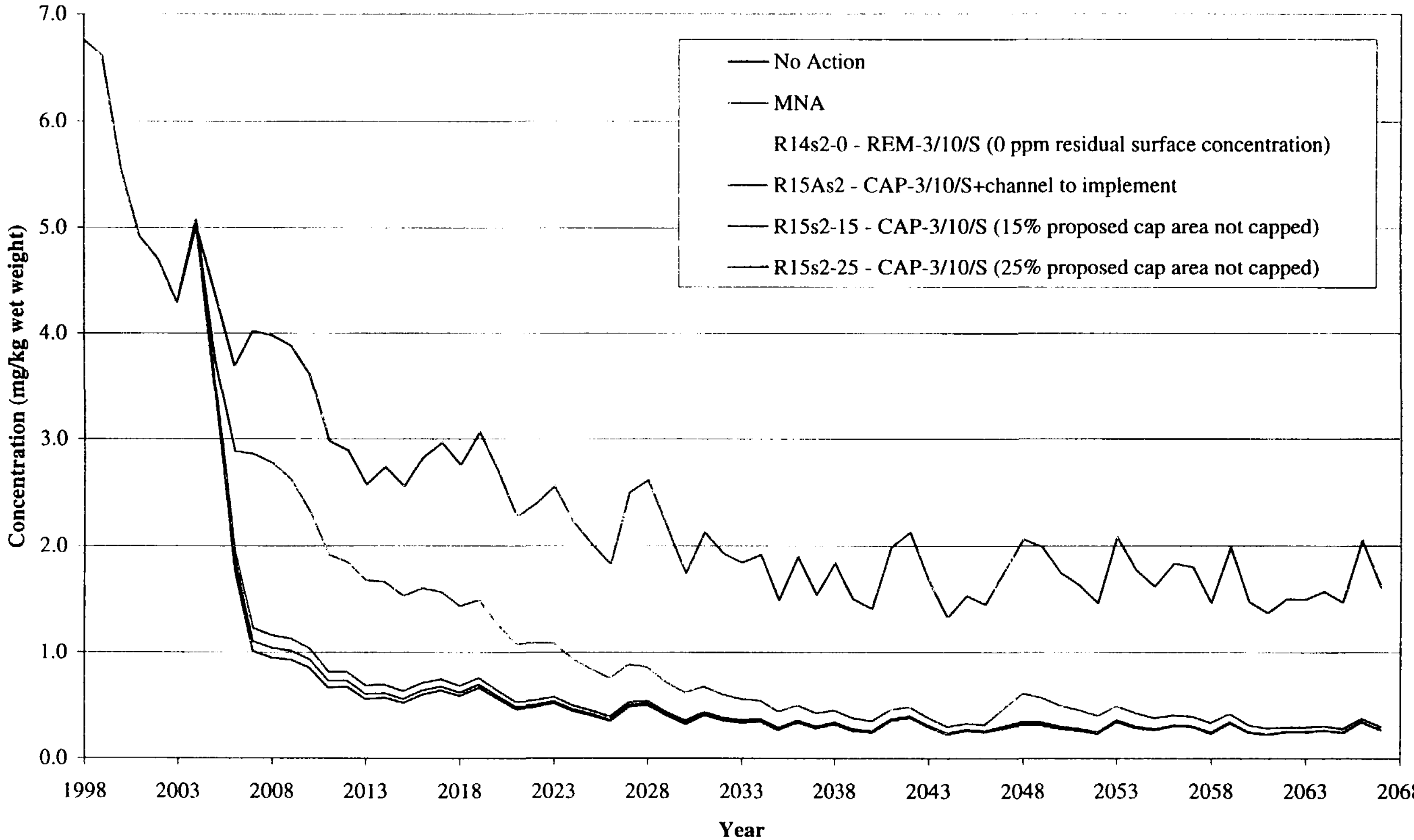
Fig_RE131_thru_RE133 11/20/00

Figure RE133. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Removal Scenarios Sensitivity Analysis



401799

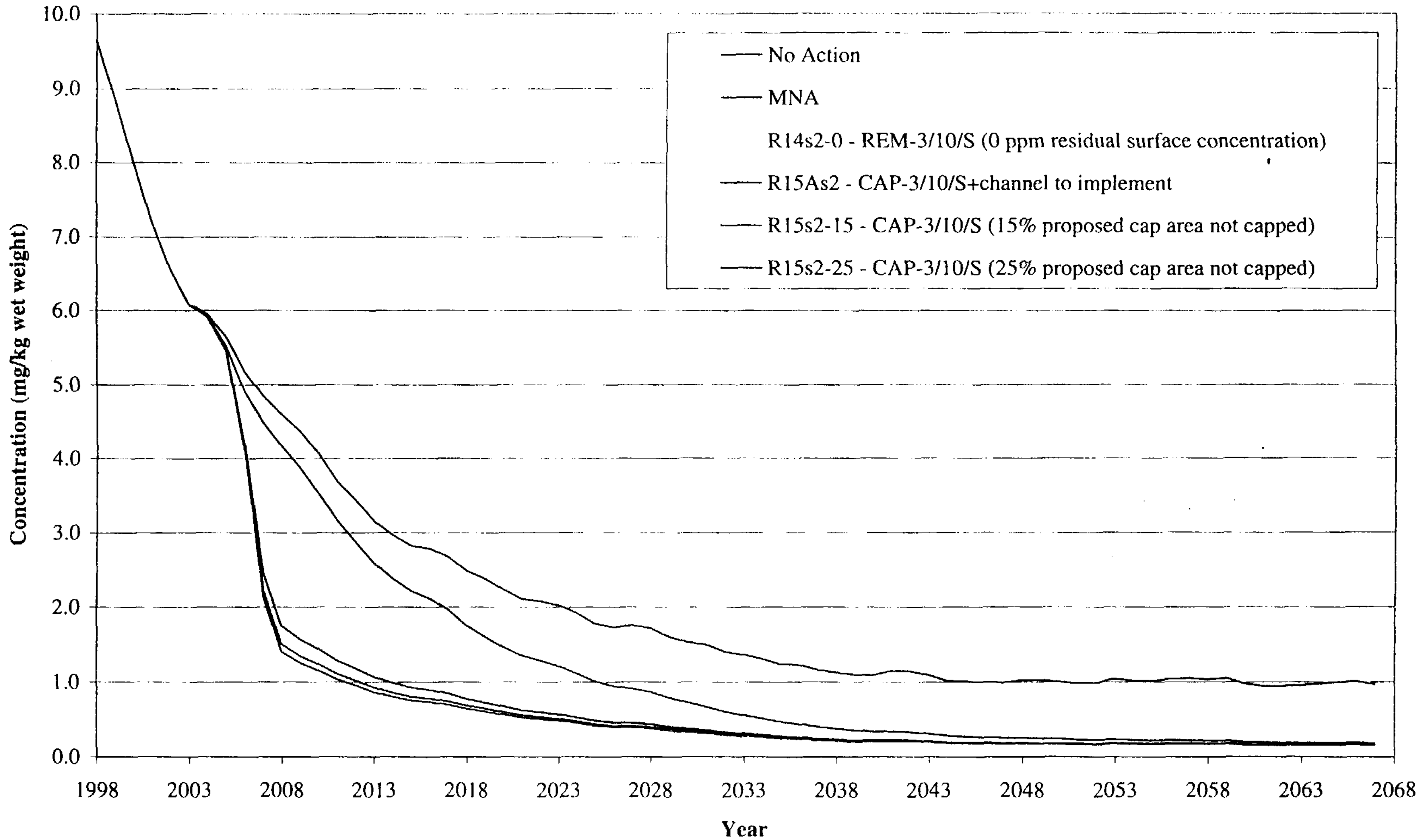
Figure RE134. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 1 - Cap Scenarios Sensitivity Analysis



401800

F: \RE134_thru_RE136 11/20/00

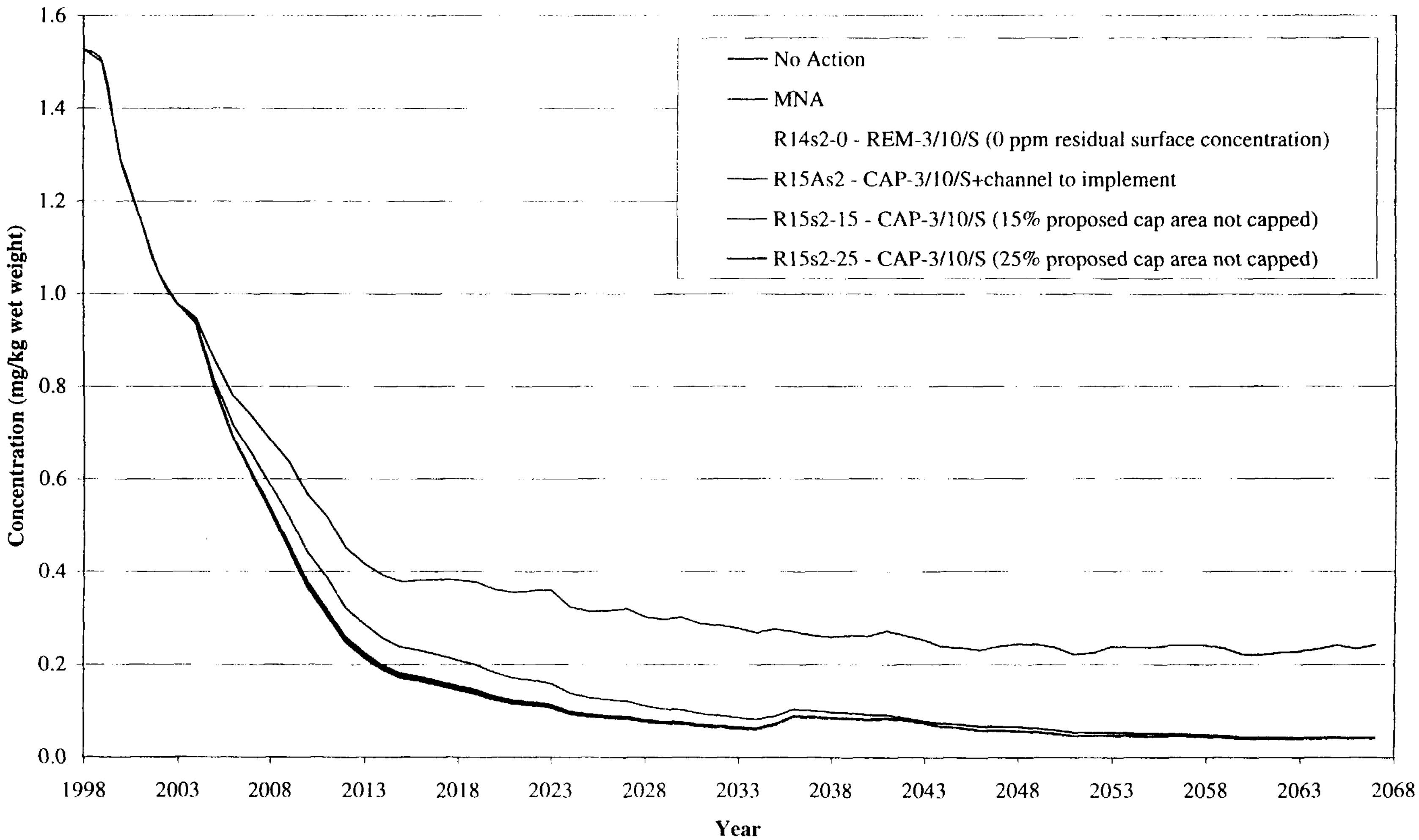
Figure RE135. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 2 - Cap Scenarios Sensitivity Analysis



401801

Fig_RE134_thru_RE136 11/20/00

Figure RE136. Comparison between Species-Weighted Fish Fillet Average PCB Concentration in River Section 3 - Cap Scenarios Sensitivity Analysis



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Appendix E

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E
ENGINEERING ANALYSIS

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.1 TECHNICAL MEMORANDUM: REMOVAL PRODUCTIVITY and EQUIPMENT REQUIREMENTS (Mechanical Dredges)

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

REMOVAL PRODUCTIVITY and EQUIPMENT REQUIREMENTS (Mechanical Dredges)

In order to establish a set of preliminary equipment requirements to accomplish removal of Upper Hudson River targeted sediments by mechanical dredges, an analysis was conducted combining information from the project's GIS database, plans of proposed dredging areas, and vendor information. The analysis was based on the use of excavators outfitted with suitable auxiliaries designed to minimize sediment resuspension and to direct accurate removal of targeted sediments.

Bathymetric data was available from a survey conducted in 1991 and 1992 (Rogers Flood, 1993); also, see Feasibility Study Chapter 4. The survey information, in final form, consisted of maps illustrating one foot depth contours in River Sections 1 and 2 (see FS Plate 3). When expanded by computer, the bathymetric maps provided a useful basis for identifying the access problems that mechanical dredging equipment would encounter along the Upper Hudson. The mapped contours were used to establish the configuration of the mechanical dredges to be incorporated in the alternative-specific analysis provided in this FS. The process of selecting removal equipment, at this conceptual stage, was interpreted from the river bathymetry data and the layout of the proposed removal areas. Various dredging contractors were contatced to obtain information on appropriate and available removal equipment for the Upper Hudson River conditions. In the event that the selected remedy includes dredging, final specification of dredging methods and equipment will be made during design and implementation. Various factors that entered into the equipment evaluation process are as follows:

- Large capacity dredging equipment may not be able to access a significant portion of targeted near-shore sediments;
- Target sediments tend to be in deposits that range from 1 to 4.5 feet in thickness suggesting that larger scale equipment would not function efficiently;
- Limiting removal work to only a single low-capacity unit that can work in both shallow and deeper river segments would impact project productivity;
- To date environmental buckets have been fabricated in a limited range of capacities;
- Environmental buckets, due to the added features, may be heavier (bucket weight/cubic yard capacity) than comparable conventional buckets;
- Hopper and deck barges cannot be fully loaded at numerous work locations due to draft limitations;
- Handling and processing capacities at transfer stations may be constrained by wharf limitations, available land area, and rail capacity.

Given the complex interaction between these factors described above, an optimal dredging strategy can not be generated for this FS. However, it is possible, by applying technical judgement, to identify equipment type, number of units, and other elements of a mechanical removal scenario. Given the above listed factors, it has been decided that two different capacity dredging units will be selected to accomplish all removal work. The characteristics of the lower capacity unit are as follows:

- Excavator fitted with a two-cubic-yard environmental bucket;
- Draft of excavator plus working platform less than three feet;
- Effective working reach of 30 feet in three feet of water;
- Unconstrained operating cycle less than one minute; and
- Proposed operating cycle of three minutes.

Characteristics of the higher capacity unit are as follows:

- Excavator fitted with four-cubic-yard bucket;
- Draft of excavator plus working platform less than five feet;
- Effective working reach of 30 feet in five feet of water;
- Unconstrained operating cycle less than one minute; and
- Proposed operating cycle of two minutes.

The in-situ volume of targeted sediments that would be removed by each of the dredging packages was determined by overlaying maps of proposed dredging areas on maps illustrating river bathymetry using the project GIS database. Then the following procedure was followed to estimate work areas and removal volumes applicable to each of the equipment packages:

- A line offset 30 feet from the mapped shoreline was drawn in all areas to be remediated; This line represents the removal limit of the dredge equipment based on an effective working reach of 30 ft.
- The post-dredge five foot contour was located;
- The 30 foot offset of the shoreline was compared to the location of the post-dredge five foot contour; if the 30 foot offset extended outboard of the post-dredge five foot contour, the larger capacity equipment package could be used to remove targeted sediments outboard of the mapped shoreline;.
- In areas where the 30 foot offset did not extend beyond the post-dredge five foot contour, the lower capacity system would be used to complete removal work not accessible to the larger system;
- It was assumed that all targeted sediment in the non-navigable river section (Lock 6 pool) will be removed with lower capacity equipment due to constraints associated with mobilizing equipment in this section;
- In River Section 3, it was assumed that the lower capacity dredge will remove targeted sediments where water depths range from zero to six feet and that the larger system will be used to remove material where water depths exceed six feet.

Using the above guidelines, target sediment removal volumes were determined for both the larger and lower capacity dredging systems. These are shown in the following table for the two removal alternatives:

Proposed Volumes to be Removed from the Upper Hudson River

Alternative	Volume by Lower Capacity System (cy)	Volume by Higher Capacity System (cy)	Total Volume Removed (cy)
REM-0/0/3	2,642,266	1,180,794	3,823,060
REM-3/10/Select	2,028,988	622,742	2,651,730

To meet alternative-specific construction durations (five years for REM-3/10/Select and seven years for REM-0/0/3) removal productivity for each dredge type was estimated. On the basis of the productivity estimate it then becomes possible to estimate the number of dredges that would be needed to complete the work. Computation of the removal productivity has been based on the following:

- Dredge equipment would operate 12 to 14 hours/day (actual dredging);
- Dredging operations would be conducted 6 days/week;
- The dredging season would be 30 weeks;
- An overlap of 15% per cut was assumed between bites;
- The larger dredge system will make a horizontal, 1.5-ft cut; and
- The lower capacity ("smaller") dredge system will make a horizontal, 1-ft cut;
- Each bucket load will consist of 80 percent sediment and 20 percent entrained water;
- The density of the in-situ sediments is 1.4 tons/cy;
- Removal with the larger system will be by means of a four-cubic-yard environmental bucket operating on a two minute cycle; and
- Removal with lower capacity system will be by means of two-cubic-yard environmental bucket operating on a three minute cycle.

Based on the above factors, the following removal rates have been computed for each of the equipment packages. It should be noted that the following tabulation provides removal rates in terms of in-situ sediment volume removed.

Dredge Productivity

Nominal Bucket Capacity	Operating Cycle	*In-situ* Sediment Removal Rate
four cubic yards	two minute cycle	82 cubic yards per hour
two cubic yards	three minute cycle	27 cubic yards per hour

Knowing the hourly productivity of each equipment package, and the daily and seasonal operating patterns, it is possible to estimate the number of dredges that would be needed to accomplish the targeted removal work in the specified number of construction seasons. Results of this analysis are summarized in the following table. It should be noted that equipment quantities presented below are averages. During actual removal operations it is possible that the number will vary according to the contractor's dredging plan.

Equipment Requirements

Alternative	Volume by 4-cy dredge (tpd)	Volume by 2-cy dredge (tpd)	Number of 4-cy Dredges	Number of 2-cy Dredges
REM-0/0/3	2,936	1,312	2	3
REM-3/10/Select	3,156	969	2	2

Targeted sediments are placed into barges for transport to either a northern or southern transfer facility. In general, it has been assumed that sediment removed by the larger equipment package would be placed into hopper barges loaded to a maximum of 1,000 tons. These barges will be towed to a southern transfer facility located south of Lock 5, potentially in the vicinity of the Albany area, for processing and disposal. Sediments removed by the lower productivity equipment will be placed onto deck barges that will be loaded to a maximum of 200 tons. The deck barges will, in general, be towed to the northern transfer facility, adjacent to the TI Pool, for processing prior to final disposal.

For purposes of this analysis, it was assumed that the northern transfer facility will be utilized to its maximum processing capacity of 1,460 tpd of in-situ sediment (based on an output of 1,600 tons per day of stabilized sediment). However, to fully utilize the estimated capacity of the northern facility, 158 tpd of sediment slated to be removed by the larger equipment package will need to be towed to the northern facility under the REM-0/0/3 alternative and 501 tpd under the REM-3/10/Select alternative.

In-river transit time to the southern transfer facility was estimated to be, on average, 9 hours and unloading of hopper barges to be 6 hours. The total turn around time for a hopper barge was estimated to be 24 hours. It was concluded that three sets of hopper barges would be required so that one barge can be loaded at the work site while the second is being unloaded at the transfer facility and a third is in transit. Based on the total amount of sediment plus entrained water being removed each day, the number of hoppers required could then be determined.

For alternative REM-0/0/3, the larger dredges remove approximately 2,936 tpd of in-situ sediment and each dredge removes 1,785 tpd of sediment plus entrained water (working 12.5 hrs/day). Since two larger machines are required for this alternative (producing 3,570 tpd of sediment plus water), 4 hopper barges will be loaded daily and 12 hoppers total are required. For REM- 3/10/Select, 3,156 tpd of sediment is removed (by the larger dredges) and each dredge removes 1,999 tpd of sediment plus entrained water (working 14 hrs/day). Since two dredges are also required for this alternative (producing 3,998 tpd of sediment plus water), 4 hopper barges will be loaded per day with 12 hoppers total required. Tow boats are assumed to work 24 hours per day so that four are required for each alternative to transport the hopper barges.

Material removed by the lower-capacity system (two-cubic-yard) will be barged to the northern transfer facility in 200-ton loads. Travel time to the northern transfer facility was estimated to be one hour on average. Time to unload the 200 tons barge loads was estimated at 3 to 4 hours. This implies a total turn around time per barge of about 6 hours. Since one small dredge will load approximately 2.5 barges per day, it was assumed that a minimum of two barges are required per dredge. This is to ensure that the equipment will not experience down time while waiting for the return of a barge. For alternative REM-0/0/3, 1,312 tpd of sediment is removed by the smaller machines and each unit removes about 571 tons sediment plus entrained water per day (working 11 hrs/day). Since three dredges are required for this alternative (producing 1,142 tons of sediment plus water), 9 deck barges are loaded per day and a total of six such barges are required (two per dredge) to avoid down time. An additional deck barge is required to transport dredged materials from the deep equipment (approximately 158 tpd) to the northern facility to ensure it is utilized to its maximum capacity.

For alternative REM-3/10/Select, 969 tpd of shallow sediment is removed and each small dredge removes 495 tons sediment plus entrained water (working 13 hrs/day). Since two dredges are required (producing 1,238 tons of sediment plus water), 6 barges are loaded per day and a total of four barges are required to avoid down time. Three additional deck barges are required to transport dredged materials from the deep equipment (approximately 501 tpd) to the northern facility to ensure it is utilized at its maximum capacity. Tow boats are assumed to operate 24 hours per day so that 3 are required for REM-0/0/3 and 2 for REM-3/10/Select.

The following table summarizes the removal equipment required per alternative.

Removal Alternative Equipment List

Alternative	Dredges	Barges[1]	Tow Boats	Work Boats [2]
REM-0/0/3	2 (4-cy) dredges 3 (2-cy) dredges	12 hopper 8 deck	4 large 3 small	1
REM-3/10/Select	2 (4-cy) dredges 2 (2-cy) dredges	12 hopper 7 deck	4 large 3 small	1

Notes:
(1) Deep dredge material being transported to the northern transfer facility to help maximize its capacity was assumed to be barged in deck barges
(2) One work boat has been assumed to aid in dredge and barge repositioning

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APPENDIX E

ENGINEERING ANALYSIS

E.2 TECHNICAL MEMORANDUM: AREAS CAPPED FOR THE CAPPING ALTERNATIVES-CONCEPT DEVELOPMENT

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

AREAS CAPPED FOR THE CAPPING ALTERNATIVES- CONCEPT DEVELOPMENT

Quantities estimated for the capping alternatives include area capped and volume of sediment removed. The assumptions used in estimating the area capped are described in this section.

Areas to be capped were delineated using the following assumptions:

- Target sediments in areas with 0 to 6 feet water depth will be removed to 1.5 feet below the sediment surface then capped. The exception to the capping specification in 0 to 6 feet water depth areas are: (1) if all contamination is removed when 1.5 feet of sediment is removed, there will be no capping in these areas, and (2) if the bottom of contamination is at 2 feet, the entire thickness of contaminated sediments will be removed with no capping.

- Target sediments in areas with 6 to 12 feet water depth will be capped; except where the bottom of contamination is at 2 feet or less, then the entire thickness of contaminated sediments will be removed with no capping.

- Target sediments in the navigation channel (defined as areas with >12 feet water depth) will be removed to the bottom of contamination. Areas with water depth greater than 12 feet but are not in the navigation channel (e.g., the river section east of Rogers Island) will be capped with no sediment removal.

- For the section of the river between Thompson Island Dam and Lock 6, all sediments in target areas will be removed, i.e., there will be no capping in this section.

- In target areas below Lock 5, it is assumed that the entire thickness of contaminated sediments will be removed with no capping. This is based on the assumption that the mobilization of capping material and equipment is likely not cost effective to cap relatively small volumes of contaminated sediments in this river section.

Results of the computational effort are displayed in the following table (Table 1). The table provides estimates of capped areas by river section and, within each section, by water depth for each target criteria.

Table 1: Estimates of Capped Areas for the Capping Scenarios

River Section	Area Capped by Water Depth (Acres)											
	Full-Section				>3 g/m^2				>10 g/m^2			
	0-6'	6-12'	>12'	Total	0-6'	6-12'	>12'	Total	0-6'	6-12'	>12'	>12'
1	108.8	64.3	1.2	174.3	103.1	52.4	-	155.5	88.6	40.7	-	129.3
2	30.6	23.0	-	53.6	30.6	22.7	-	53.3	29.5	22.2	-	51.7
3	-	-	-	-	-	-	-	-	-	-	-	-
Total	139.4	87.3	1.2	227.9	133.7	75.1	-	208.8	118.1	62.9	-	182.0

APPENDIX E

ENGINEERING ANALYSIS

E.3 TECHNICAL MEMORANDUM: VOLUME REMOVED FOR THE CAPPING ALTERNATIVES- CONCEPT DEVELOPMENT

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

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VOLUME REMOVED FOR THE CAPPING ALTERNATIVES- CONCEPT DEVELOPMENT

Quantities estimated for the capping alternatives include area capped and volume of sediment removed. The assumptions used in estimating the volume removed are described in this section.

Volume removed for the capping scenarios were estimated using the following assumptions:

- Sediments are removed to accommodate the cap without changing the hydraulic characteristics of the river in shallow areas (defined as areas with water depth less than 6 feet).
- Target sediments in areas with 0 to 6 feet water depth will be removed to 1.5 feet then capped.
- If the bottom of contamination is at 2 feet, the entire thickness of contaminated sediments will be removed with no capping.
- In target areas with 6 to 12 feet water depth, where the bottom of contamination is at 2 feet or less, then the entire thickness of contaminated sediments will be removed with no capping. Where the bottom of contamination is more than 2 feet below the sediment surface, there will be no sediment removal.
- Target sediments in the navigation channel (defined as areas with >12 feet water depth) will be removed to the bottom of contamination. Areas with water depth greater than 12 feet but are not in the navigation channel (e.g., the river section east of Rogers Island) will be capped with no sediment removal.
- For the section of the river between Thompson Island Dam and Lock 6, all sediments in target areas will be removed.
- All target sediments below Northumberland Dam will be removed, i.e., no capping will be implemented below Northumberland Dam.

The methods used to compute the volume of sediments removed for the capping scenarios are as described previously for the removal scenarios in Appendix B. Results of the computational effort are displayed in the following table (Table 1). The table provides estimates of volume removed for the capping scenarios by river section and, within each section, by water depth for each target criteria.

TABLE 1: Estimates of Volume Removed for the Capping Scenarios

River Section	Volume Removed by Water Depth (Cubic Yards)											
	Full-Section				>3 g/m^2				>10 g/m^2			
	0-6'	6-12'	>12'	Total	0-6'	6-12'	>12'	Total	0-6'	6-12'	>12'	Total
1	525,469	340,045	554,194	1,419,708	378,587	173,536	297,049	849,172	262,757	7,148	122,578	392,483
2	395,898	263,940	325,500	985,338	276,953	49,948	144,405	471,306	188,012	13,218	90,750	291,980
3	-	-	-	-	468,813	78,144	24,120	571,076	361,181	71,052	10,925	443,158
Total	921,367	603,985	879,694	2,405,046	1,124,353	301,628	465,574	1,891,554	811,950	91,418	224,253	1,127,621

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ENGINEERING ANALYSIS

E.4 TECHNICAL MEMORANDUM: CAPPING WITH DREDGING-PRODUCTIVITY and EQUIPMENT REQUIREMENTS (Mechanical Dredges)

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

CAPPING WITH SELECT REMOVAL PRODUCTIVITY and EQUIPMENT REQUIREMENTS (Mechanical Dredges)

In-situ capping is one concept being considered for remediation of contaminated sediments in the Upper Hudson River. The capping with select removal concept involves capping in water depths 0 to 6 ft and 6 to 12 ft where the depth of contamination is greater than 2 ft. In areas where the depth of contamination is 2 ft or less, removal will occur with mechanical dredging equipment. All areas requiring remediation in the channel (water depth > 12 ft) will be dredged using mechanical equipment to the depth of contamination. In areas located in water depths 0 to 6 ft where capping occurs, 1.5 ft of contaminated material will be mechanically removed so that the river shoreline location and water depths following remediation are approximately the same as the existing conditions.

In order to establish a set of preliminary equipment requirements to accomplish select removal of Upper Hudson River targeted sediments by mechanical dredges, an analysis was conducted combining information from the project GIS database, plans of proposed dredging areas overlaid on plans of proposed capping areas, and vendor information. The analysis was based on the use of excavators outfitted with suitable auxiliary equipment designed to minimize sediment resuspension and to direct accurate removal of targeted sediments.

Bathymetric data was available from a survey conducted in 1991 and 1992 (Roger Flood, 1993); also, see Feasibility Study Chapter 4. The survey information, in final form, consisted of maps illustrating one foot depth contours in River Sections 1 and 2 (see FS Plate 3). When expanded by computer, the bathymetric maps provided a useful basis for identifying the access problems that mechanical dredging equipment would encounter along the Upper Hudson. The mapped contours were used to establish the configuration of the mechanical dredges that would be incorporated in the alternative-specific analysis provided in this FS. The process of selecting removal equipment, at this conceptual stage, was interpreted from the river bathymetry data and the layout of the proposed removal areas. Various dredging contractors were contacted to obtain information on appropriate and available removal equipment for the Upper Hudson River conditions. In the event that the selected remedy includes dredging, final specification of dredging methods and equipment will be made during design and implementation. Various factors that entered into the equipment evaluation process are as follows:

- Large capacity dredging equipment may not be able to access a significant portion of targeted near-shore sediments requiring select removal to allow for cap placement;
- Target sediments requiring select removal tend to be in deposits that range from 1 to 3 feet in thickness suggesting that larger scale equipment would not function efficiently;
- Limiting removal work to only a single low-capacity unit that can work in both shallow and deeper river segments would impact project productivity;
- To date environmental buckets have been fabricated in a limited range of capacities;
- Environmental buckets, due to the added features, may be heavier (bucket weight/cubic

yard capacity) than comparable conventional buckets;

- Hopper and deck barges cannot be fully loaded at numerous work locations due to draft limitations;
- Handling and processing capacities at transfer stations may be constrained by wharf limitations, available land area, and rail capacity.

Given the complex interaction between these factors described above, an optimal dredging strategy can not be generated for this FS. However, it is possible, by applying technical judgement, to identify equipment type, number of units, and other elements of a mechanical removal scenario. Given the above listed factors, it has been decided that two different capacity dredging units will be selected to accomplish all select removal work. The characteristics of the lower capacity unit are as follows:

- Excavator fitted with a two-cubic-yard environmental bucket;
- Draft of excavator plus working platform less than three feet;
- Effective working reach of 30 feet in three feet of water;
- Unconstrained operating cycle less than one minute; and
- Proposed operating cycle of three minutes.

Characteristics of the higher capacity unit are as follows:

- Excavator fitted with four-cubic-yard bucket;
- Draft of excavator plus working platform less than five feet;
- Effective working reach of 30 feet in five feet of water;
- Unconstrained operating cycle less than one minute; and
- Proposed operating cycle of two minutes.

The in-situ volume of targeted sediments that would be removed by each of the dredging packages for this alternative was determined by overlaying maps of proposed select dredging areas with proposed capping areas on maps illustrating river bathymetry using the project GIS database. The following assumptions were made to estimate work areas and removal volumes applicable to each of the equipment packages:

- The Larger Capacity Dredge System will be used in water depths 6-12' and >12' (channel) to remove sediments requiring select removal for this alternative;

- The Smaller Capacity Dredge System will be used in water depths 0-6' to remove contaminated material in all areas requiring select removal for this alternative;

- It was assumed that all targeted sediment in the non-navigable river section (Lock 6 pool) will be removed with lower capacity equipment due to constraints associated with mobilizing equipment in this section.

Using the above guidelines, target sediment removal volumes were determined for both the larger and lower capacity dredging systems. These are shown in the following table for the capping with select removal alternative:

Proposed Volumes to be Removed from the Upper Hudson River

Alternative	**Volume Deep (cy)**	**Volume Shallow (cy)**	**Total Volume Removed (cy)**
CAP/SR-3/10/Select	825,003	907,818	1,732,820

To meet alternative-specific construction durations (five years for CAP/SR-3/10/Select), the removal productivity for each dredge type was estimated. On the basis of the productivity estimate it then becomes possible to estimate the number of dredges that would be needed to complete the work. Computation of the removal productivity has been based on the following:

- Dredge Equipment will operate 13 to 14 hrs/day (actual dredging);
- Dredging will be conducted for 6 days/week;
- The dredge season will be for 30 weeks;
- An overlap of 15 percent per cut was assumed between bites;
- The larger dredge system will make a horizontal, 1.5-ft cut; and
- The lower capacity ("smaller") dredge system will make a horizontal, 1-ft cut;
- Each bucket load will consist of 80 percent sediment and 20 percent entrained water;
- The density of the in-situ sediments is 1.4 tons/cy;
- Removal with the larger system will be by means of a four-cubic-yard environmental bucket operating on a two minute cycle; and
- Removal with lower capacity system will be by means of two-cubic-yard environmental bucket operating on a three minute cycle.

Based on the above factors, the following removal rates have been computed for each of the equipment packages. It should be noted that the following tabulation provides removal rates in terms of in-situ sediment volume removed.

Dredge Productivity

Nominal Bucket Capacity	**Operating Cycle**	***In-situ* Sediment Removal Rate**
four cubic yards	two minute cycle	82 cubic yards per hour
two cubic yards	three minute cycle	27 cubic yards per hour

Knowing the hourly productivity of each equipment package, and the daily and seasonal operating patterns, it is possible to estimate the number of dredges that would be needed to accomplish the targeted removal work in the specified number of construction seasons. Results of this analysis are summarized in the following table. It should be noted that equipment quantities presented below are averages. During actual removal operations it is possible that the number will vary according to the contractor's dredging plan.

Capping with Select Removal Productivity Equipment Requirements

Alternative	Volume by 4-cy Dredge (tpd)	Volume by 2-cy Dredge (tpd)	Number of 4-cy Dredges	Number of 2-cy Dredges
CAP/SR-3/10/Select	1,283	1,412	1	3

Targeted sediments are placed into barges for transport to either a northern or southern transfer facility. In general, it has been assumed that sediment removed by the larger equipment package would be placed into hopper barges loaded to a maximum of 1,000 tons. These barges will be towed to a southern transfer facility located south of Lock 5, potentially in the vicinity of the Albany area, for processing and disposal. Sediments removed by the lower productivity equipment will be placed onto deck barges that will be loaded to a maximum of 200 tons. The deck barges will, in general, be towed to the northern transfer facility, adjacent to the TI Pool, for processing prior to final disposal.

For purposes of this analysis, it was assumed that the northern transfer facility will be utilized to its maximum processing capacity of 1,460 tpd of in-situ sediment (based on an output of 1,600 tons per day of stabilized sediment). However, to fully utilize the estimated capacity of the northern facility, 58 tpd of sediment slated to be removed by the larger equipment package will need to be towed to the northern facility under the CAP/SR-3/10/Select alternative.

In-river transit time to the southern transfer facility was estimated to be, on average, 9 hours and unloading of hopper barges to be 6 hours. The total turn around time for a hopper barge was estimated to be 24 hours. It was concluded that three sets of hopper barges would be required so that one barge can be loaded at the work site while the second is being unloaded at the transfer facility and a third is in transit. Based on the total amount of sediment plus entrained water being removed each day, the number of hoppers required could then be determined.

For CAP/SR-3/10/Select, 1,283 tpd of sediment is removed by the larger dredges and each large dredge removes 1,714 tpd of sediment plus entrained water (working 12 hrs/day). Since one dredge is required for this alternative, 2 hopper barges will be loaded per day with 6 hoppers total required. Tow boats are assumed to work 24 hours per day so that 2 are required for this alternative to transport the hopper barges.

Material removed by the lower-capacity system (two-cubic-yard) will be barged to the northern transfer facility in 200-ton loads. Travel time to the northern transfer facility was estimated to be one hour on average. Time to unload the 200 tons barge loads was estimated at 3-4 hours. This implies a total turn around time per barge of about 6 hours. Since one small dredge will load approximately 2.5 barges per day, it was assumed that a minimum of two barges are required per dredge. This is to ensure that the equipment will not experience down time while waiting for the return of a barge. For alternative CAP/SR-3/10/Select, 1,412 tpd of sediment is removed from the smaller dredges and each small dredge removes 619 tons sediment plus entrained water per day (working 13 hrs/day). Since three shallow dredges are required for this alternative (producing 1,857 tons of sediment plus entrained water), 10 barges are loaded per day and a total of seven barges are required for this alternative (two per dredge) to ensure no down time. Tow boats are assumed to work 24 hours per day so that 3 will be required for the CAP/SR-3/10/Select alternative.

The following table summarizes the removal equipment required for the CAP/SR-3/10/Select Alternative.

Capping with Select Removal Alternative Equipment List

Alternative	Dredges	Barges[1]	Transport Tugs	Work Boats [2]
CAP/SR-3/10/Select	1 (4-cy) dredges 3 (2-cy) dredges	6 hopper 7 deck	5 3	1

Notes:
(1) Any Deep dredge material being transported to the northern transfer facility to help maximize its capacity was assumed to be barged in deck barges
(2) One work boat was assumed for this alternative to aid in dredge barge repositioning

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APPENDIX E

ENGINEERING ANALYSIS

E.5 TECHNICAL MEMORANDUM: APPLICABILITY OF TURBIDITY BARRIERS for REMEDIATION

Prepared by
YEC, Inc.
Clarkstown Executive Park
612 Corporate Way
Suite 4 M
Valley Cottage, NY 10989

On behalf of
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

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APPLICABILITY OF TURBIDITY BARRIERS TO REMEDIATION OF THE UPPER HUDSON RIVER

1.0 Introduction

Various types of turbidity barriers have been used to limit downstream migration of sediments that may be re-suspended during dredging operations. This memorandum first provides an overview of a range of turbidity barrier types. While some specialty systems may have applicability to remediation of the Upper Hudson, the remainder of the memorandum focuses on the use of non-structural systems such as silt curtains.

2.0 Overview of Turbidity Barriers

Barriers can be placed into two categories for convenience, structural and non-structural types. Structural barriers are typically employed as permanent features for in-situ containment; however, they have lately been increasing used on a temporary basis to control movement of contaminated sediments. Non-structural barriers are normally employed for the duration of a dredging project and then removed. The use of a non-structural system allows the barrier to be re-located to new dredge areas as a dredging project progresses through various stages. Portable modular systems may be used to improve re-locatability over structural systems while allowing greater hydrodynamic control and stability than non-structural barriers.

2.1 Structural Barriers

Structural barriers such as sheet piling are particularly suitable for situations where the containment area needs to be de-watered so that dry excavation work can be performed. While these systems provide considerable structural capacity, they can also be relatively expensive, and usually require significant equipment and manpower resources to install.

Sheet piling consists of a series of steel sections that interlock with one another. Piles are driven in panels to approximately the same depth. It is not anticipated that turbidity barriers comprised of structural sheeting will have general applicability to conditions in the upper Hudson. Based on acoustical surveying conducted in the river, it appears that relatively shallow rock is present at the site and could impede pile driving at many locations.

2.2 Non-Structural Barriers

Non-structural containment barriers include oil booms, silt curtains, and silt screens. Oil booms are utilized in situations where the dredged sediments could potentially release oily residues. Silt curtains are constructed of impervious

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materials that block or deflect the passage of water and sediments. Silt screens are similar to silt curtains, however these barriers allow water to flow through while impeding the passage of a fraction of the suspended load.

The advantage of using non-structural barriers is that they can easily be re-located to new work areas after dredging at a specific location has been completed. Conditions which limit applicability include strong river currents, high winds and areas where rising and falling tidal waters are present. Silt curtains are not viewed as appropriate in situations where the river current is greater than approximately 1.5 feet/second, and where the depth of the river exceeds 21 feet. However, it should be noted that if the silt curtain is set up in a configuration that is closely parallel to river flow, the curtain could function effectively in currents approaching 3 feet per second.

Typically, a silt curtain and silt screen is suspended by a flotation unit at the water surface, and held in a vertical position by a ballast chain within the lower hem of the skirt. Anchors attached to the barrier also serve to hold it in place.

2.3 Other Portable Systems

Similar to sheet piles, other available commercial products such as the Portadam™ and Aqua-Barrier™ systems are also used for construction site dewatering and containment, diversion of water flow, erosion control, and flood control. These systems are low-cost alternatives to building earthen dams or using sheet piles, and are relatively easy to set-up. These systems are generally limited to situations with a maximum water depth of up to ten feet.

The Portadam™ system utilizes a freestanding steel support structure in conjunction with an impervious fabric membrane. The support members transfer fluid loading to an approximately vertical downward load, allowing for installation on a solid impenetrable foundation. This structure free-stands on the existing bed, which eliminates the need for pile-driving equipment, cross bracing or anchorage. The membrane is placed on the outer section of the support structure, and is rolled out all the way down to the level of the bed. Hydraulic loading on the membrane assists in the sealing and stability of the entire structure. Once installed, the work area enclosed by the structure can be de-watered.

The Aqua-Barrier™ and GeoCHEM Water Structures™ systems utilize water-filled vinyl polyester-reinforced tubes to provide mass for stability, and they can be coupled together to form a barrier of any length. Punctures in the material may be easily patched with repair kits. They are lightweight, easy to transport, and re-usable. While these systems are not as sturdy as the

Portadam™ system, they can be used in cold weather conditions, and are reasonably resistant to sunlight exposure.

These systems may potentially be applicable to conditions with the Hudson River, particularly for those phases of work that involve removal of sediments in shallow embayments and secondary channels.

3.0 Deployment of Non-Structural Turbidity Barriers

3.1 Components

Components of a non-structural barrier system includes the fabric which forms the barrier itself, a floatation system to suspend the barrier in the water column, and an anchoring system to hold the barrier in place.

3.1.1 Fabrics

In general, there are two types of fabrics available. The first is a woven polypropylene design that allows water to flow through while retaining all or a portion of suspended solids. This type of fabric is generally light, and is designated with an EOS – U.S. standard sieve rating. Generally, a higher rating means that the material will allow a smaller fraction of suspended material to pass through. The second class of fabrics are generally heavier and more sturdy than the fabric described above, and consist of either a laminated or vinyl-coated polyester fabric, which prevents both water and all suspended solids from passing through the barrier. Generally, these impervious barriers are referred to as silt curtains, while the woven polypropylene designs are usually termed silt screens to reflect the difference in the functionality of the two products. The term silt curtain will be used here to refer to both silt screens and silt curtains.

Silt curtain sections are usually available in 50- or 100-foot lengths, and can be joined together a number of different ways, depending on the design selected. A typical connection between barrier sections would be through the use of rope lacing or nylon ties, but some situations may require inserting the ends of two adjoining barrier sections into a PVC pipe to provide a more effective seal. This latter system requires assembly in the field, and would not lend itself to furling of the curtain prior to deployment. As a result, set-up and removal operations would be more time-consuming and tedious.

3.1.2 Flotation System

Silt curtains are suspended from the water surface by a flotation pocket which may be heat-sealed onto the top section of the curtain. The actual flotation device is inserted inside this pocket and may consist of a cylindrical-shaped piece of material such as Styrofoam or polyethylene. The diameter of the flotation device varies depending on the buoyancy required, but in most cases is generally between 6 and 12 inches. For example, a larger section of curtain generally requires a greater degree of flotation in order to be able to support the additional weight, and consequently, the diameter of the flotation pocket would need to be proportionally larger.

3.1.3 Anchoring System

It is essential that the curtain be immobilized as much as possible, so that wind and river currents do not impact its performance. A ballast chain, typically 1/4 inch or 5/16 inch in diameter is placed inside a heat sealed pocket at the bottom of the curtain, which helps to keep the curtain in a vertical position. Anchors are also typically used to limit lateral movement of the barrier. Each anchor is usually attached to a 12 inch – 24 inch diameter mooring buoy, which in turn is attached to the top of the curtain. This arrangement minimizes the risk of submerging the barrier's flotation system under heavy loads. Anchors are placed approximately 50 to 100 feet apart, although site-specific conditions (*e.g.*, high river currents, river-bottom conditions) may require decreasing this spacing.

Some anchor types that are commonly used include mushroom anchors, danforth anchors and concrete blocks. Mushroom anchors consist of a cast iron bowl at the end of a shank. This type of anchor is usually employed in areas with sandy bottoms. The anchor will sink gradually, but once it is fully embedded, it has substantial holding power. Danforth anchors are lightweight and consist of two long, narrow flukes that pivot at the end of a long shank. The flukes engage quickly, and the anchor buries itself completely under heavy loads. Concrete blocks are simply what their name implies, and they vary in size depending on the degree of anchorage required.

3.2 Installation and Removal

Ideally, the barrier should be set up as parallel to the river flow direction as possible in order to minimize the amount of pressure that is forced onto the barrier by the river current. This would typically involve anchoring each end of the barrier to two points on the shoreline, resulting in an arc-shaped configuration. In addition, a deflector curtain may also be installed upstream of the contained area in order to reduce the river current pressure on the silt curtain. Each section of the barrier is joined together on the shore, and furled in preparation for placement in the water. Depending on conditions such as wind, current velocity, and the total length of the barrier which is to be deployed, a small boat with a three person crew may be sufficient for installation. In other situations, a crane may be required to hoist successive portions of the furled barrier while a boat pulls the barrier in place. The installation of the anchor system is coordinated with the placement of the barrier in the water.

Once the curtain is in place and properly anchored, it is unfurled. Some systems are designed to allow the depth of the curtain skirt to be adjusted up or down as required. The flotation segment is typically equipped with lines which run down to the bottom of the skirt. These lines can be pulled to lift the curtain to the desired depth. In very shallow areas, a staked barrier may be used. Some manufacturers do not recommend extending the skirt all the way to the river bottom since silt may build up on the bottom inside of the curtain and cause submersion. However, in practice, this type of installation has been used frequently and successfully for maximum possible containment of suspended sediments.

Figure 1 illustrates the cross-section of a typical silt curtain installation in a watercourse.

The removal procedure is essentially the opposite of installation. Special care must be taken during the installation and removal process so that the curtain fabric is not damaged by rocks or boulders present on the shoreline and the river bottom, or by the equipment that is utilized to install the barrier.

4.0 Example Projects Using Silt Curtains

The following subsections briefly discuss projects that involved the use of silt curtains and where, in most cases, PCB contamination was present in the sediments. These discussions focus on the experience encountered with the usage of silt curtains at these sites. The last sub-section presents details that are applicable to the Hudson River project.

4.1 Domestic Projects

4.1.1 **Cherry Farm (Tonawanda, NY)** – In this project, a turbidity curtain was placed adjacent to a weed bed where river velocities were less than two feet per second. It was essential that the curtains could withstand the river current velocity, as well as potential wave action, so that sediment re-suspension would be confined to the dredge area. In addition, an oil boom was deployed around the immediate dredging area to contain accidental releases from the dredging equipment. Dredging was performed using a hydraulic cutterhead because the sediments were found to be too hard-packed for conventional clamshell/mechanical dredging. Turbidity outside the curtain area was monitored and found to be within acceptable criteria.

4.1.2 **Ford Outfall (River Raisin, Monroe, MI)** – In this project, inner and outer silt curtains were installed over a one-week period. Concrete blocks were used as anchors. Prior to installation, a schedule was developed with commercial ship-traffic representatives for removal and redeployment of the silt curtain during a two-week shutdown period to allow commercial ship traffic to reach the port of Monroe. The proposed location of the upstream wing of the outer curtain intruded on a section of the river which was needed by commercial vessels for maneuvering into a nearby turning basin. Additionally, the silt curtain manufacturer was also concerned with the effects of propeller-wash forces and possible physical contact from passing vessels on the silt curtains or the anchoring system. Based on subsequent sediment sampling analysis, it was determined that the southern limit of the dredging area could be moved in order to allow for a wider shipping channel. However, in one instance, a ship gained unauthorized entry into the shipping channel and passed close enough to the perimeter of the outer silt curtain to cause damage to the curtain fabric. As a result, the dredging operation was discontinued temporarily while a dive crew was sent to repair the curtain. The project delay was reduced by the use of a temporary silt curtain patch, which allowed dredging to resume until the appropriate patching materials and equipment arrived.

4.1.3 **Grasse River Project 1, (Massena, NY)** - This pilot study also employed a containment system consisting of an inner and an outer turbidity curtain. This project experienced minor delays because of a redesign in the silt curtain anchoring system. This was necessary because minimal penetration (only a few inches) was achieved upon several attempts to plant the anchors to full depth. The helical screw anchors which were called for were designed to hold forces up to 20,000 pounds provided that ample penetration into the river substrate is achieved. Because attempts to properly anchor this system design failed, it was decided that the original helical screw anchoring system would be replaced with large blocks of concrete. The redesign resulted in a minimal delay to the project. An additional curtain was used to isolate a portion of the dredge area within the primary (inner) curtain. Total suspended solids (TSS) readings taken within the work area were as high as 250 mg/L, but levels outside the curtains were maintained below a specified action level of 25 mg/L above background. However, it was estimated that between approximately 5 and 30 pounds of soluble PCBs were released from the containment system during removal operations.

4.2 International Projects

4.2.1 **Welland Reef (Canada)** – This project involved the removal of mill scale material using an Amphibex, which is a combination mechanical-hydraulic suction dredge. This equipment was considered capable of completing the dredging without causing significant impact on downstream water quality. However, as a precaution, silt curtains were utilized to minimize the impact of possible sediment re-suspension. Overall, turbidity levels were found to be low throughout most of the dredging activities, but on several occasions turbidity levels downstream from the silt curtain exceeded acceptable criteria because of high river flows that caused problems with the silt curtains. This issue was resolved by cleaning or weighing down the silt curtain and temporarily halting dredging until downstream turbidity levels were reduced to acceptable levels.

4.2.2 **Lake Jarnsjon (Sweden)** – The dredging equipment that was selected for this project was also specifically designed to limit sediment re-suspension. However, based on investigations, and theoretical calculations of suspension, transport, and settling of the sediments, it was decided that the eastern portion of the lake should be dredged within a protective silt curtain barrier, and positioned in such a way that the most heavily contaminated sediments in the lake were enclosed. Total suspended solids were monitored, and in most instances, the concentrations outside the confined area were lower than those measured inside. However, the TSS concentrations measured within the enclosed area were generally low, indicating that the dredging equipment performed very well in limiting sediment re-suspension.

5.0 Applicability of Silt Curtains to the Remediation of the Upper Hudson River

The following example examines the use of silt curtains in the Upper Hudson River assuming the use of mechanical dredging equipment. It is important to note that removal utilizing hydraulic dredging equipment would require a different approach.

5.1 Possible Deployment Configuration

According to data obtained from the 1998 Data Summary Report for the 1996-1997 Thompson Island Pool Studies prepared by O'Brien and Gere Engineers, Inc., flow velocities in the Hudson river north of the Thompson Island Dam were found to range between 0.2 and 1.5 ft/sec. This data shows that silt curtains can be used effectively in these areas. In addition, near-shore flow velocities are expected to be relatively low, suggesting that silt curtains would be particularly feasible for use along the river shoreline.

A typical in-river set-up for a two-silt curtain array is shown in Figure 2. The silt curtains are installed in arc-shaped configurations that parallel the direction of river flow.

The area enclosed by each silt curtain is proposed to be approximately 2 acres. Based on this enclosed area, a typical barrier set-up is estimated to have a length of approximately 1,000 feet.

In order to allow barges to enter and exit the enclosed work area, a modified installations will be required. One possibility is to have two overlapping sections that are fastened with connectors to allow for rapid uncoupling. The entrance should be configured on the upstream side, so that the river flow will assist in reducing the amount of suspended sediments that are released each time that a barge enters or exits the work area. The entrance may also be left open by securing each end of the silt curtain to pilings. Another possibility is to use pilings to secure two sections of the barrier, and to place a third section of the barrier between to act as a gate. These two configurations are illustrated in Figure 2. Another configuration involves placing a structural barrier upstream of the silt curtain to divert the river flow from the area. A piling is attached to the upstream end of the silt curtain, leaving sufficient room for barges to enter and exit the dredge zone. According to manufacturers, no significant additional costs are expected using the first two arrangements.

5.2 Cost Estimates

5.2.1 Materials

Assuming that five mechanical dredging operations are being conducted simultaneously, it will be necessary to have one set of barriers at each location. Assuming that one spare set is always available, and all sets must be fully replaced each year, 12 sets of barriers will be required for each construction season. Therefore, over the five-year duration of the project, a total of 60 silt curtains will be needed. Table 1 shows the costs associated with the silt curtains material provided by various manufacturers. Price quotes are based on an order of at least 2000 linear feet of material, and may vary depending on the total quantity ordered.

Manufacturer	Product	EOS-US Std. Sieve	Price/ linear foot[1]
R.H Moore & Associates	Type II	N/A	$8.80
American Engineering Fabrics	Type II – AEF 650W	100	$15.00
American Boom & Barrier Company	Type Mark II	N/A	$11.35
	Type PC-2	70	$12.20
Indian Valley Industries	Carthage 6% fabric	70	$9.50
Brockton Equipment/ Spilldam Inc.	Siltdam Type II	70	$10.81

[1] Based on a 10 ft deep section of curtain, and at least 2000 total linear feet

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The highest quote given is $15 per linear foot for the Type II – AEF 650W turbidity barrier which is manufactured by American Engineering Fabrics. Note that this product has a higher EOS US Standard Sieve rating, which is reflected in the higher cost of this particular fabric. In addition to the silt curtain material itself, an anchoring system will also be required. Brockton Equipment/ Spilldam Inc. offer anchor and anchor buoy sets for approximately $140 per set. Marker light buoys are also available for approximately $92 each. Assuming that all equipment is purchased at the current (year 2000) rates, the total material cost is as follows, assuming an average barrier length of 1,000 feet as discussed previously:

<u>Silt curtain costs:</u>

1000 ft of material @ $15/foot = $15,000

$15,000 * 60 silt curtains = $900,000

<u>Anchors and marker buoys:</u>

Anchors and marker buoys are typically spaced at 50 ft and 100 ft intervals, respectively. Therefore, for a 1,000-foot section of curtain, 21 anchors and 11 marker buoys will be required. Ten sets in total will be required: Five sets for the active dredge sites, and another five sets that will be available for installation in subsequent dredge areas. Therefore a total of 210 anchors and 110 marker buoys will be required for the entire project:

Anchors:	$140 * 210 = $29,400
Markers:	$92 * 110 = $10,120

Therefore, the total cost of the materials including a 35% contingency is:

($900,000 +$ 29,400 + $10,120) * 135% = $1,268,352

5.2.2 Labor & Equipment Considerations

Labor and installation associated with the silt curtains also need to be factored into the final cost. The amount of labor required is dependent on river conditions at each location. For example, areas that have higher currents or winds will make installation of the barriers more difficult, unless additional equipment and manpower is used. In these cases, a barge with a crane may be needed to help place the curtain in the water, an additional barge may be needed to hold the curtain in place, and a tug may be required to position everything. Other areas may require only a small boat to deploy the curtain. Installation at a given location typically requires 1 to 3 full days and is dependent on the equipment used, weather conditions, and river conditions at the dredge site.

6.0 Conclusions

The use of silt curtains to control sediment re-suspension has been successfully demonstrated at several remedial dredging projects. For removal activities in the shoal areas outside the Hudson River navigation channel the use of silt curtains presents a potentially effective means to reduce downstream transport of re-suspended sediments. River current velocities are at or below the practical operational limits of silt curtains, and river geometry appears favorable to use of barriers along most near-shore areas.

Figure 1 - Turbidity Barrier Configuration (Section)

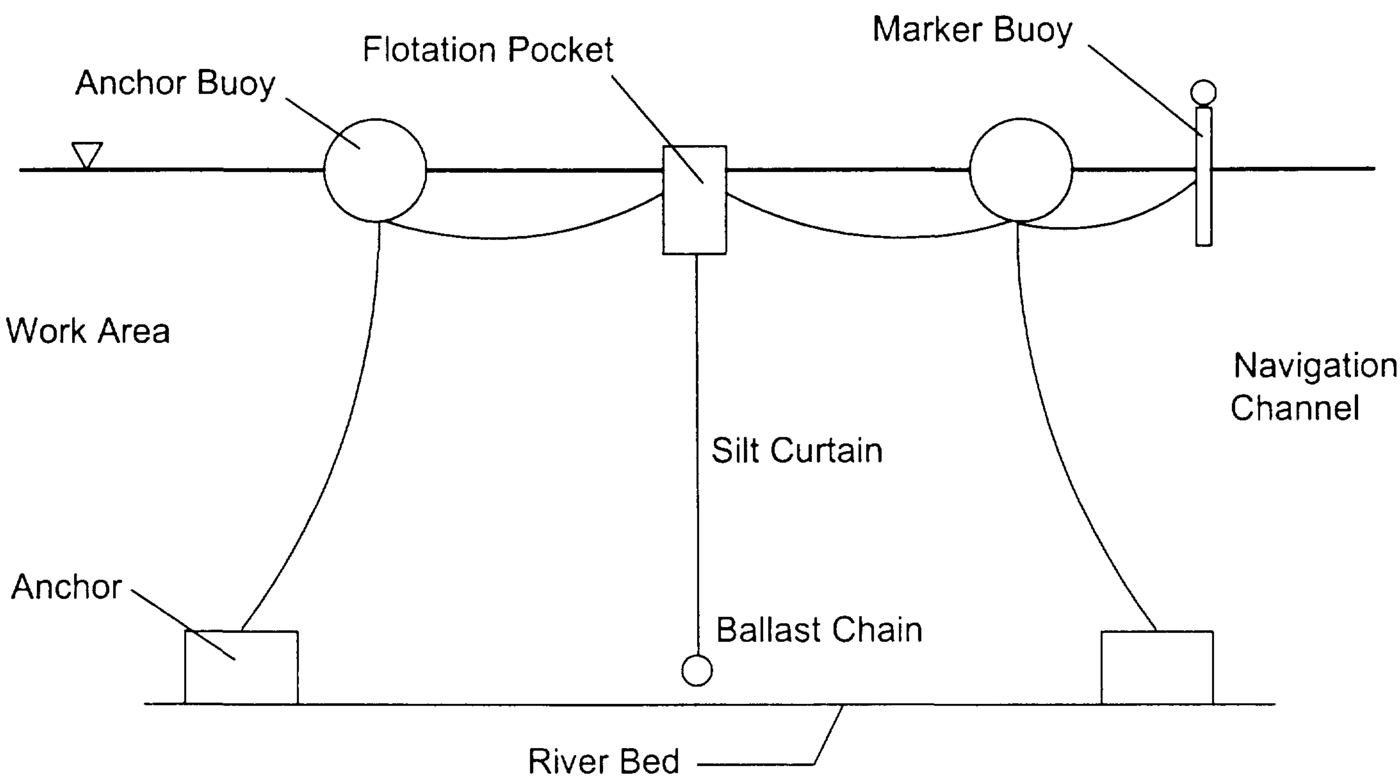
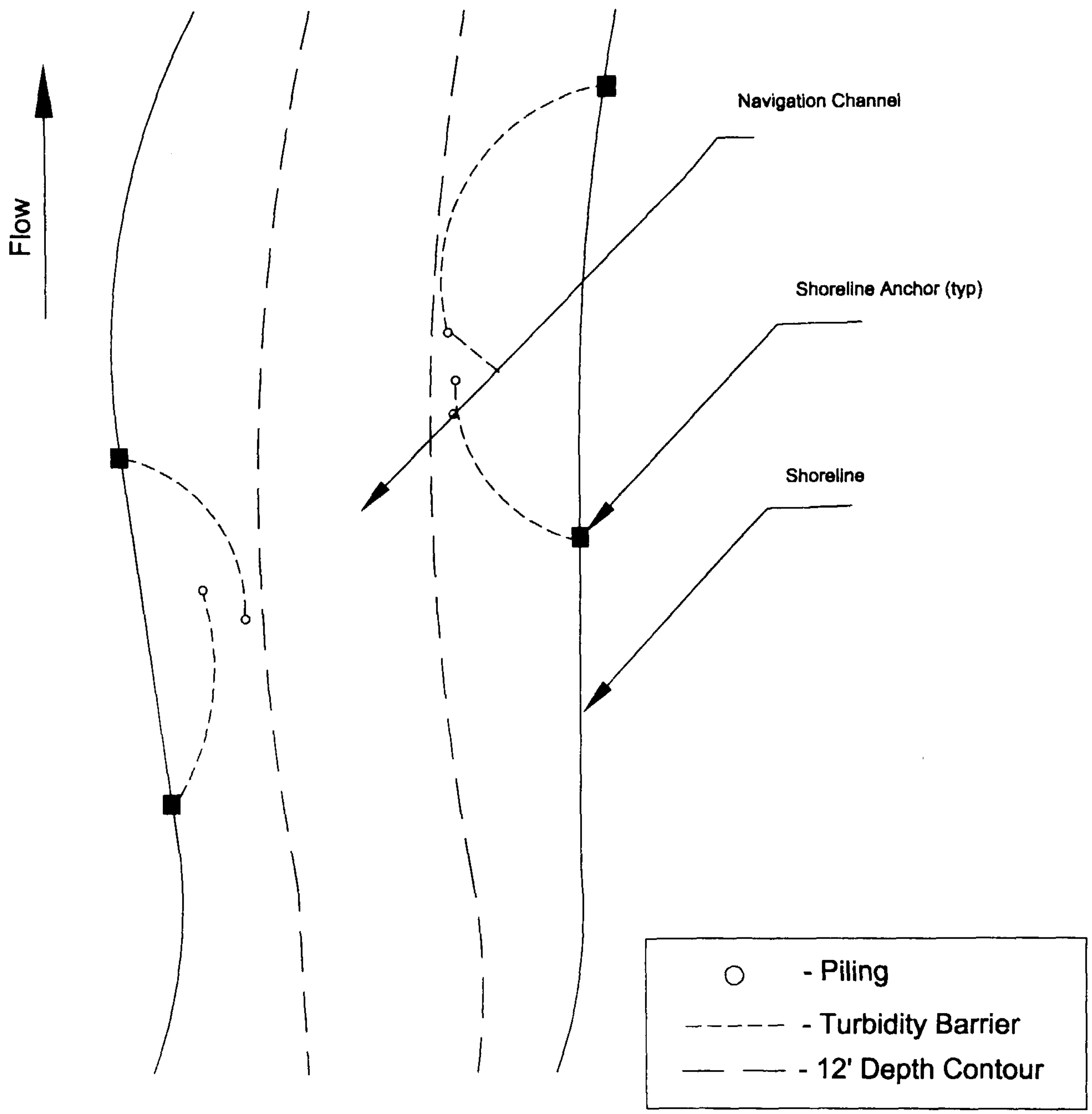


Figure 2 - Turbidity Barrier Configuration
Typical River Section



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APPENDIX E

ENGINEERING ANALYSIS

E.6 TECHNICAL MEMORANDUM: SEMI-QUANTITATIVE ASSESSMENT OF WATER QUALITY IMPACTS ASSOCIATED WITH DREDGING ACTIVITIES

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

Semi-Quantitative Assessment of Water Quality Impacts Associated with Dredging Activities

This memorandum describes the application of a model for sediment resuspension and downstream transport as a result of sediment dredging. The application deals with two dredge types, a 12-in cutter-head dredge and a 4-cy enclosed bucket dredge. The development of this model is described in the attachment to this appendix. The results of this application describe the release rate of PCBs associated with the resuspended sediments and the ensuing increase in the water column PCB concentration. The analysis is considered semi-quantitative since it does not address the exact fate of the PCBs released but rather provides an upper-bound estimate of the PCB release and increase in water column concentration. The results of the analysis and their implications are summarized in Chapter 8 of the FS.

As part of the evaluation of the short-term impacts associated with sediment removal, a semi-quantitative analysis was prepared describing sediment resuspension and downstream transport of PCBs. The purpose of the model was to provide an estimate of the amount of PCB mass liberated from the sediments during dredging. This PCB mass would subsequently be available for downstream transport where it can further contaminate sediments, water and biota. The model itself is described in the attachment to this appendix. The following discussion describes the model's application to the anticipated dredging conditions as well as the estimated impacts.

The model itself consists of two components, a resuspension term representing sediment resuspension at the dredge head, and a gaussian plume transport model which describes the dispersion and settling of the particles downstream. To estimate the impacts downstream, PCB concentrations were assigned to the resuspended sediments. Based on the rate of resuspension, the flux of PCBs to the water column as well as the resulting water column concentrations were estimated. Several assumptions regarding the application of the model should be noted as follows:

- Only fine particles and their associated PCB mass were assumed to be added to the water column. Because of their larger size, larger particles quickly fall from the water column and are expected to add little PCB.
- The PCB flux to the water column was estimated as the PCB flux 10 m downstream of the dredge head. No further removal of PCBs by settling was permitted, yielding a conservative (upper-bound) estimate of possible PCB release.
- Both cutter-head and enclosed bucket dredges were examined. However, only the conventional enclosed bucket is evaluated herein. As mentioned in the attachment to this appendix, recent advances in bucket design are expected to reduce resuspension rates beyond those applied herein.
- No adjustment was made for the silt curtains, which serve to reduce downstream movement of sediment. This represents an additional conservative (*i.e.,* upper bound) assumption.
- River flow was assumed to be 3000 cfs for the entire calculation. This low value, along with the settling assumption described above, serves to maximize PCB concentrations in the water column, again a conservative assumption.
- Sediment conditions were averaged on a river-section wide basis to yield a mean value that would be typical of the average material dredged over the course of the

remediation.

- The percentage of fine-grained sediment in the dredged sediments was estimated from the volumes of cohesive and noncohesive sediments to be removed in each river section.
- PCB content on resuspended material was assumed to be identical to that of the bulk sediment removed.
- Dredge operations were assumed to extend for 30 weeks each year.
- Dredge operations (for REM alternatives) were assumed to be 14 hours per day for the environmental enclosed bucket dredge and 17 hours per day for the cutter-head dredge, as defined in the FS. Under the capping alternative, mechanical dredging hours were reduced by 35% to 9 hours to account for the lower removal volumes.
- PCB concentration increases were calculated as daily mean conditions for the period of dredge operations each year (30 weeks).
- PCB fluxes were calculated for equivalent production rates by the two dredge types. That is, the estimates were performed for a single 12-in cutter-head dredge and three 4-cy enclosed bucket dredges.

To examine the potential impacts of each alternative on the entire Upper Hudson, the impacts are semi-quantitatively evaluated for each river section. This analysis is considered semi-quantitative because it does not describe the precise fate of the resuspended PCBs but rather provides a conservative numerical estimate of the PCB release rate and ensuing water column concentration. When necessary, properties of the better documented TI Pool are applied to the calculations for the other sections. This section clearly has the most extensive data sets for estimating mean sediment properties (*e.g.,* the 1984 NYSDEC PCB survey and the 1992 USEPA side-scan sonar survey) and is to undergo the greatest level of remediation of any section. Thus, extrapolating its properties to the other sections when necessary for the calculations should not introduce significant errors.

The estimate of the percentage of fine-grained sediment (silt and clay) in the dredged material was derived from a volume-weighted average of the fine-grained content of cohesive sediments and noncohesive sediments in the areas to be dredged. As described elsewhere in Appendix E, the fraction of fine-grained sediment is 65 percent in cohesive sediments and 20 percent in noncohesive sediments. As described in the attachment, the rate of sediment resuspension varies linearly with the fine-grained sediment content of the dredged material. Thus the proportion of the two sediment types will vary the rate of sediment resuspension and PCB release. The estimates of the fraction of cohesive and noncohesive sediment for each river section under each remediation scenario is given in Table E.6-1.

The estimate of the PCB concentration in the dredged material and the associated resuspended sediment was derived on a volume-weighted basis. The PCB concentration was simply derived as the ratio of the mass of PCBs removed by the mass of sediment removed. Note that this value will be less than the average PCB concentration for the river section, since dredging will inevitably remove both contaminated and uncontaminated material. The mass of sediments removed was derived from the volume of sediments to be removed. The total volume of sediments to be removed for each scenario was estimated as part of the engineering analysis and is given in Table 6–3 of the FS. The fractions of cohesive and noncohesive volume removed were derived for the TI Pool and then applied to the river sections downstream (see Table E.6-1). The volume of each sediment type was then multiplied by its respective solids density (0.71 tons/cy cohesive and 1.16

tons/cy noncohesive) to yield the mass of each fraction. The concentration of PCBs on the dredged material was then the PCB mass to be removed divided by this volume-weighted mass of sediments. The results of this calculation are given in Table E.6-1.

In the attachment, the PCB release rate is calculated for two separate sediment concentrations for a dredged sediment consisting of 30 percent cohesive and 70 percent noncohesive sediments. The estimated values for PCB release and downstream concentration are linear in their relationship with fine-grained material and PCB concentration. Thus the values presented in Table E.6-1 can be used proportionately to estimate PCB loads and water column concentrations at conditions different from those simulated by the model. These results are presented in Tables E.6-2, E.6-3 and E.6-4. These tables correspond to the alternatives CAP-3/10/Select, REM-3/10/Select and REM-0/0/3. The results from these tables are discussed at length in Chapter 8 of the FS. In general, the analysis found that these increases in PCB load and concentration during the period of operation would be relatively minor as compared to the ongoing releases of PCBs from the sediments of the river as well as from the Hudson Falls source.

Table E.6-1
Sediment Distributions and PCB Concentrations in Dredged Materials

Section	Scenario	Sediment Distribution Percent Cohesive	 Percent NonCohesive	Tri+ PCB Concentration on Dredged Materials [5]
1	Hot Spot Removal	62%	38%	NC [3]
	Expanded Hot Spot Removal	37%	63%	8.4
	Full Section Removal	26%	74%	7.7
	Hot Spot Capping with Select Removal	58%	42%	NC [3]
	Expanded Hot Spot Capping with Select Removal	27%	73%	8.4
2	Hot Spot Removal [1]	62%	38%	23
	Full Section Removal [1]	26%	74%	15
	Hot Spot Capping with Select Removal [1]	58%	42%	29
3	Selected Hot Spot Removal [1]	62%	38%	13
	Expanded Hot Spot Removal [1, 2]	62%	38%	14
	Selected Hot Spot Capping with Select Removal [1]	58%	42%	13

Notes:

1. Sediment percentages were taken from those for Section 1.
2. Percentages were taken to be the same as selected hot spot removal since there was little difference between the two scenarios in this section.
3. These concentrations were not calcualted since they were not needed for the alternatives calculations.
4. Cohesive sediments were assigned a dry solids density of 0.71 tons/cy. Noncohesive sediments were assigned a dry solids density of 1.16 tons/yd.
5. Tri+ PCB concentrations were estimated from the Total PCB data presented in Table 6-3 of the FS

Table E.6-2
Estimate of Dredging Resuspension Rates for the CAP-3/10/Select Alternative

Dredge Type	No. of Units in Operation	Production Rate Per Dredge cy/hr	Sediment Resuspension Losses Per Dredge: Cohesive Sediment Loss Rate [1] kg/s	Cohesive Sediment Percent Of Mass [2]	Noncohesive Sediment Loss Rate [1] kg/s	Noncohesive Sediment Percent Of Mass [2]	Mean Resuspension Rate Per Dredge kg/s	Mean Resuspension Rate Under Operation [3] kg/s	Tri+ PCB Concentration on Sediments [4] mg/kg	Duration [5] years	Resulting Downstream Instantaneous PCB Flux [6] mg/s	Resulting Downstream Concentration Increase [7] @3000 cfs ng/L	Resulting Downstream PCB Load Increase [8] @3000 cfs kg/yr	Resulting PCB Release [9] kg
Section 1 - Expanded Hot Spots														
4 -cy Conventional Enclosed Bucket	3	95	0.07	27%	0.022	73%	0.035	0.105	8	3	0.51	2.3	3.0	9
Section 2 - Hot Spots														
4 -cy Conventional Enclosed Bucket	3	95	0.07	58%	0.022	42%	0.050	0.150	29	1	2.6	12	16	16
Section 3 - Select Hot Spots														
4 -cy Conventional Enclosed Bucket	3	95	0.07	58%	0.022	42%	0.050	0.150	13	1	1.2	5	7	7
Summary of Impacts (Time-weighted)[11]														
4 -cy Conventional Enclosed Bucket	3	95	0.07	39%	0.022	61%	0.041	0.123	13	5	1.1	4.8	6	32

Notes:

1. This loss rate represents particles less than 74 µm (*i.e.,* silts and clays)
2. This is the precentage of mass being dredged which is cohesive or non-cohesive, as noted. The value is used to weight the loss rate term to yield a mean resuspension rate for the river section.
3. This represents the loss rate for 1 cutter head dredge or three bucket dredges, which yield equivalent production rates.
4. This is the volume weighted average Tri+ PCB concentration in the dredge material. The value is assumed to be the concentration of Tri+ on the resuspended sediment.
5. Duration of dredging operation in the reach.
6. This is the net Tri+ PCB flux 10 m downstream of the dredge head during operation. No further settling is assumed.
7. This concentration represents a 24 hour average net concentration increase of Tri+ in the water column. This value should be added to the estimated existing Tri+ concentration generated by the river sediments. It is based on 9 hours of operation for 3 bucket dredges. This concentration assumes the river to be well mixed and ignores further settling or dilution.
8. This represents the net additional Tri+ PCB load assuming 30 weeks of operation 6 days per week.
9. This value is the sum of additional Tri+ PCB released over the entire period of dredging in the river section
10. values.
11. This block represents time-weighted average concentrations and loads as well as cumulative PCB release for the entire remediation period.

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Table E.6-3

Estimate of Dredging Resuspension Rates for the REM-3/10/Select Alternative

Dredge Type	No. of Units in Operation	Production Rate Per Dredge cy/hr	Sediment Resuspension Losses Per Dredge: Cohesive Sediment Loss Rate [1] kg/s	Cohesive Sediment Percent Of Mass [2]	Noncohesive Sediment Loss Rate [1] kg/s	Noncohesive Sediment Percent Of Mass [2]	Mean Resuspension Rate Per Dredge kg/s	Mean Resuspension Rate Under Operation [3] kg/s	Tri+ PCB Concentration on Sediments [4] mg/kg	Duration [5] years	Resulting Downstream Instantaneous PCB Flux [6] mg/s	Resulting Downstream Concentration Increase [7] @3000 cfs ng/L	Resulting Downstream PCB Load Increase [8] @3000cfs kg/yr	Resulting PCB Release [9] kg
Section 1 - Expanded Hot Spots														
12 in Cutterhead	1	270	0.17	37%	0.053	63%	0.096	0.096	8	3	0.29	2.4	3.2	10
4 -cy Conventional Enclosed Bucket	3	95	0.07	37%	0.022	63%	0.040	0.119	8	3	0.58	4.0	5.3	16
Section 2 - Hot Spots														
12 in Cutterhead	1	270	0.17	62%	0.053	38%	0.126	0.126	23	1	1.1	9	12	12
4 -cy Conventional Enclosed Bucket	3	95	0.07	62%	0.022	38%	0.052	0.155	23	1	2.2	15	20	20
Section 3 - Select Hot Spots														
12 in Cutterhead	1	270	0.17	62%	0.053	38%	0.126	0.126	13	1	0.6	5	7	7
4 -cy Conventional Enclosed Bucket	3	95	0.07	62%	0.022	38%	0.052	0.155	13	1	1.2	8	11	11
Summary of Impacts (Time-weighted)[11]														
12 in Cutterhead	1	270	0.17	47%	0.053	53%	0.108	0.108	12	5	0.5	4	6	28
4 -cy Conventional Enclosed Bucket	3	95	0.07	47%	0.022	53%	0.045	0.134	12	5	1.0	7	9	47

Notes:

1. This loss rate represents particles less than 74 μm (*i.e.*, silts and clays)
2. This is the precentage of mass being dredged which is cohesive or non-cohesive, as noted. The value is used to weight the loss rate term to yield a mean resuspension rate for the river section.
3. This represents the loss rate for 1 cutter head dredge or three bucket dredges, which yield equivalent production rates.
4. This is the volume weighted average Tri+ PCB concentration in the dredge material. The value is assumed to be the concentration of Tri+ on the resuspended sediment.
5. Duration of dredging operation in the reach.
6. This is the net Tri+ PCB flux 10m downstream of the dredge head during operation. No further settling is assumed.
7. This concentration represents a 24 hour average net concentration increase of Tri+ in the water column. This value should be added to the estimated existing Tri+ concentration generated by the river sediments. It is based on 17 hours of operation for the cutter head and 14 hours of operation for the 3 bucket dredges. This concentration assumes the river to be well mixed and ignores further settling or dilution.
8. This represents the net additional Tri+ PCB load assuming 30 weeks of operation 6 days per week.
9. This value is the sum of additional Tri+ PCB released over the entire period of dredging in the river section
10. A flow of 3000cfs was also used in River Section 3. Note that the flow corresponding to 3000cfs in River Section 1 would be about 5000cfs in Section 3, resulting in further reduction of the Tri+ PCB concentration values.
11. This block represents time-weighted average concentrations and loads as well as cumulative PCB release for the entire remediation period.

Table E.6-4
Estimate of Dredging Resuspension Rates for the REM-0/0/3 Alternative

Dredge Type	No. of Units in Operation	Production Rate Per Dredge cy/hr	Sediment Resuspension Losses Per Dredge: Cohesive Sediment Loss Rate [1] kg/s	Cohesive Sediment Percent Of Mass [2]	Noncohesive Sediment Loss Rate [1] kg/s	Noncohesive Sediment Percent Of Mass [2]	Mean Resuspension Rate Per Dredge kg/s	Mean Resuspension Rate Under Operation [3] kg/s	Tri+ PCB Concentration on Sediments [4] mg/kg	Duration [5] years	Resulting Downstream Instantaneous PCB Flux [6] mg/s	Resulting Downstream Concentration Increase [7] @3000 cfs ng/L	Resulting Downstream PCB Load Increase [8] @3000cfs kg/yr	Resulting PCB Release [9] kg
Section 1 - Full Section														
12 in Cutterhead	1	270	0.17	26%	0.053	74%	0.083	0.083	8	4	0.25	2.1	2.8	11
4 -cy Conventional Enclosed Bucket	3	95	0.07	26%	0.022	74%	0.034	0.103	8	4	0.51	3.5	4.6	18
Section 2 - Full Section														
12 in Cutterhead	1	270	0.17	26%	0.053	74%	0.083	0.083	15	2	0.5	4	5	10
4 -cy Conventional Enclosed Bucket	3	95	0.07	26%	0.022	74%	0.034	0.103	15	2	0.9	7	9	17
Section 3 - Expanded Hot Spots														
12 in Cutterhead	1	270	0.17	62%	0.053	38%	0.126	0.126	14	1	0.7	5	7	7
4 -cy Conventional Enclosed Bucket	3	95	0.07	62%	0.022	38%	0.052	0.155	14	1	1.3	9	12	12
Summary of Impacts (Time-weighted) [11]														
12 in Cutterhead	1	270	0.17	31%	0.053	69%	0.089	0.089	11	7	0.4	3.1	4.1	29
4 -cy Conventional Enclosed Bucket	3	95	0.07	31%	0.022	69%	0.037	0.111	11	7	0.7	5	7	48

Notes:

1. This loss rate represents particles less than 74 µm (*i.e.*, silts and clays)
2. This is the precentage of mass being dredged which is cohesive or non-cohesive, as noted. The value is used to weight the loss rate term to yield a mean resuspension rate for the river section.
3. This represents the loss rate for 1 cutter head dredge or three bucket dredges, which yield equivalent production rates.
4. This is the volume weighted average Tri+ PCB concentration in the dredge material. The value is assumed to be the concentration of Tri+ on the resuspended sediment.
5. Duration of dredging operation in the reach.
6. This is the net Tri+ PCB flux 10m downstream of the dredge head during operation. No further settling is assumed.
7. This concentration represents a 24 hour average net concentration increase of Tri+ in the water column. This value should be added to the estimated existing Tri+ concentration generated by the river sediments. It is based on 17 hours of operation for the cutter head and 14 hours of operation for the 3 bucket dredges. This concentration assumes the river to be well mixed and ignores further settling or dilution.
8. This represents the net additional Tri+ PCB load assuming 30 weeks of operation 6 days per week.
9. This value is the sum of additional Tri+ PCB released over the entire period of dredging in the river section
10. A flow of 3000cfs was also used in River Section 3. Note that the flow corresponding to 3000cfs in River Section 1 would be about 5000cfs in Section 3, resulting in further reduction of the Tri+ PCB concentration values.
11. This block represents time-weighted average concentrations and loads as well as cumulative PCB release for the entire remediation period.

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APPENDIX E

ENGINEERING ANALYSIS

ATTACHMENT TO E.6: PRELIMINARY ASSESSMENT OF WATER QUALITY IMPACTS ASSOCIATED WITH HUDSON RIVER PCBs SUPERFUND SITE CLEANUP ACTIVITIES

Prepared by
Donald F, Hayes, Ph.D., P.E.
an associated of
OA Systems Corporation
2201 Civic Circle, Suite 511
Amarillo, TX 79109-1843

On behalf of
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

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1.0 INTRODUCTION

EPA is investigating alternative remedies for the Hudson River PCBs Superfund site. One alternative under consideration is to dredge the sediments from the river using either hydraulic or mechanical dredges. TAMS Consultants is completing a comprehensive evaluation of dredging alternatives including an evaluation of the implications of applying various dredging technologies.

1.1 Scope

The purpose of this report is to provide a preliminary evaluation of the water quality impacts that will be associated with dredging. Site conditions, operational plans, and dredge production estimates used in the preliminary evaluation are all based upon work by TAMS Consultants with support from Gahagan and Bryant and YEC, Inc.

For the purposes of this report, the term "water quality impacts" refers only to resuspension and transport of suspended sediment and associated PCB concentrations. The majority of the report focuses on sediment resuspension although a short discussion of PCB transport and partitioning is provided in Section 5.

1.2 Review of Pertinent Site Conditions

The hydraulics of the Upper Hudson are relatively complex, typical for a large river channel with widely varying water depths. Water depths in the river system range from 2 to 23 ft. Current velocities range from 0.05 to 1.5 ft/sec. Chemical and physical characteristics of the PCB contaminated sediments vary spatially in both the lateral and vertical dimensions. Sediment characteristics range from cohesive sandy-silt sediments to non-cohesive silty-sand sediments. Removal thickness is predominantly 2 to 5.5 ft in most areas.

As a result of these variations, the characteristics of the dredging operation will also vary significantly from between areas. This assessment will not attempt to consider all of these complexities, but rather focus on typical dredging scenarios. Only cohesive sediments are considered since they will result in the highest resuspension. Depending upon the dredging scenario, however, a considerable portion of the dredging will involve dredging non-cohesive sediments that will have substantially lower water quality impacts.

1.3 Existing Procedures for Estimating Sediment Resuspension from Dredging Operations

Defensible estimates of water quality impacts require three components: source term estimates, far-field transport estimates, and review of field data from comparable sites. The latter is necessitated by the large uncertainty associated with source term estimates. This section briefly summarizes the current state-of-the-science, focusing primarily on near-field models and available field data.

1.3.1 Summary of Available Field Data

Interest in sediment resuspension resulting from dredging activities primarily began in the 1970s. The early work in the US was conducted by Huston and Huston (1976), Bohlen and Tramontaro (1977), and Barnard (1978). These included limited data from a few field studies, with the most comprehensive data collected by Bohlen and Tramontaro (1977). Despite these initial US efforts, Japanese researchers seem to have conducted most comprehensive studies of sediment resuspension resulting during the 1970s. A number of papers and reports were published describing field studies including Yagi, *et al.* (1975), Koba (1976), Koiwa *et al.* (1977), Yagi, *et al.* (1977), and Nakai (1978). Although these reports seem to describe very comprehensive field studies, the reports are not in sufficient detail to utilize the data to its fullest. It is clear from these reports and papers that the studies conducted during this time were primarily focused upon navigational dredging efforts rather than remedial dredging.

Efforts in the 1980s began to focus on contaminated sediments. However, the focus was more on contaminated sediments that had migrated into the navigation channel and were impacting navigational dredging operations than dredging aimed at remediation. Japanese efforts continued as described by Koba and Shiba (1981, 1982), Koba (1985), and Kaneko, *et al.* (1984). Herbich and Brahme (1991) provide an excellent summary of research conducted by US and Japanese researchers until about 1985.

In the US, the U.S. Army Corps of Engineers and others undertook a number of field studies. Pertinent references include Raymond (1984), Hayes, McLellan, and Truitt (1988), McLellan, *et al.* (1989), and Kuo, *et al.* (1985). Still, most of these studies focused on navigational dredging rather than remediation. For example, barge overflow occurred during all of the bucket dredging operations. Only Hayes, McLellan, and Truitt (1988) describes investigations aimed primarily at remediation dredging and the bucket dredge study described there also included barge overflow. In 1989, several dredges were field tested in New Bedford Harbor to determine their suitability for dredging contaminated sediments. Sediment resuspension and PCB release data collected during the dredging operations are reported in (NED 1990).

Several field studies have also been conducted in the 1990's and these have focused more specifically on remediation dredging. Additionally, water quality monitoring in association with actual remediation dredging operations provides some data that is worthy of consideration. These data, however, are less useful since most consist of only a few data points and usually without specific association to dredging operations.

Field studies of sediment resuspension and transport around cutterhead dredging operations were conducted in association with pilot dredging operations in Lavaca Bay, Texas during August 1998 and January 1999. First, extensive data on sediment resuspension were collected around an 18-inch dredge removing silty sediment above a clay bottom in about 20 ft of water. Then, a 12-inch dredge was monitored while removing 3 to 5 ft of silty clay sediment from a shallow mud-flat. Data from these field studies is provided in Wu and Hayes (2000).

Hayes, *et al.* (2000) describe suspended sediment and turbidity data collected in the immediate vicinity of bucket dredging operations in Boston Harbor in August 1999. Three bucket types were monitored during this study – enclosed clamshell, standard clamshell, and CableArm navigational bucket. Since all of the data were collected while dredging similar sediments under similar conditions, they provide a reasonable comparison of the bucket characteristics.

1.3.2 Near-field Models

The near-field model most often used is that proposed by Nakai (1978). The most attractive feature of Nakai's approach is its simplicity:

$$W_O = TGU\left[\left(\frac{R_O}{R_{74}}\right)Q_S\right]$$

where W_o = total quantity of turbidity generated by dredging, tons
TGU = turbidity generation unit, tons/m^3
R_{74} = fraction of particles with a diameter smaller than 74 microns
R_0 = fraction of particles with a diameter smaller than the diameter of a particle whose critical resuspension velocity equals the current velocity in the field
Q_s = in situ volume of dredged materials, m^3

The TGU term is intended to integrate site conditions and dredge type, size, and operation into a single value while the remainder of the formulation incorporates sediment properties. Nakai provided a table of TGU values for a variety of dredges and dredge sizes calculated by measuring TSS along laterals normal to flow at 30 m and 50 m downstream from the dredging operation. Only limited descriptions of the field investigations on which these values are based were provided in the paper. Pennekamp, *et al.* (1996) provide additional TGU values based upon field studies in Europe.

A few items are worthy of note. First, Nakai used turbidity to refer to suspended solids concentration rather than actual turbidity (i.e. light absorption) measurement. Secondly, the immediate focus is on the rate of solids resuspended as required for input to transport models. Nakai's original equation can be modified to give rate of resuspension:

$$w_O = TGU\left[\left(\frac{R_O}{R_{74}}\right)q_S\right]$$

where

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w_0 = rate of sediment resuspension by dredging, tons/sec
q_S = in situ volume of dredged materials, m^3/sec

Nakai's approach, however, has a fundamental problem, specifically the term R_0Q_S/R_{74}. R_0Q_S represents the fraction of sediment that, if resuspended would theoretically remain in suspension forever since the ambient velocity exceeds their critical resuspension velocity; if the velocity is sufficient to resuspend the particles, they will certainly stay in suspension at that velocity. However, the $1/R_{74}$ term modifies W_0, incorrectly; as the fraction of particles smaller than 74 microns increases, W_0 decreases. Logically, more resuspension is expected from smaller particle sizes. Nakai's equation receives widespread use despite this erroneous behavior. It may be because, except in extreme situations, $R_0 < R_{74}$ so the term

$$\left(\frac{R_0 Q_S}{R_{74}}\right) < Q_S$$

which tends to mask the problem. It is surprising that this problem has not been noted more widely.

The only other known source-strength models began their development with Hayes (1986). These models focus solely on cutterhead dredges and attempt to integrate dredge operation characteristics with site conditions and are based only upon field studies with predominantly fine-grained sediments. The latest models, published by Wu and Hayes (2000), are of the form:

DM: $$\hat{g}_{DM}(\%) = \frac{(C_S t_C)^{0.676} V_S^{\,2.008}}{10^{3.647} L_S^{\,13.899}} \left(\frac{A_E}{d_C}\right)^{14.575} \left(\frac{Q}{D^2}\right)^{0.805}$$

NDM: $$\hat{g}_{NDM}(\%) = 10^{-3.3293} \left(\frac{A_E}{L_S d_C}\right)^{13.503} \left(\frac{Q}{D^2 V_S}\right)^{0.388}$$

where

$\hat{g}$ = predicted rate of sediment suspended by the cutter and available for transport away from the dredging operation as a fraction of sediment mass dredged (percent)
C_S = in-situ sediment concentration (g/L)
t_c = thickness of cut (m)
V_S = swing velocity at the tip of the cutter (m/sec)
a = cutter rotation speed (rev/sec)
L_s = dredge stepping distance (m)
A_E = cutter surface exposed to free water (m^2)
d_C = diameter of cutter (m^2)
Q = volumetric flow rate through dredge (m^3/sec)
D = sediment inlet pipe diameter (m)

The DM and NDM designations refer to the basis used for developing the empirical models as described by Hayes *et al.* (2000). Although different, both models provide equally valid estimates for source strength. Hayes *et al.* (2000) also provides equations to calculate A_E based upon the cutter size, ladder angle, and cutting depth.

The variable $\hat{g}$ is analogous to Nakai's TGU, although the units are different. The actual rate of sediment resuspension, g, can be calculated from $\hat{g}$ as:

$g = m_s(\hat{g}/100)$

where

$$m_S = 3600 C_S L_C t_C V_S$$

and

g = predicted rate of sediment suspended by the cutter and available for transport away from the dredging operation (kg/hr)
L_C = length of the cutterhead (m)

The primary drawback of this approach is that it requires some basic knowledge of the dredging operation to utilize.

Collins (1995) developed a similar model for bucket dredges. Unfortunately, the bucket dredge model is much less developed than the hydraulic dredge models.

1.3.3 Far-field Models

Many suspended sediment models have been developed that are capable of estimating suspended solids concentrations in the vicinity of the dredging operation. However, a few have been developed specifically for dredging sources. Cundy and Bohlen (1980) developed the first known model of this type. The models recommended for use here combine simplifying assumptions and characteristics of the dredge operation to allow analytical solutions to the transport equation. While these are not the most accurate transport models available, they are adequate for the planning-level reviews in this report. The far-field transport model for hydraulic cutterhead dredges was developed by Kuo, *et al.* (1985):

$$c(x,y,z) = \frac{1000g}{4\pi x\sqrt{k_Y k_Z}} e^{-\left[\frac{u(z+wx/u)^2}{4k_Z x}\right]}$$

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where

$c(x,y,z)$ = TSS concentration at any x, y, z coordinate, mg/L
k_y = lateral (y-direction) dispersion coefficient, m^2/sec
k_z = vertical (z-direction) dispersion coefficient, m^2/sec
u = ambient velocity in x-direction , m/sec
w = settling velocity of suspended sediment particles, m/sec

A similar far-field transport model was developed by Kuo and Hayes (1991) for bucket dredging operations and is given by

$$c(x, y) = \frac{g}{uh\sqrt{4\pi k_Y x / u}} e^{-\left[\frac{uy}{4k_Y x} + \frac{wx}{hu}\right]}$$

2.0 HYDRAULIC CUTTERHEAD SOURCE STRENGTH ESTIMATES

Hydraulic cutterhead dredges are capable of dredging the Upper Hudson River and are an alternative under consideration for removing the contaminated sediments. It is assumed that a 12-inch hydraulic cutterhead dredge will be used for the project. The estimated the average production rate and flowrate of the dredge are 270 cy/hr (353 m^3/hr) and 8,000 gpm, respectively. The 600 HP dredge would use a 40-inch diameter by 42-inch long basket-type cutter.

Generally, swing speeds that result in a tangential speed at the cutter of less than 1 ft/sec are recommended to minimize turbidity generation. However, swing speed and step should be matched with the sediment thickness being removed so that the amount of sediment "attacked" by the dredge is similar to the anticipated production rate. Faster swing rates will result in excessive residuals; slower feed rates will reduce the solids concentration in the slurry. For a cut thickness of 2 ft and a forward step of 2 ft, a swing speed of about 0.5 ft/sec mathematically provides the appropriate sediment feed rate to the suction.

Based upon data collected during studies of the Upper Hudson River, the cohesive sediments to be removed are primarily sandy-silts with a density of 0.71 tons/yd^3 (58 percent solids or 844 kg/m^3). Non-cohesive sediments are primarily silty-sands with a density of 1.16 tons/yd^3 (76 percent solids or 1,379 kg/m^3). Both sediments should be free-flowing and require little cutting effort by the cutter blades; thus, their primary function will be in guiding the sediments to the suction pipe. This can be accomplished with a relatively slow rotation speed. A rotation speed that results in a tangential cutter speed of 1 ft/sec will be used for resuspension assessments. This probably represents a normal or above normal value for this size dredge and it seems practical to reduce that to 0.5 ft/sec during the actual dredging operation if possible. Many dredges of this size do not have variable cutter speeds, but that could be installed at a nominal cost for this project.

2.1 Nakai's TGU Estimates

Nakai provided TGU values for three hydraulic dredging studies removing silty sediments in his original paper. The values were 5.3, 9.9, and 22.5 kg/m^3. Nakai provided only pump horsepower as a reference to dredge size and two of the three studies used a dredge with a 4,000 HP pump; the 9.9 kg/m^3 was from a dredge with 2,500 HP. These suggest much larger dredges than the 12-inch, 600 HP dredge proposed for the Hudson River. Pennekamp, *et al.* (1996) did not provide any new TGU values. However, these three studies involved sediments consisting of 94 to 99 percent smaller than 74 mm where the Hudson River sediments are closer to 65 percent (cohesive sediments) and 20 percent (non-cohesive sediments). If Nakai's formulation is followed exactly, this discrepancy illuminates the problems with the R_{74} term described previously. To combat this problem, it seems logical to attempt to recreate Nakai's observed rate of resuspension for the projects; i.e.

$$\frac{W_0}{Q_S} = TGU\left(\frac{R_O}{R_{74}}\right)$$

Nakai did not provide values of R_0, but a conservative value of 1.0 can be used and the equation simplifies to TGU/R_{74}. The three field studies presented by Nakai yield 5.4, 10.5, and 22.8 kg/m^3. For an in situ sediment density of 0.71 $tons/yd^3$ (844 kg/m^3), these values represent mass loss rates of 0.64 percent, 1.24 percent, and 2.70 percent (percent values are by mass). Using a production rate of 270 cy/hr (206 m^3/hr), the mass generation rates, w_0, are 0.53 kg/sec, 1.03 kg/sec, and 2.24 kg/sec. Of these values, the middle values of 10.5 kg/m^3, 1.24 percent, and 1.03 kg/sec are associated with the smaller dredge with 2500 HP. All of these values should be rather conservative since only the fine fraction of particles (smaller than 74 microns) are subject to sediment resuspension. In cohesive Thompson Island Pool sediments, this is only about 65 percent of the total sediment mass and far less in the non-cohesive sediments.

2.2 Wu and Hayes Model Estimates

Both models presented by Wu and Hayes (2000) were used to estimate the rate of sediment resuspension for the physical and operational dredge characteristics described above and ranges of sediment removal thickness and water depths that represent the expected site conditions. The resulting estimates are shown in Table 1.

All estimates for the 40-inch cutter are less than 0.5 percent loss except for those with a 3-ft cut. The larger values for the 3-ft cut result from having a cutter diameter larger than the sediment removal thickness. It is generally accepted that more resuspension results from times when the cut thickness is less than the cutter diameter. However, the field data on which Wu and Hayes' equations are based contained only a few observations of these type cuts. Thus, it is believed that these values result from the power forms of the equations that are overly sensitive to A_E and probably do not represent reliable estimates. It should be noted that such high resuspension rates have not been observed in any field studies to date.

Table 1. Resuspension estimates from Wu and Hayes models for different sediment removal thickness and pre-dredging water depths.

Water Depth (ft)	$\hat{g}_{DM}$ (%)	$\hat{g}_{NDM}$ (%)	Water Depth (ft)	$\hat{g}_{DM}$ (%)	$\hat{g}_{NDM}$ (%)	Water Depth (ft)	$\hat{g}_{DM}$ (%)	$\hat{g}_{NDM}$ (%)
t_c = 3 ft			t_c = 4 ft			t_c = 5 ft		
40-inch cutter								
5	1.0	0.7	5	0.4	0.3	5	0.5	0.3
10	2.8	1.7	10	0.4	0.3	10	0.5	0.3
15	7.5	4.2	15	0.4	0.3	15	0.5	0.3
20	18.9	10.1	20	0.4	0.3	20	0.5	0.3
36-inch cutter								
5	0.2	0.2	5	0.1	0.1	5	0.1	0.1
10	0.6	0.4	10	0.1	0.1	10	0.1	0.1
15	1.6	1.0	15	0.1	0.1	15	0.1	0.1
20	4.0	2.4	20	0.1	0.1	20	0.1	0.1
Operating and site characteristics used to calculate the values above:								
V_S = 0.21 m/sec			Q = 0.50 m^3/sec			D = 0.30 m		
L_s = 0.46 m			C_S = 844 g/L			d_C = 0.76 m		

For comparison purposes, Table 1 also includes values for a 36-inch cutter. These values are much more reasonable with only a few values greater than 1 percent and the largest value of 4.0 percent. While this suggests that it might be reasonable to use a smaller cutter, it also verifies the expectation that the extremely high numbers for the 40-inch cutter are erroneous.

2.3 Comparable Field Data

Two field studies have gathered resuspension data near the cutter of 12-inch cutterhead dredges – the Dubuque in Calumet Harbor, IL in 1985 and the Tyro, Jr. in Lavaca Bay in 1999. Unfortunately, site conditions at neither of these represents the Upper Hudson, although Calumet Harbor is the closest. Calumet Harbor sediments were a silty loam with about 85 percent smaller than 74 microns. The Dubuque used a 3-ft diameter cutter and approximately 3 ft of sediment was removed during all passes from a depth of 27 ft. Current velocities were generally less than 0.3 ft/sec. The Lavaca Bay study involved dredging about 4 ft of silty-clay sediment from a shallow flat (1 to 5 ft deep) subject to strong tidal conditions. The cutter diameter was similar and many different operational strategies were used. A shroud covered the top of the cutter during much of the operation, but it is unclear if it had any significant impact upon sediment resuspension.

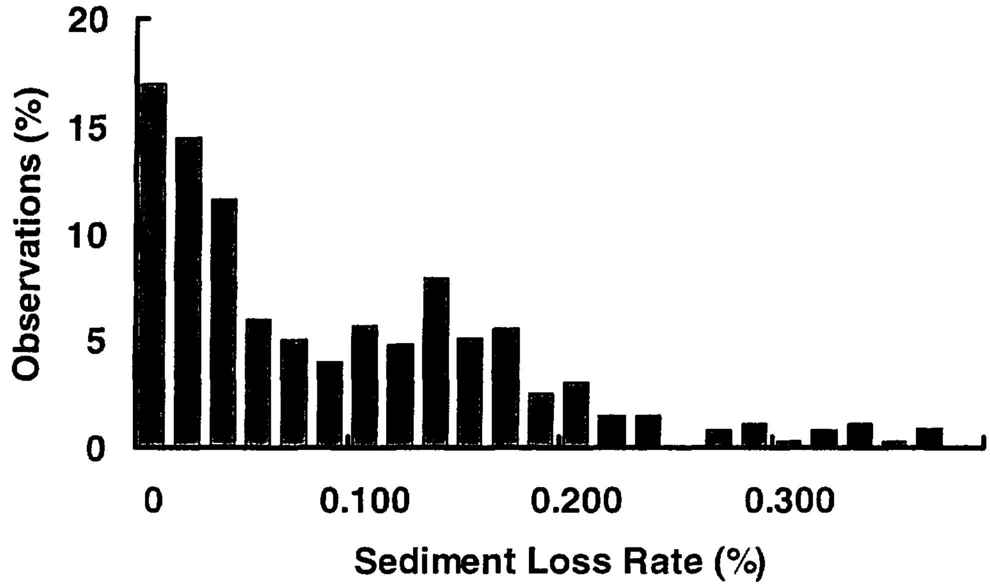

Figure 1. Histogram of observed sediment resuspension rates as percent of sediment removed.

In both cases, water samples were taken very near the cutter and analyzed for total suspended solids (TSS) concentration. Data taken simultaneously were averaged and combined with the dredge operation to calculate the mass rate of sediment resuspension. Dividing by the rate of sediment removal and multiplying the result by 100 gives the rate of sediment loss due to resuspension in percent. Figure 1 shows the observed resuspension rates during the two field studies. All observed values were below 0.4 percent with the majority less than 0.2 percent.

2.4 Summary

The field data and model results are in reasonable agreement with both suggesting sediment loss rates of less than 0.5 percent. Nakai's single observation from a much larger dredge seems to give a higher loss rate of 1.24 percent using rather conservative assumptions. Assessing these independent observations suggests that selecting a sediment loss rate of approximately the maximum observed for a 12-inch dredge during the Calumet Harbor and New Bedford operations, about 0.35 percent, should represent a reasonably conservative estimate of sediment resuspension during the dredging of the Upper Hudson. The sediment resuspension rate for a dredge production of 270 cy/hr (206 m^3/hr) in sediment with an in situ density of 0.71 tons/cy (844 kg/m^3) with a 0.35 percent loss would be approximately 0.17 kg/sec.

3.0 ENCLOSED CLAMSHELL SOURCE STRENGTH ESTIMATES

Bucket dredges are another option for removing the PCB-contaminated sediments. Mechanical dredges have several advantages including being more mobile and having less impact on vessel traffic. Three main disadvantages have been cited. First, the material must be rehandled, thereby increasing the costs. However, there may be little economic penalty for the Upper Hudson River project because the long distances to the treatment and disposal areas pose difficulties for hydraulic dredges. Second, traditional buckets result in an uneven bottom and must remove more excess uncontaminated sediments to get the contaminated layers. Fortunately, new buckets are available that dredge a flat bottom. Lastly, a perception that water quality impacts associated with bucket dredges are significantly higher than for hydraulic cutterhead dredges persists based primarily on data gathered during navigational dredging operations that allowed barge overflow (McLellan *et al.* 1989). Barge overflow is not usually allowed in environmental dredging operations. Additionally, new buckets such as the watertight clamshells, the CableArm Environmental Bucket, and the Horizontal Profile Bucket have been designed to reduce resuspension during dredging.

The enclosed clamshell bucket (referred to as a "watertight" bucket by some) is a relatively inexpensive modification to a traditional clamshell bucket and has been demonstrated to generate substantially less resuspension than the traditional bucket. Thus, it is expected that any bucket dredging operations in the Upper Hudson Project would either use a watertight clamshell dredge or a bucket that would generate even less resuspension. Considering the available draft and limited size of locking facilities on the Upper Hudson, it is assumed that a 4-cy bucket will be used in the area. Typical 4-cy bucket dredging operations operate at a cycle time of 45 to 60 seconds. However, additional restrictions such as reduced bucket fall speeds and extra care on behalf of the operator will increase the cycle time. A 2-minute cycle time is estimated to be realistic and is used in all calculations. That yields a production rate of 95 cy/hr for an 80 percent fill rate.

3.1 TGU Estimates

Nakai (1978) provided TGU values for three sizes of bucket dredges (note that Nakai's term is "grab" dredger) – 3 m^3 (3.9 yd^3), 4 m^3 (5.2 yd^3), and 5 m^3 (6.5 yd^3). Nominal production rates for these type buckets is estimated to be 190 cy/hr, 250 cy/hr, and 500 cy/hr respectively assuming an 80 percent fill rate and 1-minute cycle time. Although not specifically mentioned, these were almost certainly standard clamshell buckets. Observed TGU values were 89.0 and 84.2 for the two larger buckets working in silty clay and clay sediments; three TGU observations of 15.8, 11.9, and 17.1 kg/m^3 were provided for the smaller bucket dredging silty loam sediments.

Pennekamp *et al.* (1996) calculated a TGU value of 3 kg/m^3 for an open clamshell with a production rate of 118 cy/hr (90 m^3/hr). They also determined the TGU for a watertight clamshell with a production rate of 217 cy/hr (166 m^3/hr) to be 19 kg/m^3. They also indicated that a vertically averaged TSS concentration of 100 mg/L above background was observed during the dredging operation. Assuming a typical cycle time and fill rate suggests that it was probably a 3 m^3 (3.9 cy) bucket.

It seems that the TGU of 19 kg/m^3 observed by Pennekamp *et al.* (1996) is the most representative of a dredging operation that used a bucket size applicable to the Upper Hudson. For an in situ sediment density of 0.71 tons/yd^3 (844 kg/m^3), this represents a sediment resuspension rate of 2.2 percent and a source generation rate of 0.38 kg/sec for a 95-cy/hr (73 m^3/hr) production rate.

3.2 Comparable Field Data

Several field studies of sediment resuspension resulting from bucket dredging operations have been conducted. Kuo and Hayes summarized the best estimates of source strength from three of these studies; the results are shown in Table 2.

Table 2. Summary of estimated resuspension losses for several bucket operations (from Kuo and Hayes 1991).

Field Study Location	Resuspension Loss (%)	Original Data Source
Thames River	0.88	Bohlen *et al.* (1979)
St. Johns River	0.11	Collins (1995)
Black Rock Harbor	0.28	Collins (1995)

The most recent data were collected in Boston Harbor in August 1999 (Hayes *et al.* 2000) during the operation of a 39-cy enclosed bucket. The enclosed bucket was a conventional 26-cy bucket converted to an enclosed bucket with a 39-cy capacity. The bucket removed about 2 feet of sediment from the 38-ft bottom with an observed depth-averaged TSS concentration of 50 mg/L. Assuming that concentration occurs across a 10-m width in a current velocity of 0.17 m/sec the source strength is about 1.1 kg/sec. The dredge production was about 2,000 cy/hr. Assuming the sediment concentration was the same as in the Hudson River, the sediment lost to resuspension is 0.31 percent. The source generation rate for this loss is 0.06 kg/sec for a 95-cy/hr (73 m^3/hr) production rate.

3.3 Summary

Observed sediment resuspension rates from enclosed bucket operations range from 0.11 percent to 2.2 percent. For a bucket size applicable to a dredging operation in the Upper Hudson, this represents a range of source strengths from 0.06 kg/sec to 0.38 kg/sec. The data from Pennekamp *et al.* (1996) seem out of line with the other observations. It is expected that the Boston Harbor data are probably more representative, especially considering that the operation will be conducted in a very conservative manner. Thus, a sediment loss rate of 0.3 percent seems to be a reasonable estimate for bucket dredging operations in the Upper Hudson River. This loss rate represents a source of 0.07 kg/sec.

4.0 HORIZONTAL PROFILER DREDGE SOURCE STRENGTH ESTIMATES

A hydraulically operated dredge called the horizontal profiler conducted test-dredging operations in New Bedford Harbor during the summer of 2000. The horizontal profiler utilizes a bucket attached to a hydraulically operated arm rather than a steel cable. The rigid arm increases operational control and should reduce sediment resuspension by eliminating bottom impact. Additionally, the bucket is outfitted with relief valves to reduce hydraulic pressure inside the bucket and seals to reduce leakage. Thus, it is expected that the total resuspension rate will be considerably less than for the enclosed bucket operations described above. Unfortunately, resuspension data from the New Bedford operations are not available at the time of this writing.

In the absence of field data or any predictive methodologies, the only approach to estimating the source rate is to assume that it is some fraction of the resuspension rate for the enclosed bucket. Since the horizontal profiler is expected to use the same size bucket, *i.e.* 4-cy, and the same cycle time of 2 minutes, a direct proportion seems justifiable. A reduction of approximately 50 percent compares to a source rate of 0.15 percent or 0.035 kg/sec. This seems to be a reasonable estimate assuming the dredge is operated with care.

5.0 ASSESSMENT OF WATER QUALITY IMPACTS

Near-field source estimates represent the rate at which sediment particles are introduced into the water column. They do not, however, provide any information on the downstream water quality impacts that result from the suspended sediments being transported away from the dredging site by ambient and induced currents. Additionally, dredge operation strongly influences the initial geometry of the resuspended sediments in the water column. In turn, this geometry has considerable influence on downstream transport.

A complete evaluation of water quality impacts requires integrating a calibrated hydrodynamic model of the system with a water quality model capable of predicting changes due to advection, turbulent diffusion, and settling of the suspended particles. Such a model is beyond the scope of this evaluation. It could even be debated that such a sophisticated transport model is unwarranted in any circumstances where the source rate is so uncertain. However, some assessment of downstream water quality impacts is useful to put the source terms in context. Fortunately, steady-state models for both cutterhead and bucket dredging operations have been developed (Kuo *et al.* 1985; Kuo and Hayes 1991). These models combine source geometry and hydrodynamic simplifications with an assumption of steady-state conditions to allow analytical solutions to the transport equation. Although their application is limited, these models provide reasonable estimates of water quality impacts.

5.1 Average Source Strength Values

Sections 2 and 3 described the basis for estimating sediment resuspension rates expected during dredging of the Upper Hudson River. These rates do not consider the makeup of the sediments being dredged. Only 65 percent of "cohesive sediments" is smaller than 74 microns and realistically available for resuspension and transport. About 20 percent of the non-cohesive

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sediments is smaller than 74 microns. Even if the resuspension rates developed above are assumed to apply to the cohesive sediments in the Upper Hudson, resuspension from the non-cohesive sediment areas will be considerably less. It is estimated that resuspension during dredging of non-cohesive sediments will be about 31 percent (0.20/ 0.65 = 0.31) of that from cohesive sediments. The long-term average resuspension rate should take into account that 70 percent of the sediments to be dredged from the Upper Hudson are non-cohesive. Table 3 summarizes the resulting sediment resuspension rates. These rates are used in the plume modeling described below.

Table 3. Summary of estimated resuspension losses for dredging operations in the Upper Hudson River.

	Sediment Resuspension Loss (kg/sec)		
Dredge	Cohesive Sediments (30%)	Non-cohesive Sediments (70%)	Average
12-inch cutterhead	0.17	0.053	0.088
4-cy enclosed bucket	0.07	0.022	0.036

5.2 TSS Plume Estimates

Depth-averaged TSS concentrations were predicted using the far-field transport equations described above using conditions and values representative of the Upper Hudson River. A water depth of 3 m is used with a steady, unidirectional current velocity of 0.12 m/sec in the downstream direction. Chapra (1997) suggests a range of 3 to 30 m/d for the settling velocity of silt particles. Since data on settling rates were not available, a median value for settling velocity of 16.5 m/d (1.9 x 10^{-4} m/sec) was used in the transport calculations. Chapra (1997) also shows that lateral turbulent diffusion ranges from 5 to 10^6 cm^2/sec (5 x 10^{-4} to 10^2 m^2/sec). A value of 10 m^2/sec was used based upon the discussion by Kuo *et al.* (1985). Additionally, Kuo *et al.* found that a vertical diffusion coefficient (k_z) of 0.0005 m^2/sec was representative for the James River. Since this is consistent with Chapra's ranges, it was also used for the Upper Hudson River.

Kuo and Hayes' (1991) far-field transport equation gives depth-averaged TSS concentrations resulting from bucket dredging operations directly. Figure 2 shows the TSS isopleths for a source rate of 0.036 kg/sec.

The far-field transport equation presented by Kuo et al (1985) for hydraulic dredging operations gives TSS concentrations at specific depths. Depth-averaged TSS concentrations were determined from TSS values calculated for depths of 0.25, 0.75, 1.25, 1.75, 2.25, and 2.75 meters. Figure 3 shows the TSS isopleths for a source rate of 0.088 kg/sec. It should be noted that this assumes that the source is at the very bottom of the river as suggested by Kuo *et al.* (1985).

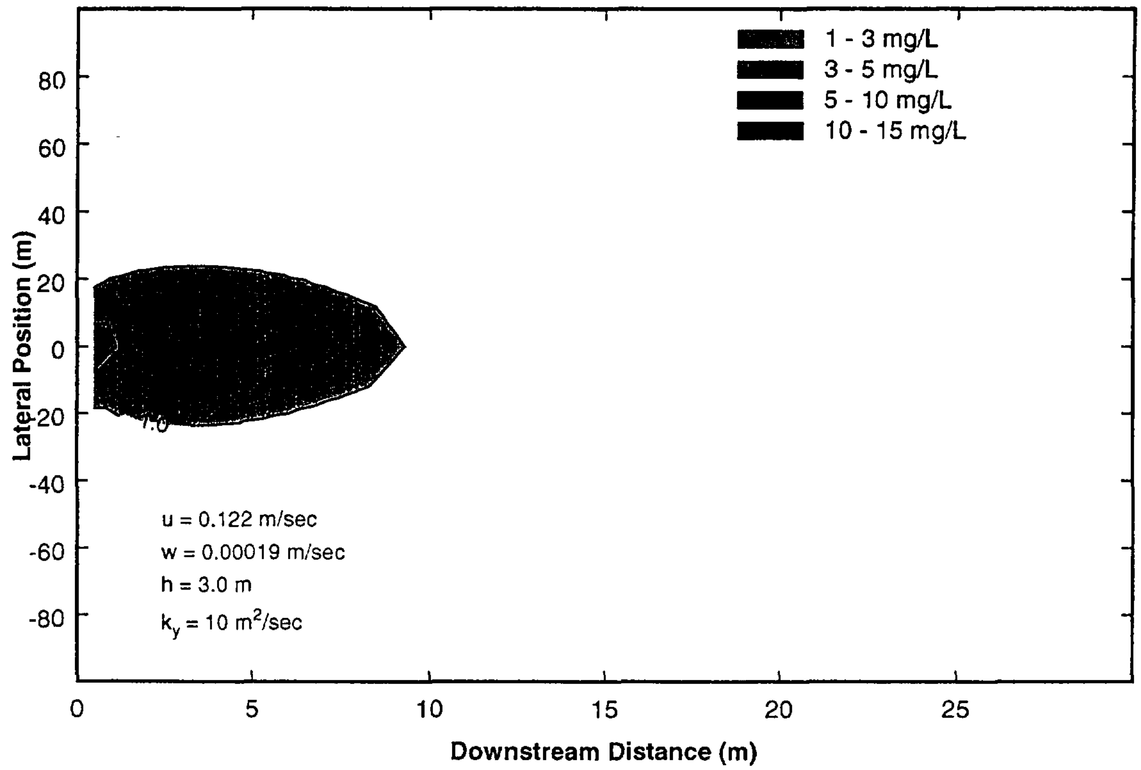

Figure 2. Depth-averaged TSS concentrations for enclosed bucket dredge operating in the Upper Hudson River.

Since the cutter resuspends sediments in the immediate vicinity of the cutter about 1 meter or so vertically into the water column, it might be more realistic to move the source to 1 m above the bottom. This would increase the resulting TSS plume.

5.3 PCB Plume Estimates

5.3.1 Background

Solid-liquid partitioning of toxic contaminants is a complex physico-chemical process. A simple linear partitioning theory has been developed to represent the process. This is the basis for virtually all water quality models that include toxic contaminants. The basis for the concept is that the total contaminant concentration consists of both dissolved and particulate phases such that

$$C_T = C_d + C_p$$

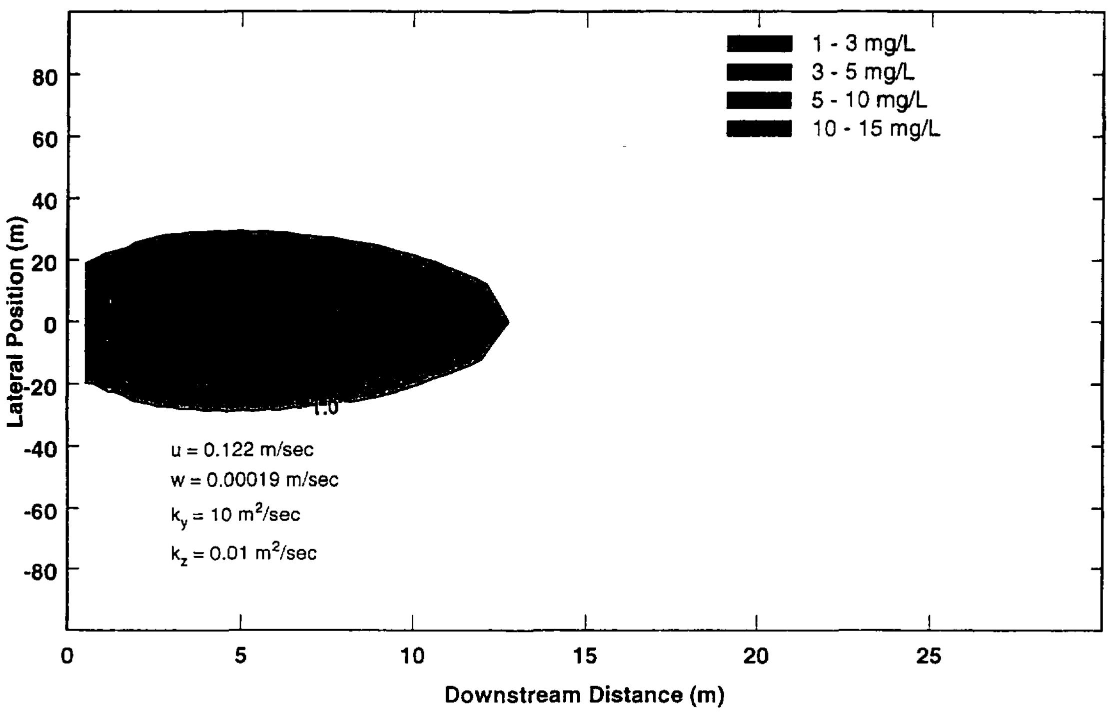

Figure 3. Depth-averaged TSS concentrations for hydraulic cutterhead dredge operating in the Upper Hudson River.

where

C_T = total contaminant concentration, mg/L
C_d = dissolved-phase contaminant concentration, mg/L
C_p = particulate-phase contaminant concentration, mg/L

And, the components are assumed to represent fixed fractions of the total concentration, *i.e.*

$$C_d = F_d C_T \qquad \text{and} \qquad C_P = F_P C_T$$

where

F_d = fraction of total contaminant concentration that is in the dissolved phase
F_P = fraction of total contaminant concentration that is in the particulate phase

These fractions are functions of the contaminant partitioning properties and the suspended solids concentration in the water. They can be calculated as:

$$F_d = \frac{1}{1 + K_d TSS} \qquad \text{and} \qquad F_P = \frac{K_d TSS}{1 + K_d TSS}$$

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where

K_d = partitioning coefficient, L/kg
TSS = suspended solids concentration, mg/L

Ideally, these models would be incorporated into a transport model of the toxic constituent then solved simultaneously with the TSS transport equations that form the basis of the models presented by Kuo *et al.* (1985) and Kuo and Hayes (1991). Time limitations prevent that type of comprehensive model development. A conservative alternative is to apply the partitioning equations to TSS concentrations predicted by the applicable transport models presented previously. Particulate and dissolved concentrations tend to be higher using this approach because of the inability to consider dilution of the dissolved constituent and the effect of continually reduced bulk toxic constituent concentrations on particulate concentrations.

5.3.2 Congener Concentrations

Further transport calculations in this document consider only tri+ PCB congener concentration because of their ecological toxicity (USEPA 1998). It is estimated that the dredged material removed from the TI Pool will average between 8 and 9 mg/kg. However, based on historic sampling events, TI Pool contaminated sediments were found to average approximately 25 mg/kg. Computations will be completed for two sediment concentrations, 10 mg/kg to represent the average concentration in TI Pool dredged sediments and 25 mg/kg to represent historic analytical data.

5.3.3 Tri+ PCB Congener Transport

TSS concentrations from the TSS plume transport calculations described previously form the basis for estimating water column PCB concentrations. The partitioning coefficient (K_d) applicable to Hudson River tri+ PCB congeners is 10^5 L/kg based on analyses conducted for BZ #44 (USEPA 1997). Total tri+ PCB congener concentrations in the water column were calculated using the fundamental relationship

$$C_T = M_{PCB} TSS$$

where

M_{PCB} = mass of PCB absorbed on to the in situ sediment, mg/kg

For the two conditions described above, total tri+ PCB congener concentrations were determined as:

$(C_T)_{avg} = 10*TSS$ and $(C_T)_{max} = 25*TSS$

where the resulting concentration values of C_T are in parts per trillion (ppt).

Figures 4 and 5 show predicted tri+ PCB congener water column concentrations for the average concentration of 10 ppm. Figures 6 and 7 show predicted tri+ PCB congener water column concentrations for the maximum average sediment concentration of 25 ppm.

While these estimates of total tri+ PCB congener concentrations represent cummulative concentrations, dissolved or particulate tri+ PCB congener concentrations may be of even greater interest. In particular, the dissolved water column concentrations tend to be of greater concern because of their increased bioavailability. Dissolved and particulate concentrations can be calculated as the product of F_d or F_p and the total tri+ PCB congener concentrations. F_d and F_p vary with TSS concentration as shown in Figure 8.

6.0 SUMMARY

Conservative estimates of TSS resuspension rates for enclosed bucket and hydraulic dredging operations in the Upper Hudson River were developed. These TSS source estimates were used as the drivers for simple TSS and PCB transport modeling. TSS transport model results suggest the turbidity plume during dredging operations will persist at low concentrations approximately 20 m downstream. Tri+ PCB congeners are the primary constituent of concern and exist at an average concentration of about 10 mg/kg in the TI Pool sediments and at concentrations about 25 mg/kg in cohesive sediments. The PCB plume exists in all areas of elevated TSS. However, the tri+ PCB congener concentrations are estimated to be under 20 ppt just downstream of the dredging operation. Table 4 shows estimates of the flux that leaves the dredging area, defined arbitrarily as 10 m downstream of the point of dredging.

The predicted TSS and PCB tri+ congener plumes from both dredging operations are relatively small. However, there are water quality impacts that must be considered. Additionally, applying the information presented here requires additional consideration in the construction phase of the project. Specifically, although the water quality impacts from a 12-inch hydraulic cutterhead dredge is greater than that of the 4-cy bucket dredge, the rate at which it can remove sediments is also higher. It is likely that multiple bucket dredges may need to operate simultaneously to achieve a reasonable project duration. The results of this analysis suggest that both dredge types can operate with limited water quality impacts and dredge selection should probably be based upon other factors such as cost, availability, and site conditions.

Table 4. Estimated tri+ PCB congener flux concentrations 10 m downstream from the dredging operation.*

Dredge	Plume Width (m)	Approx. Avg PCB Conc (ppt)	Estimated PCB Flux (µg/sec)
10 mg/kg sediment PCB concentration			
12-inch cutterhead	60	15	330
4-cy enclosed bucket	40	15	220
25 mg/kg sediment PCB concentration			
12-inch cutterhead	60 m	40	660
4-cy enclosed bucket	60 m	30	490

**Based upon a water depth of 3.0 m and average current velocity of 0.122 m/sec.*

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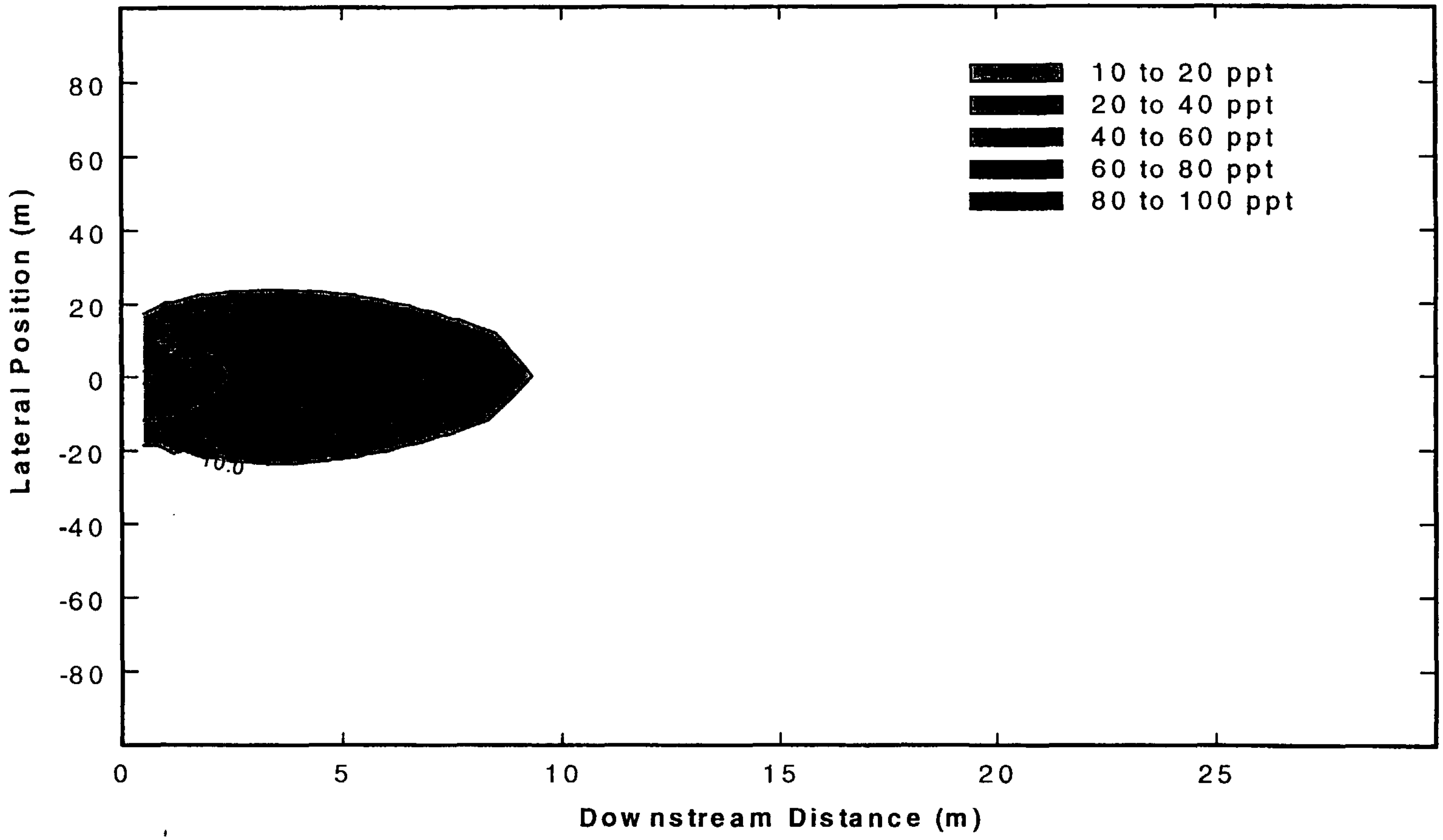

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Figure 4. Estimated total tri+ PCB congener water column concentrations (ppt) during enclosed bucket dredging operations in the Upper Hudson based upon a sediment bulk Tri+ PCB concentration of 10 mg/kg.

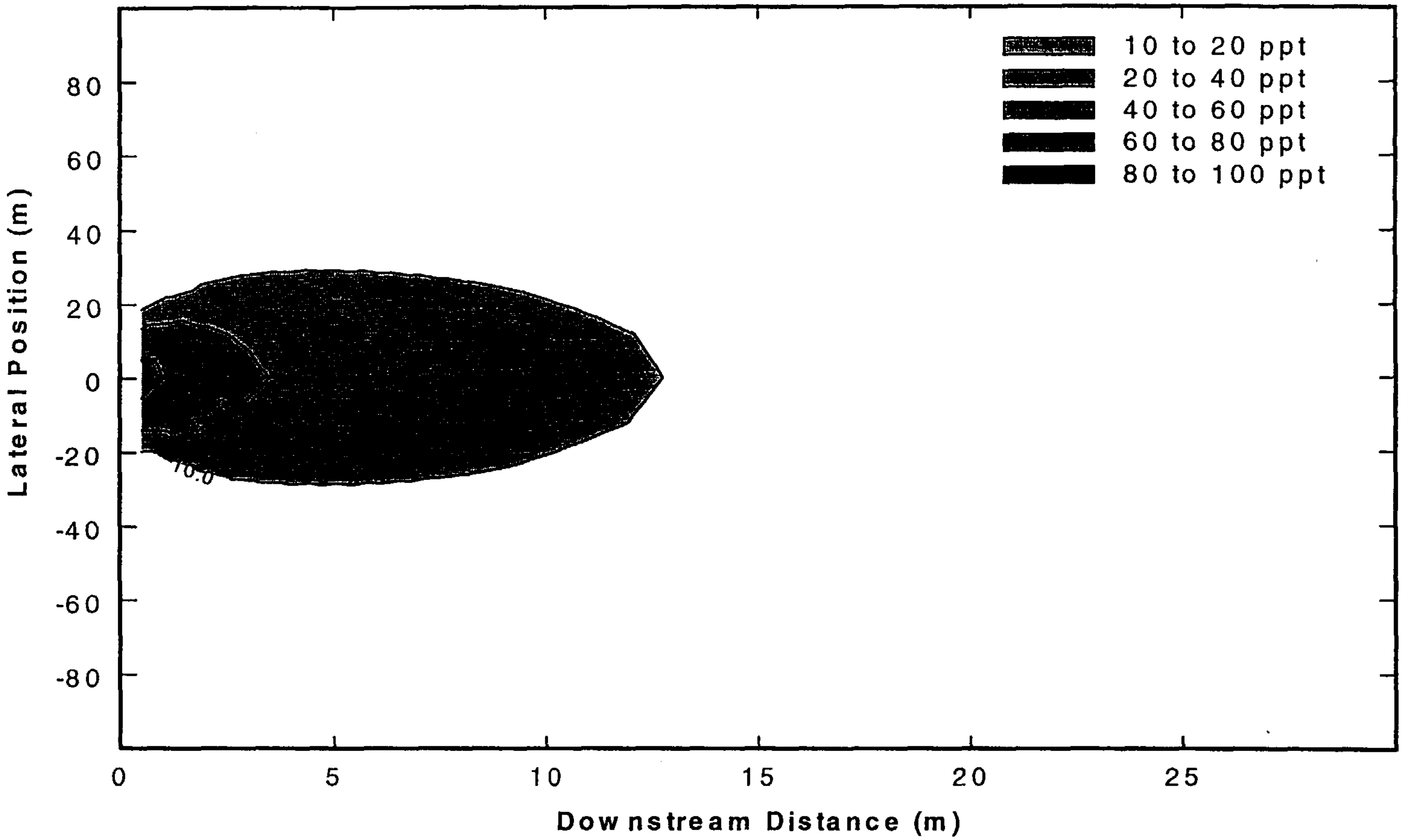

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Figure 5. Estimated total tri+ PCB congener water column concentrations (ppt) during hydraulic cutterhead dredging operations in the Upper Hudson based upon a sediment bulk Tri+ PCB concentration of 10 mg/kg.

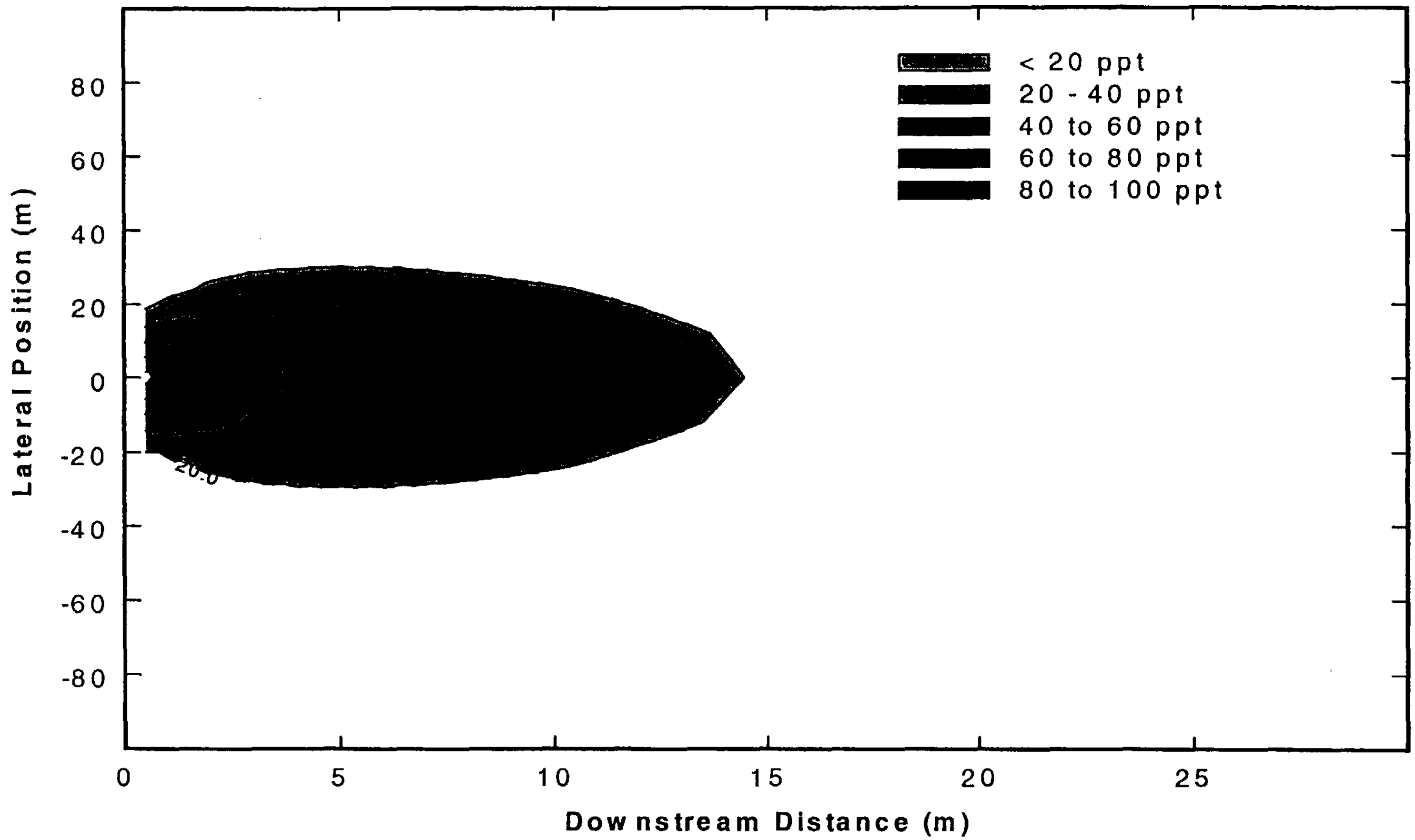

Figure 6. Estimated total tri+ PCB congener water column concentrations (ppt) during enclosed bucket dredging operations in the Upper Hudson based upon a sediment bulk Tri+ PCB concentration of 25 mg/kg.

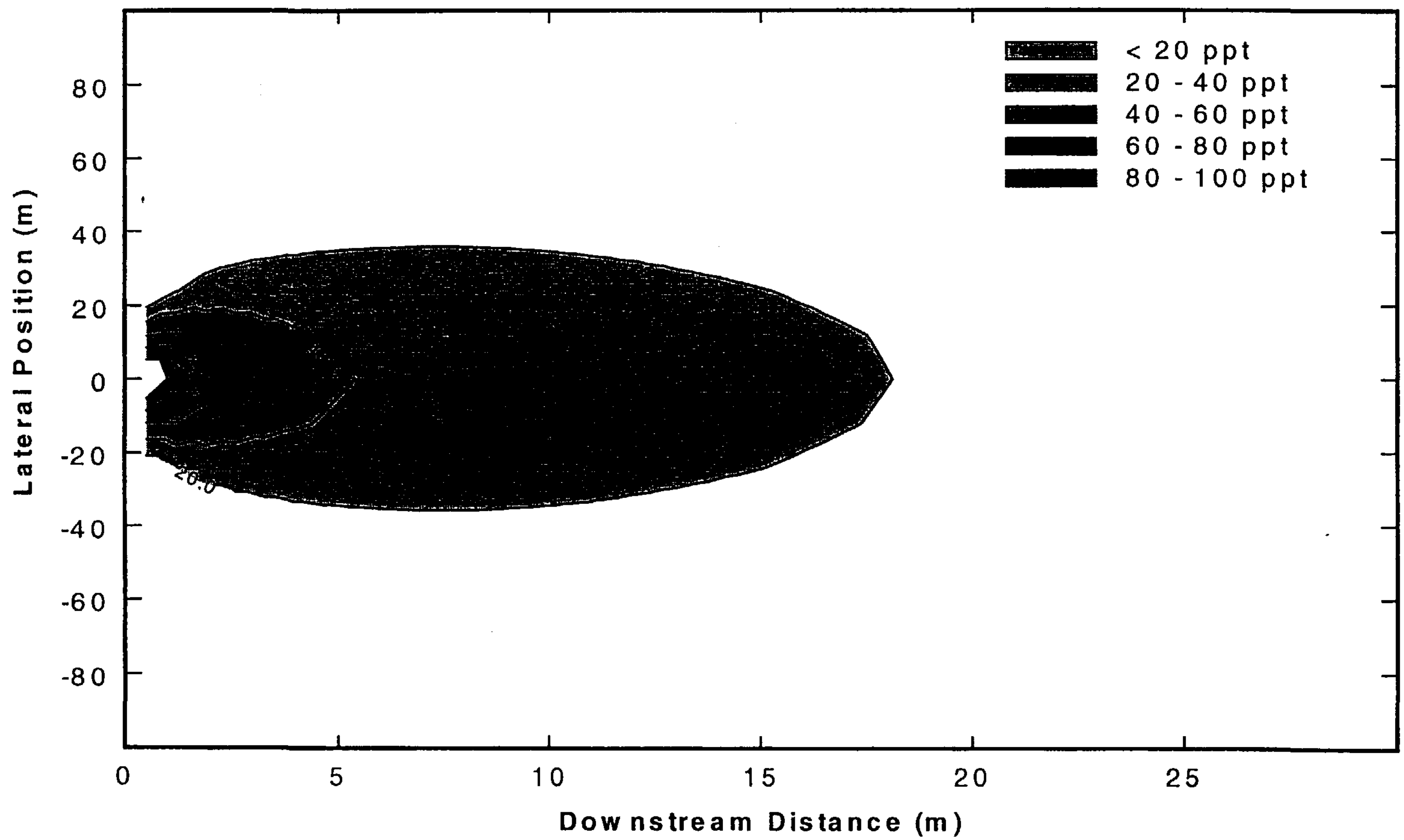

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Figure 7. Estimated total tri+ PCB congener water column concentrations (ppt) during hydraulic cutterhead dredging operations in the Upper Hudson based upon a sediment bulk Tri+ PCB concentration of 25 mg/kg.

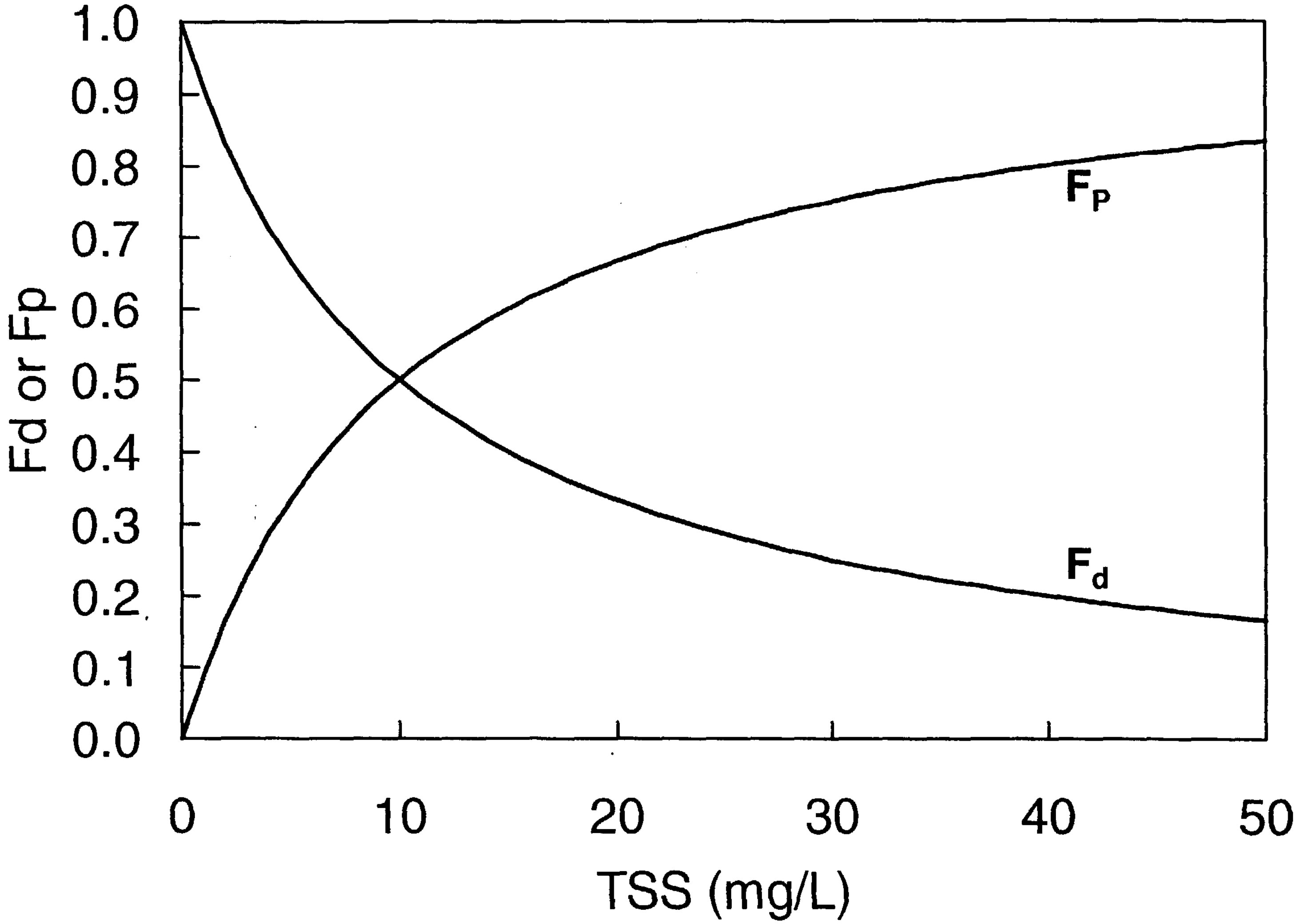

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Figure 8. Variation of F_d and F_p with TSS concentration.

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.7 TECHNICAL MEMORANDUM: BACKFILL ESTIMATES CONCEPT DEVELOPMENT

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

BACKFILL ESTIMATES CONCEPT DEVELOPMENT

Backfilling is necessary to help prevent resuspension of PCBs into the water column and to aid in habitat replacement. Backfilling of the Hudson River will occur as a separate operation following the removal alternatives or capping with dredging alternative. Backfill material will be placed in all areas remediated except in the navigation channel (water depth >12 ft).

Backfill Estimates for the Removal Alternatives

For these alternatives, the backfill scheme will consist of the following:

- Areas with water depth >12 ft: No backfill will be placed
- Areas with water depth from 6 ft to 12 ft: Backfill will consist of 0.5 ft layer of sand followed by 0.5 ft gravel layer.
- Areas with water depth from 0 ft to 6 ft: Backfill will consist of 1 ft layer of sand in all areas except for near shore wetlands where 0.5 ft sand will be placed followed by sufficient amount of fine material to bring the area back to its initial grade (elevation).

Amounts of material required for backfill were computed per alternative per dredge area per water depth. The dredge area was broken down into surface area located in 6 ft to 12 ft water depth and surface area located in 0 ft to 6 ft water depth.

Required amounts of backfill for each removal alternative are shown in the following table:

Removal Alternative	Total Gravel (cy)	Total Sand (cy)	Total Fine Material (cy)
REM-3/10/Select	327,133	327,133	197,368
REM-0/0/3	612,842	612,842	245,154

An additional 15 percent of backfill was added to all volumes in the above table for purposes of bank reconstruction and habitat replacement. The total volumes of sand and gravel were altered for ecological purposes to reflect an even distribution of sand and gravel throughout the river.

Backfill material will be applied to all removal locations once removal operations are complete in the dredge area and upstream of that dredge area. Equipment required for placement of the backfill material includes:

(2) Hopper Barges (150'X42')
(2) Transport Tugs
(1) Deck Barge
(1) Telescoping conveyor
(1) Conveyor belt
(1) Bobcat

Backfill Estimates for the Capping with Dredging Alternative

For the CAP-3/10/Select alternative, the backfill scheme will consist of:

- Areas with water depth > 12 ft: No backfill will be placed.
- Areas with water depth from 6 ft to 12 ft: All capped areas at this depth will be backfilled with a mixture of sand and gravel at a thickness of 0.5 ft and dredged areas will receive backfill consisting of 6 inches sand and 6 inches gravel.
- Areas with water depth from 0 to 6 ft: 1 ft sand will be placed in all areas except critical areas and capped areas. For near shore wetland areas, 0.5 ft sand will be placed followed by sufficient fine material to bring the area back up to its initial grade and in all capped areas a mixture of sand and gravel will be placed at a thickness of 0.5 ft.

Required amounts of backfill for the CAP-3/10/Select alternative is shown in the following table:

Alternative	Total Gravel (cy)	Total sand (cy)	Total Fine Material (cy)	Total (Sand + Gravel) (cy)
CAP-3/10/Select	121,903	121,903	197,368	192,227

An additional 15 percent of backfill was added to all volumes in the above table for purposes of bank reconstruction and habitat replacement. The total volumes of sand and gravel were altered for ecological purposes to reflect an even distribution of sand and gravel throughout the river.

The same equipment as listed for the removal alternatives will be used for backfill placement for the capping alternative.

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.8 TECHNICAL MEMORANDUM: HABITAT REPLACEMENT/RIVER BANK RESTORATION CONCEPT DEVELOPMENT

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

HABITAT AND VEGETATION REPLACEMENT CONCEPT DEVELOPMENT

The areas requiring habitat and vegetation replacement were estimated using the following assumptions:

- After remediation, areas identified as potential wetlands will be backfilled with a mixture of sand and fine material to restore pre-remediation elevations. Following backfilling, these areas will be planted. Approximately half of the area will be planted with submerged vegetation, and the other half will be planted with emergent vegetation.

- Shallow areas (defined as areas in 0 to 6 feet water outside critical areas) will be backfilled with one foot of sand. Following backfilling, approximately one-third of the area will be planted with submerged vegetation. The remaining areas will not be planted.

RIVER BANK STABILIZATION CONCEPT DEVELOPMENT

The length of river bank requiring stabilization or reconstruction after remediation was estimated using the following assumptions:

- There are three types of proposed shoreline stabilization concepts. The types of shoreline stabilization depend on the depth of removal adjacent to the shoreline. All shoreline areas will be backfilled with approximately one foot of sand prior to bank stabilization.

- Shoreline areas where removal of sediments is to a depth less than 2 feet will be stabilized by hydroseeding above the water line.

- Shoreline areas where removal of sediments is between 2 feet and 3 feet will be stabilized through placement of a vegetation mat (approximately 20 feet wide) along the shoreline.

- Finally, shoreline areas where removal of sediments exceeds 3 feet will be stabilized by using a log type of revetment system in addition to the vegetation mat discussed previously.

The following tables present areas for habitat replacement and length of shoreline for bank stabilization by alternative.

Habitat and Vegetation Replacement

Alternative	Area with Shallow River Habitat Replacement (Acres)	Area with Emergent Wetland Habitat Replacement (Acres)
CAP/SR-3/10/Select	75.8	21.0
REM-3/10/Select	76.0	21.5
REM-0/0/3	150.6	37.0

River Bank Stabilization

Alternative	Total Shoreline Disturbed (LF)	Shoreline Adjacent to Sediment Removal Depth of <2 feet	Shoreline Adjacent to Sediment Removal Depth of 2 to 2.5 feet	Shoreline Adjacent to Sediment Removal Depth of >3 feet
CAP/SR-3/10/Select	91,955	77,764	12,481	1,710
REM-3/10/Select	91,955	17,075	46,564	28,316
REM-0/0/3	173,773	92,446	50,052	31,275

Notes:
All shoreline lengths were computed using GIS/Database software.

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.9 TECHNICAL MEMORANDUM: REQUIREMENTS FOR A TRANSFER FACILITY ADJACENT TO THE THOMPSON ISLAND POOL

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

REQUIREMENTS FOR A TRANSFER FACILITY ADJACENT TO THE THOMSPON ISLAND POOL

1.0 Introduction

Sites for transfer facilities require adequate land area to support the equipment and systems needed to process incoming dredged material. While a number of existing locations in the Albany area may potentially be dedicated to processing sediments removed from the Upper Hudson, there are essentially no operating industrial sites, adjacent to the TI Pool that can provide the required support. Thus, a site, that does not have an active industrial or materials handling use will need to be identified and developed for this purpose.

Principal facilities/systems that will need to be established at a transfer facility adjacent to the TI Pool area as follows:

- Barge basin and mooring facility;
- Barge dewatering and unloading systems;
- Temporary sediment storage and drainage area;
- Sediment stabilization system (mechanical dredging);
- Slurry processing facility (hydraulic dredging);
- Wastewater treatment facility
- Stabilized sediment storage area;
- Rail connection to mainline;
- Rail car storage area; and
- Rail car loading facilities.

The transfer facility's capacity for processing sediments is a function of the scale of the equipment and systems that can reasonably be placed at the site. The scale of those systems is in turn dictated by available land area, site topography, property configuration, and the orientation of the site in relationship to principal transportation modes (barge, rail, and roadway). The general implications of each of the principal systems on transfer facility capacity and, therefore, site requirements is described here.

2.0 River Front Operations (Mechanical Dredging)

Mooring and berthing facilities need to be provided for incoming barges loaded with dredged material. In the case of the northern transfer facility, either deck barges loaded with about 200 tons of cargo or hopper barges loaded with about 1,000 tons of cargo will arrive at the facility throughout the working day. Loaded hopper barges are expected to draw about eight feet of water and, therefore, a basin depth of about ten feet will be adequate to accommodate the barges (and towboats). It is possible that some barges will be loaded with more than 1,000 tons of cargo and, therefore, the basins will need to be deepened further.

Sizing the barge basin will depend on the number of barges that it is planned to unload at any one time and on the number of barges that need to be temporarily stored. It is likely that barge storage can be accommodated in-river and, therefore, the scale of mooring facility will primarily be dictated by the decision made with regard to barge unloading. The large barges that will be used as part of an active remedy will be about 150 feet in length. Thus, a wharf or dock designed to unload one barge at a time will be about 200 feet long and, for simultaneous unloading of two barges, about 400 feet long. A decision on one versus two unloading positions depends on the processing rate required at the transfer station.

Once barges arrive at the transfer facility, the barges will be tied to the dock/wharf and unloaded. For this analysis, it has been assumed that one barge will be unloaded at a time and a total of three deck barges and one hopper barge will be unloaded per day (1,600 tons/day). The following are expected durations for each principal component of dockside operations:

Barge tie-up .... 0 min

Pump-out excess water from barge at 50 gpm per pump:

- The volume of excess water is based on the dredge productivity which consists of 20 percent water/ 80 percent sediment per dredge cycle
- Assume 3 deck barges at 200 tons each and 1 hopper barge at 1,000 tons
- Volume of water to be remove from the deck barge = 6,500 gallons
- Time to pump-out one deck barge = 100 min using two pumps (1.1 hours)
- Time to pump-out 3 deck barges..195 min (3.25 hrs)
- Volume of water to be removed from hopper barge = 32,500 gallons
- Time to pump-out hopper barge (2 pumps) ....25 min (5.4 hrs)

Unload sediment from hopper and deck barge:

- Assume 4-cy clamshell used to unload the hopper and deck barges
- The cycle time of the clamshell is one minute with 75% efficiency
- Time to unload hopper barge (870 tons sediment).........................207 min (3.5 hrs)
- Time to unload three deck barges (1 @ 175 tons sediment)..........125 min (2.1 hrs)

Empty barge departs/loaded barge arrives and moored (4 barges/day) ....120 min (2 hrs)

Total time to accomplish unloading with one active berth.............................1,004 min (16.25 hrs)

Thus with one active position it will be possible to unload four barges in about 16 to 17 hours. This would suggest that the length of wharf/dock needed at the northern transfer facility (assuming 1,600 tons per day throughput) is about 200 feet. However, since it can be anticipated that barges will arrive for unloading in a somewhat random pattern, there would be value in having a second berth to allow an incoming barge to be readied for unloading while actual unloading operations occur in the adjacent berth. Thus, one concept for the transfer facility would be to construct a 400 foot long wharf/dock with only one barge being unloaded at any one time.

3.0 Rail Car Loading (Mechanical and Hydraulic Dredging)

On the assumption that the northern transfer facility is limited to exporting about 1600 tons of stabilized sediment each day, it will be necessary to establish a logistics system that integrates on-site processing operations with practices of the originating railroad. Stabilized sediment will be shipped to landfills in rail gondolas capable of carrying 100 tons of cargo. Thus, on average, 16 car loads of stabilized dredged material will depart the transfer facility each working day. It is possible that this output will be temporarily stored in the nearest yard operated by the originating railroad.

Rail car storage and loading facilities will need to be provided at the transfer facility so that on-site operations can be smoothly transitioned into those of the railroad. It would be reasonably cost effective to have one pick-up and drop-off of rail cars each day. In order to do so, it will be necessary to place about 1,000 feet (about 60' per car) of storage/loading track exclusive of any lead in and distribution lines. The dimensions of the on-site rail yard (rail storage plus materials storage), assuming loading at each of two tracks, may be approximately 500 feet by 125 feet with much of that area devoted to storage of stabilized sediments prior to load-out. Alternative geometries will be evaluated during the design phase of any particular remedy.

If rail car loading will be accomplished with two 2-yard pay loaders operating on a 1 minute cycle time, material would be loaded at a rate of four yards per minute. Thus, 1,600 tons could be loaded into gondolas in about 7 hours without accounting for loading inefficiencies, car switching activities, and other impediments to loading operations. In any event, it does not appear that rail car loading will be as significant a constraint on transfer facility throughput as will barge unloading in the event that the goal is to process and load-out 1,600 tons of stabilized sediment. It can be expected that as the targeted throughput is increased, rail operations will increase in complexity and will become a more significant in relationship to waterfront operations.

4.0 Sediment Stabilization (Mechanical Dredging)

Stabilization of mechanically dredged sediments is described in detail in Appendix E, section E.10. Principal components of the system are feed hoppers, conveyors, pug mills, and storage facilities for both stabilization agents and processed dredged material. Land area requirements for the stabilization equipment will be substantially less than for the rail yard described above; consequently, it is not expected that this particular component system of the transfer facility will importantly influence site selection.

Conveyors and pug mills (the principal active elements of the stabilization system) are available in a range of capacities and the target processing rate of 1,600 tons per day can be accomplished by commercially available equipment. In addition, it is possible to increase system throughput in several ways, including installing parallel processing trains, in order to attain a targeted processing rate (*e.g.*, 1,600 tons per day). Consequently, it is not expected that the stabilization system will be a constraint on processing stabilized sediments at the northern transfer facility.

5.0 Slurry Dewatering (Hydraulic Dredging)

The functioning of this system is described in Appendix H. Its major components are a series of screens, hydrocyclones, flocculation and settling tanks, and belt presses. In addition, a fairly substantial water treatment system must be installed, under the hydraulic dredging scenario, to process about 8,000 gpm of incoming water. A design has not been developed for either the dewatering or water treatment systems at this feasibility stage. While considerable historic experience exists with all elements of the dewatering and treatment systems, the scale of equipment needed to support hydraulic dredging operations in the Upper Hudson is substantial. Therefore, it is not possible to comment on land area requirements for erecting an integrated processing complex or on limitations that dewatering and water treatment may impose on throughput at the northern transfer facility.

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.10 TECHNICAL MEMORANDUM: DREDGED SEDIMENT PROCESSING CONCEPT

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

and

YEC, Inc.
Clarkstown Executive Park
612 Corporate Way
Suite 4 M
Valley Cottage, NY 10989

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DREDGED SEDIMENT PROCESSING

1.0 Introduction

1.1 Project Background

Removal by dredging is among the alternatives being considered for remediating contaminated sediments found within the Upper Hudson. Sediments found in the river have varying physical properties that may influence both the dredging methods, sediment handling and final disposal of the dredged material.

One of the methods evaluated for removal of contaminated sediments is mechanical dredging. Based on a review of applicable mechanical dredging technologies, a system consisting of an excavator fitted with suitable auxiliary equipment appears to be a viable approach for accomplishing the required removal work.

The identified mechanical equipment is capable, under ideal conditions, of removing sediments at their *in-situ* moisture levels. However, it is expected that in actual practice, approximately 20% additional water will be captured with each removal cut of the dredge. Both the *in-situ* and entrained water will complicate the handling and disposal of sediments that have been removed from the river bed. In order to load the dredged material into rail gondolas it is expected that the railroad will require the sediments to pass a paint filter test (essentially no free water). In addition, it is possible, given the quantities being disposed, that receiving landfills may require the incoming material to be stackable without it being blended with other soils that may otherwise be available.

This memorandum addresses possible methods for improving the properties of excavated sediments to render them suitable for transportation to either disposal or beneficial use facilities.

1.2 Sediment Characteristics

The sediments of the Upper Hudson River have a range of physical properties but can be placed into two principal categories for general assessment purposes: (1) finer-grained, cohesive sediments; and (2) coarser-grained non-cohesive materials. The following tabulation provides the principal physical characteristics of sediments in each of these categories:

Properties of Hudson River Sediment

	Non-cohesive sediment	Cohesive sediment
Typical location	Deeper areas and channel	Shallower areas
Fine sand or coarser (%)	80	35
Silt or finer (%)	20	65
Solids (%)	76	58
In-situ Density (gm/cc)	1.82	1.45
Organic content (%)	1 to 2	3 to 4

As shown in the table above, the non-cohesive sediments are largely sand with some silt while the opposite is the case for the cohesive materials, although the cohesive portion has a relatively high sandy fraction. The organic content of the Upper Hudson sediments ranges from 1 percent to 4 percent. Therefore, physical characteristics of the sediment indicate they would drain well. The *in-situ* solids contents combined with other physical properties of the material also suggest that handling properties of the dredged sediments could be readily improved by any one of several processes including gravity draining, mechanical dewatering, and chemical stabilization.

1.3 Dredged Material Handling

The moisture content of mechanically dredged sediments will reflect both its *in-situ* condition and the water that has been entrained during dredging operations. It is expected that as much free water as possible will be withdrawn (by pumping) from incoming barges at the temporary sediment transfer and processing facilities. Since it is expected that 10 to 12 hours may be required to barge sediments to an Albany area transfer facility, considerable solids separation is likely to occur, in the barge, prior to its unloading at Albany. Removing that free water will reduce the moisture content of the dredged material and, therefore, improve its handling properties. It should be noted that it may be possible to configure transport barges so that maximum advantage can be taken of the in-river transport time to reduce the water content of the dredged material.

Due to the variability of the properties of the dredged materials, the in-barge solids separation may not sufficiently improve its handling properties, therefore, it may be necessary to further process the incoming dredged material before rail loading. Additional processing may consist of either mechanical dewatering or chemical stabilization.

2.0 Mechanical Dewatering

Mechanical dewatering technologies have been used extensively in sediment remedial projects to reduce the amount of water and to prepare the sediments for further treatment or disposal. These systems press or draw water from the feed material by applying energy.

Generally, mechanical dewatering technologies can increase the solids content up to 70% by weight.

3.0 Chemical Stabilization

Several chemical stabilization methods are available to further improve the handling properties of the sediments removed from the Hudson River. This section explores different methods that can be used to stabilize/solidify the sediment matrix (referred to collectivity as stabilization). A series of bench tests using actual sediment samples would be needed in order to select the most suitable mix of reagents.

3.1 Sorbents

Sorbents include materials that act by absorption or adsorption of drainable liquid. Since sorbents retain liquid in the matrix of the absorbing material, absorption is considered a reversible process. According to EPA regulations (40 CFR 264.314(b)) "the placement of non-containerized liquid hazardous waste or hazardous waste containing free liquids (whether or not sorbents have been added) in any landfill is prohibited." Based on this requirement, it can be assumed that sorbed free liquids are still considered free liquids. Thus, use of sorbents alone may not be considered a viable stabilization process for landfill disposal of river sediments.

Certain sorbents have a role in the stabilization of contaminated materials. For instance, activated carbon can adsorb organic contaminants that could otherwise interfere with reagents added to chemically stabilize the sediment. Other sorbents can also contribute to chemical reactions. If the stabilized matrix gains strength over time, the stabilizing reagent is considered to be involved in chemically transforming the matrix. Examples of sorbents that can chemically react with other reagents or available compounds in the soil include: zeolites, oxide/hydroxides, volcanic ash, fly ash, lime, kiln dust, rice hull ash. Unsuitable sorbents (presumably because they act by sorption alone) include vermiculite, bentonite, fine-grained sands.

USEPA regulations (40 CFR 264.314(e)) further state "sorbents to be used to treat free liquids to be disposed of in landfills must be non-biodegradable". Thus, materials such as shredded paper, sawdust, corn cob dust, etc. are not acceptable.

3.2 Binders

Binders improve handling properties by generating a cementitious reaction without necessarily reacting with the contaminant. Several additive reagents capable of accomplishing this goal have been identified. Refer to Table 1 for estimated cost and properties of selected reagents. Refer to Table 2 for chemistry information for selected reagents.

3.2.1 Inorganic Binders

3.2.1.1 Pozzolan-Portland Cement Materials

These materials create cementitious compounds (calcium-silica hydrates, calcium-alumina hydrates) upon hydration, causing a gain in strength over time. They are fine powders that require enclosed transport and storage systems to reduce dust migration and premature hydration. Several of these compounds are caustic in nature and need to be handled with care.

Limitations include interference of the contaminants (calcium sulfate, borates, carbohydrates) on setting and stability of the final product. Oil and grease can prevent bonding and decrease strength. Organic solvents and oils can impede setting and may volatilize because the hydrating reaction is exothermic. Some metals (nickel, lead, zinc) can have increased solubility at the high pH occurring during reaction.

Portland Cement

- Creates cementitious compounds (calcium silicate and aluminate hydrates) upon hydration;
- The reaction is not limited to fine grained soils;
- It provides free lime available for pozzolanic reaction;
- It provides high strength gain at low addition rates, minimizes volume increase, minimizes temperature rise;
- The more product added, the higher the strength gain;
- It is useful for reducing initial water content;
- It is most effective at temperatures above 40 degrees;

Five different types of Portland cement are available with Type I being the most widely used and lowest cost. Type II has a low-alumina content and is designed to be used in the presence of moderate sulfate concentrations. Type III is a rapid-set cement. Type IV has a low heat of hydration and a long set time. Type V is a low-alumina, sulfate resistant cement used with high sulfate concentrations.

Lime

- Lime reacts with soil via: a) hydration (good for quickly drying fine-grained soils); b) flocculation (cations adsorb to clay surfaces and exchange with calcium, increasing strength and impermeability); c) cementation (a slower reaction, limited to amount of available silica);
- It increases the optimum water content of sediment;
- Lime hydration forms calcium hydroxide, which is soluble and subject to attack by weak acids, salts, or other sulfates;

- Lime is not considered effective for coarse-grained soils;
- Adding lime to the point of achieving a soil pH of 12.4 ensures that pozzolanic reactions will occur;

  Hydrated Lime – ($Ca(OH)_2$) reacts with Class F fly ash to provide long term strength without temperature rise. It has less available lime than quicklime.
  Quick Lime – (CaO) – produces a greater temperature rise, a greater volume increase and quickens the reaction. It can burn skin or corrode equipment. It needs a silica source (*i.e.* silicates in soil, fly ash) for pozzolanic reaction. It has 25% more available lime than hydrated lime therefore less product is required than with hydrated lime, although it is initially more expensive. One part quicklime reacts with 0.32 parts water (by weight).

Fly Ash – Fly ash is a coal combustion byproduct collected from the power plant dust removal systems. It can be used to replace a portion of Portland cement to increase the cementitious compound formed, thereby adding strength. It can replace from 10 percent to 30 percent of cement. Through pozzolanic activity, the silica in the fly ash will react with the free lime from Portland cement to form similar cementitious compounds to those produced during the hydration of Portland cement. This action forms a denser, higher strength concrete with lower permeability. The permeability rate of a 70/30 Portland cement/fly ash compound was shown to have a 6 times reduction in the permeability rate compared with 100 percent Portland cement. Its fine particles also fill voids, making more homogeneous cement. It is also useful for reducing plasticity and slowing reaction speed.

Fly ash acts as a pozzolan with sources of lime such as cement kiln dust, lime kiln dust, or quicklime to produce a low strength cementitious compound. When used alone, large quantities can be added to quickly reduce a soil's moisture content; however this is a sorption process.

- Class F Fly Ash – is a good bulking agent that does not harden by itself ($pH<11$). It requires the addition of lime to produce strength (reaction pH 12.5 until lime is consumed).
- Class C Fly Ash – is self cementing due to the increased proportion of lime. It has a higher initial pH than Class F but final pH is <11.5. This material is not available in the vicinity of the Upper Hudson River.

Cement or Lime Kiln Dusts – Cement kiln dust (CKD) is a byproduct of Portland cement production and thus has a similar composition. Lime kiln dust (LKD) is the byproduct of lime production and thus has a high lime content. Both provide good strength gain at relatively low dose rate and low volume increase but with temperature and pH increase. They tend to have inconsistent lime contents. The LKD has around 30 percent available lime. CKD and LKD can be used with a source of silica (*i.e.* fly ash, soluble silicates) to form a cementitious compound upon hydration.

Soluble Silicates– increase the water demand and gelling of concrete. They flash set Portland cement to produce low-strength concrete and possibly reduce the interference from metal ions in a waste stream. They decrease the amount of cement needed and react with the available lime produced by Portland cement hydration. Alkalis may enhance reactions with amorphous silica. Silica fume can also be used, which has the advantage of more available silica, making it a very efficient pozzolanic material. In concrete with a water-cement ratio of 0.55 and higher, 1 pound of silica fume can replace 3-4 pounds of cement

Slag – (low ratio of calcium to silica) – creates cementitious compound and silicon dioxide upon hydration. The silicon dioxide then reacts with available lime to create secondary cementitious compounds. It has a reduced heat of hydration, increased setting time and increased strength when used in combination with Portland cement. However, this product is not readily available in the vicinity of the Upper Hudson River.

Fluidized Combustion Bed or Dry Scrubber Ashes - (quicklime and sulfur)- high surface area material used to achieve rapid strength gain at low addition rates. This type of ash tends to be coarser than fly ash and thus would not react as quickly.

3.2.1.2 Cement Additives

Additives can be blended into cement to improve its reaction in the presence of interfering contaminants.

Activated Carbon – increases the binder effectiveness for organics when introduced with Portland cement. It adsorbs contaminants, which then can become physically bound to the matrix produced by the cement.

Calcium Chloride – adds strength, lowers plasticity, quickens process, but is costly.

Gypsum – is used in Portland cement to retard the dissolution of tricalcium aluminate which if unimpeded tends to quickly form hydrate crystals over silicate particles, inhibiting their further hydration.

Lignin – Calcium Lignosulfonate provides dispersive characteristics, making it a useful addition to cement mixes. It reduces the amount of water required to use the product effectively.

3.2.1.3 Other Cements

Sulfur Polymer Cement (95 percent elemental sulfur, 5 percent organic modifier) – This cement is useful in treating incinerator ash and radioactive wastes. It is not compatible with wet waste, nitrate salts, organics or ion-exchange resins. It is highly resistant to alkaline and acidic environments. The reaction forms a linear polymer, which requires 24 hours to complete.

Phosphate Ceramics (trade name Ceramicrete) – is formed via hydration of magnesium oxide and monopotassium phosphate. It yields a hard, dense ceramic. It is a fairly new technology that can be used to treat inorganic waste – alkaline or acidic. Thus far, it has been demonstrated successful in the treatment of ash, salts, radioactive waste, and mercury.

3.2.2 Organic Binders

Organic binders or polymers are more expensive and more difficult to use than inorganic binders. They are typically heated and combined with waste streams to thermoplastically encapsulate the waste into a solid matrix. They are used to solidify radioactive wastes or hazardous organic compounds. They include asphalt, epoxide, unsaturated polyesters, and polyethylene.

3.3 Recent Solidification Projects/Studies

United Heckathorne, Richmond, CA - The sediment from this project was solidified with a combination of 5 percent Portland cement and 2 percent sodium silicate to achieve enough strength to make the mix stackable for landfilling. The material was mixed in holding ponds and ready for shipment the next day. The sodium silicate was added to increase the gelling and water demand of the Portland cement. Without the addition of sodium silicate, 18 percent Portland cement would have been needed to stabilize the sediments. Also considered was the use of class F fly ash, but that would have required a 45 percent addition to stabilize the sediments.

Ford Outfall, Monroe MI – The sediment from this dredging project was solidified with 12 to 13 percent Portland cement to achieve a strength of 25 psi, sufficient to support maintenance traffic on the placement lagoon.

Willow Run Creek, Ypsilanti, MI – The sediment from this dry excavation project was solidified with calciment (a mixture of lime and Portland cement) fly ash and then cement kiln dust. Reagent availability was a problem due to a construction boom at the time. The sediment was an oily sludge mixed with a backhoe with a cure time of from 3 days to 2 weeks. The strength requirement was 10 psi.

NYCDOS Marine Transfer Station, NYC and Brooklyn, NY – Powdered quicklime was used as a stabilizing agent during an evaluation program on dredged material from two DOS Marine Terminal Stations. The dredged material consisted of: 4 to 20 percent sand and 80 to 96 percent silt and clay; initial moisture content of 126 to 259 percent; organic content of 7 to 18 percent. It was determined that the addition of about 8 percent quicklime was needed to raise the pH to 12.4 (pH required for pozzolanic reaction). A moisture content reduction of 67 percent was achieved in 28 days. The greatest rate of reduction occurred immediately (around 50 percent reduction).

Given the previously mentioned beneficial properties of portland cement, its widespread use for sediment stabilization, and information obtained from various technical publications (see references). Portland cement has been selected as the stabilizing agent for the purpose of preparing a cost estimate.

3.4 Other Considerations

A number of factors can affect the selection of the reagent used for stabilization beyond its ability to reduce free liquids. These include cost, availability, handling, reaction time required, weather effects, dosage required, as well as landfill costs for increased weight. Trucking costs for obtaining stabilizing reagents can easily exceed costs of the reagents. Using pressurized tankers to deposit reagents directly into silos reduces dust migration, product hydration, and material handling. The speed of reaction can be affected by weather conditions. Sediment material storage space will most likely be at a premium, therefore reaction rate can be important. However, short reaction times are usually associated with exothermic reactions, which could lead to volatilization of contaminants. Increasing dosages of reagents can quicken reactions, however this also increases the costs of product and of landfilling. If multiple reagents are to be used and mixed on-site, there would be additional silo costs, material transport costs, and conveyance costs.

4.0 Conclusions

Preliminary data on sediment characteristics indicate that the dredged material may drain easily in a temporary storage facility and would not require mechanical dewatering or chemical stabilization. However, due to the variability in sediment properties and dredging scenarios stabilization with 8 percent cement has been included as a process in the cost analysis.

As previously stated, the selection of a reagent should be based on bench scale testing. Possible outcomes of bench-scale testing and cost optimization may include the following options:

- use of other stabilizing materials; for example, a preliminary project trade-off analysis revealed that 8 percent cement is equivalent in cost to about 18 percent fly-ash.
- use of a low cost mechanical dewatering system to dewater the entire mass, or fraction of the dredged material so that it meets shipping requirements.

Selection of the appropriate dewatering process for improving the handling properties of dredged sediment can have an important impact on project cost. For instance, if gravity drainage is found to improve the handling properties to the extent that removed sediments are acceptable for transportation and disposal to landfills, then the project cost could be substantially reduced.

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Table 1
REAGENT PROPERTIES/COST

Product	Density	SG	Cost	Destination	Reference
Portland Cement	90 pcf	3.15	$81/ton	Albany, NY	Dan C. Gorke Blue Circle Cement Ravena, NY 800-631-2777
Slag		2-2.5	n/a		
Sodium Silicate		2.2 (fume)	$0.397/lb	Butler, NJ	Fax Quote: PQ Corporation Valley Forge PA 610-651-4200
Silica Fume		2.2	$800/ton	Albany, NY	Phone Quote: Mark Master Builders 800-722-8899
Fly Ash Class F	75 pcf	2.25	$12/ton	Albany, NY	Leo Palmateer (Pozzoment) Blue Circle Cement 518-756-5085
Fly Ash Class C		2.2-2.6	n/a		
Quick lime	70 pcf		$93/ton	Adams, MA	Fax Quote: Karen Flank Specialty Minerals, Inc. 610-861-3575
Hydrated Lime	40 pcf		$97/ton		
Lime Kiln Dust		2.7	$30/ton	Albany, NY	Leo Palmateer (Pozzoment) Blue Circle Cement 518-756-5085
Lime Kiln Dust			$10/ton	Adams, MA	Phone Quote: Jerry Lewis Specialty Minerals, Inc. 413-743-6279
Cement Kiln Dust			$15/ton	Albany, NY	Phone Quote: Paul Minor St. Lawrence Cement 513-452-3001

Table 2
CHEMICAL PERCENTAGES OF REAGENTS (approx.)

	Portland Cement	Slag	Silica Fume	Quicklime	Hydr.Lime	Fly Ash F	Fly Ash C	CKD	LKD
Reference	*6*		*8*	*4*	*5*	*6*	*6*	*3*	*2*
Silica	22	36	99			55	40	15	4
Alumina	5.1	12				26	17	3	2.5
Lime (CaO)	63.8	39		96		9	25	42	58 (29 avail)
H.Lime ($Ca(OH)_2$)					67				
Iron	2.4	.4		0.1		7	6	2	1
Sulfur	2.4	1.4				.6	3.3	9	.5
Magnesium	2.7	11		0.8	32	2	5	1	
Avail. Alkalies	0.5					0.5	1.3		
LOI				0.1				21.4	

PORTLAND CEMENT CHEMISTRY (*Reference 1, 9*)

Initial Compound	Formula	Abbreviation	% Wt.	% wt. water bind	Heat generated	Comments
Tricalcium silicate	Ca_3SiO_5	C_3S	50	25	500kJ/kg	quick reaction, high early and final strength, resistant to sulphur attack
Dicalcium silicate	Ca_2SiO_4	C_2S	25	20	250kJ/kg	slower reaction, high final strength
Tricalcium aluminate	$Ca_3Al_2O_6$	C_3A	10	40-210	900kJ/kg	Quick reaction, high early strength, low final strength
Tetracalcium aluminoferrite	$Ca_4Al_2Fe_{10}$	C_4AF	10	37-70	300kJ/kg	low strength
Gypsum	$CaSO_4.2H_2O$		5			avoids quick set of C_3A

Main Compounds Formed:

Calcium silicate hydrate	$3CaO.2SiO_2.4H_2O$	CSH				cementitious compound responsible for strength
Calcium hydroxide	$Ca(OH)_2$	Free lime				quick hydration, soluble

Cement Reaction: Portland Cement + Water = CSH + Free Lime (up to 20 wt.%)
Pozzolanic Reaction: Free Lime + Silica Source (soil, flyash, sodium silicate, etc.) = CSH

Maximum water demand of Portland cement = 45% (calculated) by wt.
Water demand of Quicklime = 30%

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APPENDIX E

ENGINEERING ANALYSIS

E. 11 TECHNICAL MEMORANDUM: EVALUATION OF OFF-SITE LANDFILLS FOR FINAL DISPOSAL OF DREDGED SEDIMENTS

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

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EVALUATION OF OFF-SITE LANDFILLS FOR FINAL DISPOSAL OF DREDGED SEDIMENTS

Introduction

Disposal locations for dredged sediments were evaluated in two categories: (1) facilities permitted to accept sediments containing PCB levels at or above 50 ppm and, (2) those which are permitted to accept sediments having PCB concentrations below 50 ppm. Candidate landfills were analyzed on the basis of distance from the Hudson Valley, rail access, seasonal capacity limitations, projected operating life, and published or verbally quoted disposal costs. It should be noted that this screening is for purposes of evaluating implementability and estimating costs only; not for purposes of final selection of a disposal facility.

1.0 TSCA Landfills

Landfills that can accept sediments with 50 ppm or greater PCB levels require a TSCA permit. A nationwide list of these facilities was obtained from USEPA and these were then evaluated in terms of the factors stated above.

Based on USEPA's input, it was determined that the number of candidate facilities is limited and that only one such facility exists in New York State. The closest TSCA-permitted landfill outside New York State is the Wayne disposal facility, located in Belleville, Michigan. Rail facilities are situated within 10 miles of the landfill and, therefore, disposal there would involve a final truck haul from the rail head. Trucking services would be provided by the Wayne facility but at an additional cost to the disposer. Additionally, a state hazardous waste tax must be paid when disposing at this facility. Total cost would be approximately $150/ton (including disposal, transportation from RR spur, and state tax). Operations are anticipated to continue there for the next 20 to 25 years; however, based on costs and limited rail access, this facility has been screened out as a candidate for receiving TSCA regulated sediments from the Hudson River.

TSCA-permitted facilities located farthest from the Hudson River include Chemical Waste Management in Kettleman City, Ca, Chemical Waste Management of the Northwest in Arlington, OR, Envirosafe Services Inc. of Idaho in Boise, ID, and US Ecology in Beatty, NV. These facilities are comparable in terms of tipping fees, capacity limitations, expected years of operation, and rail access to the facilities discussed below. However, all these landfills were screened out due to their distance from the Hudson River; a factor which can be expected to inflate transportation costs beyond those presented below.

The remaining TSCA-permitted facilities include Chemical Waste Management in Emmelle, AL, Waste Management Model City Facility in Model City, NY, Safety-Kleen Grassy Mountain Facility in Knolls, UT and Waste Control Specialists, LLC of Andrews, TX. Of these landfills, Waste Control Specialists in Texas is the only facility with rail service directly into the landfill while the Grassy Mountain Facility in Knolls, Utah has rail access located in proximity to their facility. The Model City Facility in NY state has no rail access and Waste Management in Emmelle, Alabama has rail connections within 10 miles of their facility. Based on this information, Waste Management of Emmelle, AL has been screened out.

The Model City Facility in NY State is retained due to its proximity to the Hudson River. In comparing the Utah facility with that in Texas, both have rail access but the Texas facility has on site rail facilities, has published a disposal cost of about $52/ton (including local taxes), and provides considerable disposal capacity. The facility in Utah published a disposal cost of about $70/ton, is somewhat farther from the Hudson River than the Texas site, but also has considerable disposal capacity. On the basis of total cost and distance from the Hudson Valley region, the Grassy Mountain Facility in Knolls, Utah has been screened out and the facility in Andrews, Texas is retained.

Thus, two candidate TSCA facilities are considered possible disposal locations for purposes of the FS: Waste Management's Model City facility in Model City, NY and Waste Control Specialists LLC in Andrews, Texas. The principal distinctions between the two is that Model City is located closest to the Hudson River and is limited to truck access. The facility in Texas is considerably farther from the Hudson River than the Model City Facility but it provides direct rail access into the landfill. In terms of disposal costs, tipping fees at Model City are about $75/ton with an additional 6% local tax while for the Texas facility tipping fees are approximately $45/ton with a $7.50/ton local tax. The remaining factor that needs to be considered in making a selection between the two facilities is transportation costs.

The Canadian Pacific RR, which serves the upper Hudson Valley region was contacted to obtain an estimate for transporting stabilized PCB-contaminated dredged material by gondola car to the Texas landfill. While obtaining a shipping cost proved difficult in this case, it was suggested that assuming a cost of about $5000 per 100 ton car load would be a reasonable approximation for a large project. On this basis the cost of rail transportation to Texas has been estimated at $50 per ton. A comparison can now be made between use of a truck accessed landfill in New York State and a rail fed facility in Texas.

The cost of trucking to Model City, NY is estimated as follows:
- daily rate of truck, driver, fuel, etc. = $700
- Model City is one day round trip from the transfer stations
- truck carries 25 tons for a unit cost of $28/ton

The total cost comparison between Model City and Texas is as follows:

- Texas = $50 to ship plus $52 to tip = $102/ton
- Model City = $28 to ship plus $79 to tip = $107/ton

While disposal costs vary somewhat between the two disposal options, given the preliminary nature of this analysis it is difficult to reach a definitive conclusion on the basis of estimated costs alone. For purposes of the analysis conducted in this FS report, however, it will be assumed that TSCA regulated material will be shipped to Texas for disposal.

2.0 Non-TSCA Landfills

Sediments with PCB levels below 50 ppm can be disposed in landfills that are not permitted pursuant to TSCA. Given that overall project costs are particularly sensitive to transportation factors, it would be logical to identify facilities in New York State for disposal of non-TSCA sediments. Unfortunately, many of the landfills within NY State are either not permitted to accept PCBs, are permitted to handle PCBs only at very low levels, or have other permit imposed limitations on accepting particular waste sources. Thus, only two New York landfills have been identified as potential candidates for disposing contaminated sediments. As a result, the evaluation of non-TSCA landfills was expanded beyond New York to include Canada, Atlantic region states, and states in the mid-West.

Results of this search produced the following candidates: BFI Waste Systems of North America, Inc. Niagara Falls Landfill (formerly CECOS) in Kenmore, NY., CINTEC in LaSalle, Quebec, Enfoui-Bec in Quebec, Franklin County Regional in Constable, NY., Horizon Environment in Grandes Piles, Quebec, two landfills in Maine, and several landfills in West Virginia, Ohio, and Michigan.

The two New York State landfills are not ideal candidates for disposal of Hudson River sediments. The Franklin County Regional Landfill is extremely limited in terms of the PCB materials they can accept for disposal. NYSDEC only permits Franklin County to accept materials with PCB concentrations in the ppb range; this level is not relevant to management of Upper Hudson sediments. BFI Waste Systems is problematic due to their capacity limitations. They have stated that they can accept 500 tons/day which translates to about 90,000 tons per construction season (May to November). Thus, this facility can manage less than half of the non-TSCA material that is expected to be generated during removal operations, assuming no other customers.

Another set of potential disposal sites were identified in Canada. CINTEC, located in LaSalle, Quebec, is not able to accept waste directly from the US, therefore, CINTEC has been screened out. Enfoui-Bec, located in Quebec along the St. Lawrence River, did not identify any problems with importing waste from the US; however, they have a remaining capacity limitation of about 300,000 tonnes and, therefore, have been eliminated from further consideration. The final Canadian facility considered was Horizon Environment, situated in Grandes Piles, Quebec. They required that an agreement be reached between Environment Canada and USEPA to use their facility. This landfill has managed about 100,000 tons of sediment from Cumberland Bay, Lake Champlain. They do not have direct rail access; however, rail service is available about 2.5 miles from their facility. The landfill appears to have adequate capacity to handle a substantial fraction of sediments from the Upper Hudson River. Disposal costs are about $50/ton and if rail were selected as the mode of transportation, they would add trucking costs from the rail line to the landfill.

In addition to the above Canadian disposal facilities, landfills located in the US mid-West and Atlantic Region were also investigated as alternatives to manage the non-TSCA material that would be generated by a removal alternative. This search has produced several possibilities in Maine, West Virginia, Ohio, and Michigan.

Maine:

1) Waste Management - Norridgewock. No specific information has yet been obtained for this facility.

2) Sawyers Environmental- Hampden. Can accept less-than-50 ppm PCB material. Rail line near site but no direct line into site. Expect to close in 15 years. No capacity limitations in terms of the amount of material they can receive in any one given period. Have permit that may open three million cubic yards of additional capacity but they are presently in litigation with the locality.

Ohio:

It was determined from conversations with DEP, that MSW facilities in the state can accept less-than 50-ppm PCBs but the landfill operator must establish appropriate operating and handling procedures. A list of disposal facilities throughout the state was obtained and several were contacted.

West Virginia:

The State environmental agency indicated that as long as PCB concentrations fall below the hazardous waste limit, landfills in this jurisdiction can potentially accept sediments from the Upper Hudson River. A list of possible landfills throughout the state was obtained for future evaluation.

1) Northwestern Facility - Parkersburg, WV. This landfill can accept less-than-50 ppm PCB material and is capable of accepting 30,000 tons per month. They have enough capacity to foresee future operation for the next 30 years at current usage rates. Costs for disposal were quoted at $34.05/ton, however, no rail access exists at this landfill.

2) Meadowfill Landfill - Bridgeport, WV. This landfill can accept less-than 50-ppm PCB material and is capable of accepting 23,500 tons per month. They have enough capacity to foresee future operation for the next 30 years at current usage rates. Costs for disposal were quoted at $37/ton, however, no rail access exists at this landfill.

Michigan:

Information has not yet been received from this jurisdiction.

A final step in the program to identify non-TSCA landfills was contacting several full-service waste management companies that operate disposal facilities in various regions of the country. Based on responses received to these inquiries, it has been decided to apply, for purposes of this Feasibility Study, a unit cost of $50 per ton to transport and landfill stabilized non-TSCA sediments. This cost is exclusive of rail car loading and assumes that rail cars will be loaded with approximately 100 tons of material.

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.12 TECHNICAL MEMORANDUM: DISTRIBUTION OF SEDIMENT VOLUME BY PCB CONCENTRATION RANGE IN THE THOMPSON ISLAND POOL AND BELOW THOMPSON ISLAND DAM

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

Distribution of Sediment Volume by PCB Concentration Range in the Thompson Island Pool and Below Thompson Island Dam

1. Introduction

This attachment describes the approach used to estimate the volume of sediments requiring treatment as TSCA wastes. TSCA wastes, because of their higher levels of contamination, involve substantially greater costs in handling and landfilling. Thus it was important to determine a reliable estimate of the volume of these materials from the available data. The volume estimate varies with the remedial scenario, as might be expected. In any river section, the fraction of these materials is greatest in the 10 g/m^2 removal scenario and lowest in the full section removal. On an absolute basis the amount of TSCA material under the 10 g/m^2 removal scenario is roughly three-quarters of the TSCA material mass under the full section removal.

Several data sets were required to estimate the mass of sediment requiring TSCA treatment. In particular, different data sets are available for different river sections and so the TSCA estimate had to be completed differently for each river section. Additionally, a few general assumptions concerning the data and the nature of removal were required before the data could be applied for these purposes. These are as follows:

a) The dredge removal depth was assumed to be approximately equal to the depth of contamination at most sampling sites.
b) Based on (a), the length-weighted-average concentration (LWA) provides the closest approximation to the actual concentration to be removed from the location. To the extent that some overcutting does occur during dredging, use of the length-weighted-average concentration should provide an upper-bound estimate on the actual amount of TSCA waste.
c) In the TI Pool, the 1984 NYSDEC sediment sampling data were taken to represent conditions at the time of dredging. No correction for PCB losses from the sediments were made. Since losses have been documented (LRC - USEPA, 1998), this approach provides an upper bound on the actual amouint of TSCA material to be generated.
d) Below TI Pool, the 1994 USEPA sediment coring data were taken to be representative of river sections 2 and 3. The proportions of TSCA material were estimated from the 1994 for the areas studied and extrapolated to *hot spot* areas not covered in 1994.
e) TSCA material was defined as any sediment having a length-weighted-average concentration greater than 32 mg/kg. This value provides a sufficient margin of safety for the landfills accepting non-TSCA materials, *i.e.*, the chances of a non-hazardous waste landfill accepting TSCA wastes are substantively reduced. (A sensitivity analysis was also performed setting the TSCA boundary at 50 mg/kg.)

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An additional calculation was performed from this analysis to estimate the volume of sediment less than 10 ppm in each removal scenario. These materials have the greatest potential for beneficial use subsequent to their removal from the river. Beneficial use can frequently reduce the overall cost of the remediation, as discussed in the main report. In the following discussions, the detailed approach and calculations to estimate the sediment volumes are described for each river section.

2. Estimation of the Mass of TSCA Materials in the TI Pool

The calculation of TSCA materials involved several steps for the TI Pool as listed below:

a) Calculate a length-weighted-average concentration and a depth of contamination at each sampling point.
b) Estimate the area of river bottom to be assigned to each sampling point based on polygonal declustering.
c) Obtain the intersection of the proposed removal boundaries and these polygons to determine the length-weighted-average concentrations in the areas to be removed.
d) Calculate the volume of sediment at each concentration based on the polygons and the depth of sediment contamination.
e) Estimate the volume of material less than the specified concentration for each scenario.

This calculation is based on the length-weighted-average concentrations and contamination depths of 1984 NYSDEC data. Only 1984 data were used to estimate the percentage in TI Pool.

Calculation of the LWA and contamination depth for each 1984 location

The 1984 NYSDEC sediment data have been extensively discussed and analyzed in the Phase 2 reports (DEIR USEPA, 1997, LRC USEPA 1998, DEIR Resp Summ USEPA 1998, LRC Resp Summ USEPA, 1999). This data set represents both core and grab data, with grabs outnumbering cores by about 2 to 1. The process to convert the concentration data to length-weighted-average concentrations is described briefly below.

For the 1984 grab samples, the LWA at each location is set equal to the measured concentration since only one value is available for the site. As part of the sample collection process, NYSDEC also collected sediment texture data and matched pairs of core and grab samples. On the basis of these data, NYSDEC assigned a contamination depth of 12.2 inch to coarse-grained sediment grabs and a depth of 16.9 inches to fine-grained sediment grabs. These depths were used without correction in this analysis.

The calculation of the LWA and depth of contamination for the cores was more involved. It was not appropriate to include all core layers in the calculation since frequently there were deeper layers with essentially no PCB contamination. To avoid the dilution of concentration caused by the inclusion of deep non-detected layers or "cold"-screened layers in the LWA, the criteria listed below were developed and applied. Note that the value of "3.3" is the concentration assigned to "cold"-screened sediment samples based on the analysis in USEPA (1997)- DEIR. Non-detect values were assigned a value of zero by NYSDEC in the original report.

a) If the first non-detected layer appears shallower than the first screen layer and only non-detected or screen layers follow the first non-detected layer, LWA concentration and depth are calculated based on all the layers above the first non-detected layer. For example, in a core with a surface to depth sequence of concentrations (ppm) of 10, 30, 5, 0, 3.3, 3.3, only the first three layers 10, 30, and 5 are used to calculate the LWA and depth of contamination. Similarly, for a core with a profile of 10.5, 0, 3.3, 0, only the first layer, 10.5, was used in the calculations.

b) If the first low level layer is a "cold"-screened result followed by subsequent non-detected or "cold"-screened layers, the LWA is calculated based on all the layers above the first "cold"-screened layer plus the first "cold-screened layer itself. For example, a core with the profile of 10, 30, 5, 3.3, 3.3, 0, the first four layers 10, 30, 5 and 3.3 were used to calculate the LWA.

c) Any non-detected layer or "cold"-screened layer which appears shallower than detected layer(s) were included in LWA concentration calculation. For example, a core with the profile of 0, 122.4, 3.3, 0, the first three layers 0, 122.4 and 3.3 were used to calculate the LWA concentration.

Based on these criteria, the contamination depth ($D_{contamination}$) of the core samples is equal to:

$$D_{\text{contamination}} = \sum_{i=1}^{n} D_i$$

Where:

D_i is the depth of each core segment. 1 represents the top segment and n is the deepest segment to be included in LWA calculation.

LWA is calculated as:

$$LWA = \frac{\sum_{i=1}^{n}(D_i * C_i)}{D_{\text{contamination}}}$$

Where:

C_i is the measured concentration of each layer.

The results of the LWA calculation are presented on Plate A-3 in Appendix A of this report. In reviewing the plate, it is evident that, like the MPA data presented in the main body of this report, the LWA values correlate with location. The highest LWA values are found in the near-shore environment in previously identified *hot spots* and areas of fine-grained sediment.

Estimate the area of river bottom to be assigned to each sampling point based on polygonal declustering

The second step involves the assignment of river bottom area to each sampling location. This has been done previously for the purposes of estimating sediment inventory (DEIR USEPA, 1997; LRC Resp Summ USEPA, 1999). The same mathematical approach is used here as was performed in Appendix B of the Low Resolution Sediment Coring Report Responsiveness Summary. A brief description of the polygonal declustering technique used in this analysis is transcribed from page 4-33 of the DEIR (USEPA, 1997):

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A simple method for addressing the problem of irregular sample spacing (or coverage) and clustering of data is a graphical technique known as polygonal declustering (Isaaks and Srivastava, 1989). As with other approaches to estimating total mass from spatial data, this relies on a weighted linear combination of the sample values. Weighting is formed graphically, however, without any assumptions regarding the statistical distribution of the data, and spatial correlation is not explicitly modeled. In this method, the total area of interest is simply tiled into polygons, one for each sample, with the area of the polygon representing the relative weighting of that sample. The polygons, called Thiessen polygons or *polygons of influence*, are drawn such that a polygon contains all the area that is closer to a given sample point than to any other sample point. Polygonal declustering often successfully corrects for irregular sample coverage. Because no complicated numerical methods need be applied, polygonal declustering provides a useful rough estimate of total mass to which the estimates obtained by other methods can be compared.

In the analysis presented here, Thiessen polygons are formed around all 1984 cohesive sample points. This procedure was repeated for the noncohesive sample points. Using the side scan sonar sediment classifications (Flood, 1993), the Thiessen polygons are clipped so that the LWA area for the cohesive sample points (based on visual texture classification) is applied only to cohesive areas of the river (defined by side-scan sonar) and, similarly, the LWA area for the noncohesive sample points is applied only to the noncohesive areas. For the side scan sonar sediment classification, cohesive areas are defined as fine- or finer-grained and noncohesive areas are coarse- or coarser-grained based on the original interpretation of the side-scan sonar images (Flood, 1993). Plate A-3 shows the result of this calculation, with each polygon coded according to its LWA.

<u>Obtain the intersection of the proposed removal boundaries and the sample polygons to determine the length-weighted-average concentrations in the areas to be removed.</u>

After assigning all areas of the TI Pool bottom to a specific sampling location, a further calculation was performed using a geographical information system (GIS) to match the areas to be removed with the LWA and depths of contamination estimated from the 1984 data. Each of the removal programs, full section, greater than 3 g/m^2 and greater than 10 g/m^2 yields an area of the TI Pool to be removed. This was matched to the polygons and clipped so that only those polygons contained within each removal zone were considered. Thus the number of polygons was fewest under the 10 g/m^2 scenario and greatest under the 3 g/m^2

<u>Calculate the volume of sediment at each concentration based on the polygons and the depth of sediment contamination.</u>

The volume of each polygon contained within the removal zones was determined in two ways, using the calculated depth of contamination described above, and using the dredge zone depth determined from the collection of sampling points contained within each dredge zone. The estimated volume was simply the product of the polygonal area and this depth.

The volume estimates were then grouped by PCB concentration and normalized to the total volume to be removed to produce the diagrams in Figure 1. These diagrams show the cumulative sediment volume at any given sediment concentration. Two curves are shown on each plot, one for the site-specific depths and one for the assigned dredge zone depths. The agreement between the two approaches is quite close. From these curve it is possible to estimate the percentage of sediment volume above or below any given concentration. For example, sediments at 32 ppm or above represent approximately 37 percent of the volume removed at 10 g/m^2, 28 percent at 3 g/m^2, and 20 percent under the full section removal. Similar but slightly lower values are obtained at 50 ppm (*i.e.*, 29 percent, 21 percent and 15 percent, respectively).

These results indicate that a relatively small portion of the dredged sediment (less than 37 percent in all cases) will require TSCA handling and disposal. It is important to note that this estimate does not account for losses of PCB inventory from the sediment since 1984 as documented in the LRC (USEPA, 1998) nor does it account for the inclusion of any uncontaminated material picked up during dredging. Both these concerns have the potential to decrease the volume of TSCA material by 10 percent or more.

The diagrams in Figure 1 can also be used to estimate the volume of sediment below 10 ppm, which would available for beneficial use. For the three removal scenarios, the percentages less than 10 ppm are 37, 44 and 46 for the 10 g/m^2, 3 g/m^2, and full section removal programs, respectively.

3. Estimation of the Volume of TSCA Materials Below the TI Dam

Below the TI Dam, the data available to estimate sediment volumes is much more limited. In particular, two data sets provide some information but neither is sufficient to estimate sediment volume in the fashion applied to the TI Pool. The first of these data sets, the 1976-1978 sediment survey by NYSDEC is vertically limited, that is, most sample collection depths do not extend below 12 inches. As shown in the LRC (USEPA, 1998), this shortcoming led to the underestimation of sediment inventory in at least one *hot spot*. Thus the 1976-1978 survey cannot be used to estimate sediment volume directly via a polygonal declustering approach. The 1994 USEPA survey is limited spatially, focusing on a limited number of *hot spots*. Thus this data set cannot represent all areas of the region. However, the coverage provided by the 1994 survey can be used for the more limited removal options (10 g/m^2 and 3 g/m^2), as discussed below.

In the 1994 USEPA low resolution sediment coring program, the program objectives below the TI Dam were to spatially characterize the PCB inventories and concentrations in a limited number of *hot spots*. The *hot spots* selected represented more than 75 percent of the mass of PCBs estimated from the 1976-1978 NYSDEC surveys (see Table 1). Based on this coverage, the 1994 survey was deemed to be sufficiently representative of the *hot spot* areas below TI Dam to characterize the sediment volumes. Additionally, the placement of cores in these areas was approximately evenly spaced with no preferential sampling of any area within the *hot spot*. Plate A-8 presents the 1994 results as LWA for each coring location.

Unlike the 1984 data, it was judged that there was an insufficient number of points to apply a polygonal declustering analysis to assign an area and calculate the sediment volume associated with each individual core location. Instead the cores were weighted solely on the basis of their length, effectively assigning an equal area to each core. On this basis, all 1994 cores obtained within the 10 g/m^2 and 3 g/m^2 scenario boundaries were used to estimate the respective distributions of the sediment volumes.

Core length and LWA were determined based on the core segment data, with deeper segments excluded when the concentration fell below 1 ppm. Because of the extremely low detection limits achieved by the USEPA as well as the issue of cross-contamination, it was decided that a 1 ppm cutoff would most accurately represent the true thickness of contaminated sediment with in a core. The procedures for calculating LWA and core length were the same as those used for the 1984 data. The criteria for inclusion of a core segment in the calculation for a single core paralleled that used for the 1984 cores. Specifically, if deeper core segments fell below 1 ppm consistently, all of these segments were excluded from the calculation. For example, in the sequence of 10, 30, 0.8, 0.9, top to bottom, only the first two segments (10, 30) would be included in the LWA and core depth calculations. Cores which had low surface concentrations but higher levels at depth would include all segments until less than 1 ppm was reached at depth. For example, in the top to bottom sequence of 0.7, 3, 4, 0.6, the first three segments would be used in the calculations. Cores with less than 1 ppm concentrations in the top most core segment layer and all lower segments had a LWA and depth based solely on the first segment.

To estimate the distribution of the sediment volume as a function of the LWA, the core lengths, rather than an calculated core volume, were used as weighting factors. In this approach, longer cores are weighed more heavily than shorter ones, essentially accounting for the greater removal depth and volume associated with them. Tables 2 and 3 present the results of the calculations for the 10 g/m^2 and 3 g/m^2 scenarios, respectively. In each case the percentage of sediment volume above 50 ppm, 32 ppm and less than 10 ppm are estimated based on the sum of core lengths with LWA values above or below the criterion relative to the sum of all core lengths. This calculation is equivalent to assigning the same surface area to each core and calculating a volume for each core using the core length for depth.

These calculations estimate a larger proportion of the sediment removal will require TSCA handling below the TI Dam relative to the results from the 1984 data in the TI Pool. Specifically, for the 3 g/m^2 removal scenario, 66 percent of the material removed exceeds 32 ppm as compared to 28 percent for the same conditions in the TI Pool. However, the areas requiring remediation under 3 g/m^2 represent a substantially smaller portion of the river bottom below TI Dam relative to the TI Pool.

A similar condition is seen for the 10 g/m^2 removal scenario, with 77 percent of the material removed requiring TSCA treatment below TI Dam. This is in contrast to the 37 percent estimated for the TI Pool under this removal scenario.

As would be expected the proportion available for beneficial use under these scenarios is a much smaller proportion of the total relative to the TI Pool. Note that the volume proportions estimated here apply to all areas below TI Dam, that is Sections 2, 3a, 3b and 3c.

Finally, it should be noted that a similar set of estimates could not be made for the full section removal scenario because a consistent set of data are lacking. In particular, both the 1976-1978 NYSDEC survey data and the 1991 GE composite samples do not provide sufficient vertical measurements for the purposes of a removal calculation. It is anticipated, however, that the majority of the difference between the 3 g/m^2 scenario and the full section removal in Section 2 would add little to the TSCA volume estimates as well as substantially increase the volume of material for beneficial use.

Table 1
***Hot Spot* PCB Inventory Below TI Dam**

1984 NUS Report		**Areas Covered by LRC**
Hot Spot No.	PCB Quantity (lbs)	PCB Quantity (lbs)
21	360	
22	600	
23	180	
24	520	
25	2,440	2,440
26	460	
27	340	
28	9,090	9,090
29	220	
30	690	
31	8,150	8,150
32	170	
33	950	
34	12,350	12,350
35	2,090	2,090
36	5,000	
37	11,860	11,860
38	1,300	
39	3,720	3,720
40	3,750	
Total	64,240	49,700
Precentage of Estimated inventory		**77.4**

Table 2

Estimation of Sediment Volumes Below TID for the 10 g/m^2 Removal Scenario

Distribution of Length Weighted Average (LWA)

1/2 Log_{10} Bins (ppm)	Total Core Length (in.)	No. of Cores
<-1.5		
<0.0	8	1
<0.5	7	1
<1.0	43	5
<1.5	192	14
<2.0	337	15
<2.5	272	12
<3.0	238	7
	1097	

Sediment Volume Estimates

	Sum of Core Lengths	%Length
<=32 ppm	250	23%
>32 ppm	847	77%
Total	1097	

	Sum of Core Lengths	%Length
<=50 ppm	355	32%
>50 ppm	742	68%
Total	1097	

	Sum of Core Lengths	%Length
<=10 ppm	58	5%
>10 ppm	1039	95%
Total	1097	

Notes:
1. Grouped by length weighted average 1/2 log base 10 steps.
2. Samples with concentrations <1 ppm omitted unless all samples in the core were below 1 ppm.

Table 3

Estimation of Sediment Volumes Below TID for the 3 g/m² Removal Scenario

Distribution of Length Weighted Average (LWA)

1/2 Log_{10} Bins (ppm)	Total Core Length (in.)	No. of Cores
<-1.5		
<0.0	8	1
<0.5	24	3
<1.0	104	11
<1.5	307	20
<2.0	337	15
<2.5	272	12
<3.0	238	7
	1290	

Sediment Volume Estimates

	Sum of Core Lengths	%Length
<=32 ppm	443	34%
>32 ppm	847	66%
Total	1290	

	Sum of Core Lengths	%Length
<=50 ppm	548	42%
>50 ppm	742	58%
Total	1290	

	Sum of Core Lengths	%Length
<=10 ppm	136	11%
>10 ppm	1154	89%
Total	1290	

Notes:
1. Grouped by length weighted average 1/2 log base 10 steps.
2. Samples with concentrations <1 ppm omitted unless all samples in the core were below 1 ppm.

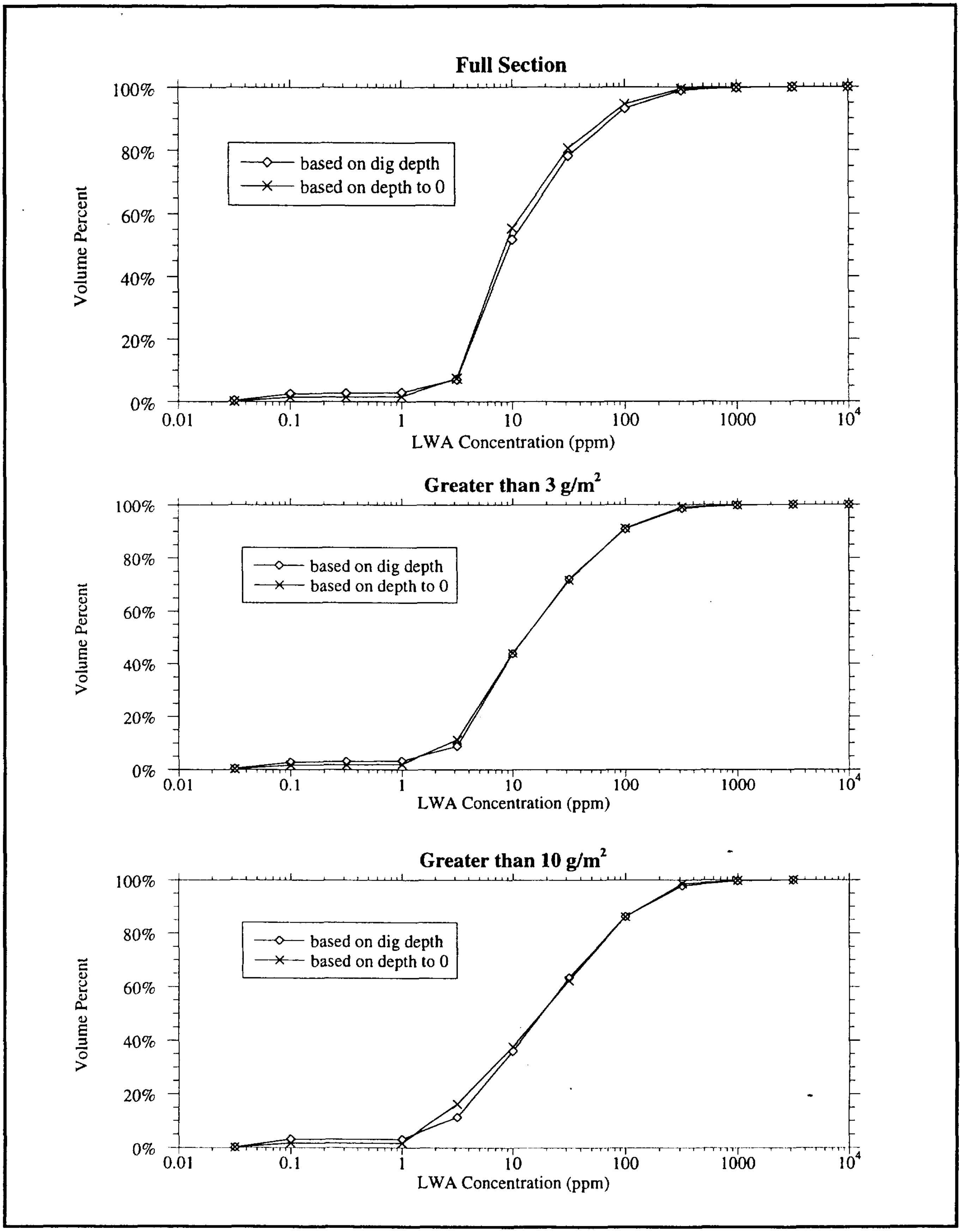

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Figure 1

Cumulative Percentage of Sediment Volume Removal based on Length Weighted Average Concentration for Different Alternatives within TI Pool

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX E

ENGINEERING ANALYSIS

E.13 TECHNICAL MEMORANDUM: ESTIMATION OF SEDIMENT PCB INVENTORIES FOR REMOVAL

Prepared by
TAMS Consultants, Inc.
300 Broadacres Drive
Bloomfield, NJ 07003

NOVEMBER 2000

Estimation of Sediment PCB Inventories for Removal

1. Estimation of the PCB Inventory in River Section 1

Removal

The PCB inventory of the TI Pool has been extensively examined during the Phase 2 investigation. As discussed in Section 3.3.2.3 of the report, the most current estimate combines the 1992 USEPA side-scan-sonar data with the 1984 NYSDEC sediment survey results (converted to mass per unit area) to estimate the inventory of River Section 1. The NYSDEC 1984 survey represents the only data collection effort of sufficient magnitude to enable the direct calculation of the PCB inventory, estimated to be 15.4 metric tons or about 34,000 pounds. As documented in the LRC and its responsiveness summaries, this inventory is likely to have declined since 1984 but the exact amount of decline can only be estimated for the areas of highest contamination.

For the purposes of the FS, PCB removal estimates were needed for each of the removal scenarios. To accomplish this, the removal zones for each individual removal scenario ($10 g/m^2$, Expanded Hot Spot remediation and Full-Section remediation) and the polygonal declustering results were integrated onto a single map. The intersection of the polygonal declustering results and the scenario-specific removal zones defined a set of polygons representing the sediments to be removed under each scenario. The summation of the mass of PCBs in these polygons was taken as a best estimate of the PCBs to be removed. The mass estimate was calculated using the area of each polygon and the MPA estimate derived from the 1984 data as:

$$Mass_{Removal} = \sum_{i=1}^{n} (Area_i * MPA_i)$$

where:

n is the total number of polygons within the removal zone; and
removal target refers to $10 g/m^2$, Expanded Hot Spot remediation or Full-Section remediation.

The application of the 1984 data is described in detail in the Data Evaluation and Interpretation Report (USEPA, 1997) and Appendix B of the Responsiveness Summary for the Low Resolution Sediment Coring Report (LRC, USEPA, 1999).

The formula given above was used to estimate the PCB mass removed for the individual removal zones as well as for the entire removal scenario. A table summarizing the mass of PCB removed by scenario is provided in chapter 3 of the FS report and the calculations are not repeated here. An effective removal efficiency of 100 percent was assumed for the estimate of PCB mass removed. Residual sediments were not assumed to be completely free of PCBs however. This is discussed in the main body of the report under the model simulations.

Capping with Dredging

Under this remedial approach, River Section 1 is separated into several zones based on water depth and depth of sediment contamination. These zones undergo various degrees of removal and capping as appropriate. This is described in detail in the main body of the FS. Effectively, the capping with dredging concept divides the river bottom into zones as follows:

For water depth between 0-6 ft:

If depth of contamination is less than or equal to 2 ft, dredging only with backfill.
If depth of contamination is greater than 2 ft, dredge to 1.5 ft and then cap and backfill (*i.e.*, dredging followed by capping).

For water depth between 6-12 ft:

If depth of contamination is less than or equal to 2 ft in the vicinity of dredging only in the 0-6 ft area, dredging only with backfill.
If depth of contamination is greater than 2 ft, cap and backfill (*i.e.*, capping only).

For water depth greater than 12 ft (navigation channel):

Dredging only, no capping.

In general, the depth of sediment PCB contamination exceeds 2 ft so the areas without a cap are relatively small under each capping with dredging target area delineation.

The calculation of the mass of PCBs removed under the capping with dredging target area delineations was performed in a fashion similar to that for the removal delineations. Using the Hudson River GIS, the intersection of the polygonal declustering coverage with each of the various capping zones listed above was used to identify the polygons affected by each zone. The estimate for the actual mass removed depended on the zone. For the zones with dredging or dredging and backfill (*i.e.*, less than 2 ft of contamination or greater than 12 ft of water depth), 100 percent removal was applied as follows:

$$Mass_{Removal} = \sum_{i=1}^{n} (Area_i * MPA_i)$$

where:

n is the total number of polygons within the "dredging only" zone.

For zones undergoing capping with dredging (*i.e.*, capping in areas with water depths less than 6 ft and more than 2 ft of contaminated sediment), 50 percent removal was applied to the samples whose contamination depth is greater than 1.5 ft. So, PCB mass removal in the zone of "dredging followed by capping" ($Mass_{DredgingFBC}$) was calculated as follows:

$$Mass_{DredgingFBC} = \sum_{i=1}^{n_1} (Area_i * MPA_i) + \sum_{j=1}^{n_2} (Area_j * MPA_j * 0.5)$$

where:

n_1 = the number of polygons corresponding to the samples whose contamination depth is less than 1.5 ft.;

n_2 = the number of polygons corresponding to the sample whose contamination depth is greater than 1.5 ft.; and

$n_1 + n_2$ = the total number of polygons within the "dredging followed by capping" zone.

Finally, for areas undergoing capping only (*i.e.*, areas with water depths from 6 to 12 ft and more than 2 ft of contaminated sediment), no PCB removal mass was calculated.

Note that the calculation only summarizes the PCB mass removed and not the entire PCB mass remediated by a capping with dredging target area delineation.

2. Estimation of the PCB Inventory in River Section 2 and 3

In River Sections 2 and 3, data are far more limited for the purposes of estimating PCB mass removed. In particular, only two data sets exist which can provide this kind of information, the 1976-1978 NYSDEC survey and the 1994 USEPA low resolution coring program. The former study is limited in its applicability because of its age and more importantly because PCB inventory at depth was not well represented (cores and grabs did not extend below 12 inches in the vast majority of instances). The spatial coverage provided by this survey was also far less extensive than the 1984 survey in River Section 1 but this would not preclude the use of the 1976-1978 survey *per se*.

The 1994 survey provided useful estimates of PCB mass in the eight areas studied. However, its spatial coverage is limited to just these areas and cannot provide a section-wide PCB inventory estimate although these areas are considered representative of the cohesive sediments in this region of the Hudson.

Several approaches were used to examine the PCB inventory in this region. The 1976-1978 NYSDEC survey was used to approximate the proportion of PCBs in cohesive and non-cohesive areas. It was also used to estimate the absolute inventory in the areas outside the Expanded Hot Spot remediation boundary. (It should be noted as well that the 1976-1978 survey data along with the 1994 data were used in constructing the Expanded Hot Spot remediation and Hot Spot remediation boundaries.) The 1994 data were used to estimate the PCB inventories contained within the Expanded Hot Spot remediation and Hot Spot remediation boundaries as well as in the cohesive sediments.

Sediment Removal

Application of the 1976-1978 NYSDEC Survey Data

A review of the Hudson River Reassessment Database and a recent report from NYSDEC prepared by Malcolm-Pirnie (1992) revealed several discrepancies between the data sets. Specifically, some data were found in the Hudson River Reassessment Database that were not included in the Malcolm-Pirnie presentation, and *vice versa*. Additionally some data were assigned different locations in the Hudson River Reassessment Database relative to the Malcolm-Pirnie report. The number of discrepant locations were large and, therefore, had to be reconciled prior to their use. In total, there were 665 sample locations and associated PCB data that were found both on the Malcolm-Pirnie maps and in the USEPA electronic database; 100 locations were found on the Malcolm-Pirnie maps but not in the electronic file; and 154 locations were found in the electronic file but not on the Malcolm-Pirnie map. Of the 154 unique locations in the USEPA database, 12 appeared to match locations on the Malcolm-Pirnie maps but at slightly different coordinates. Lacking further information, it was assumed that the coordinates on the Malcolm-Pirnie maps were correct for these 12 samples. This resolution yielded a total of 907 unique sampling locations. A portion of these data (22 samples) appeared to represent field duplicates. Only the first station listed in the database was used in these instances. This yielded a total of 885 locations for subsequent polygonal declustering calculations.

The data from these locations were used to calculate the PCB inventory (MPA) at the time of the NYSDEC survey. The calculation of the MPA is given in subsection 3.3.4 of the FS. The sampling locations themselves were used to create a polygonal declustering coverage for River Section 2. This coverage with the associated MPA values was used to estimate the PCB inventory outside the Expanded Hot Spot remediation boundary (7.3 metric tons). However, in light of the uncertainties associated with the 1976-1978 survey, as noted above, one half of this value was used as a lower bound estimate for the purposes of PCB mass removal under the Full-Section removal target area delineations.

Application of the USEPA Low Resolution Sediment Coring Data

As discussed above, the 1976-1978 NYSDEC survey was only used to estimate the sediment inventory in the areas outside the Expanded Hot Spot remediation boundary. The areas inside this boundary were characterized by the 1994 low resolution sediment coring survey. This survey was designed to characterize the current inventory in 7 *hot spots* originally defined by NYSDEC. Additionally, this survey was compared with dredge zones later defined by NYSDEC in a draft report from Malcolm-Pirnie (1992). The 1994 USEPA coring effort successfully inventoried these areas of the Upper Hudson and provided a basis for the total PCB inventory in the study areas.

In general, these areas tended to be regions of cohesive sediment as defined by the 1992 USEPA side-scan-sonar survey. As part of the original study design, the areas selected for low resolution sediment coring represented the major portion (more than 75 percent) of the *hot spot* inventories originally identified by NYSDEC (NUS, 1984). This is illustrated in Table RE-1 which lists all of the NYSDEC *hot spots* below TI Dam along with their estimated inventories. Also shown are the seven *hot spot* inventories covered by the USEPA survey and the fraction of the total PCB inventory they represent (77 percent). Thus, although the USEPA study did not cover all areas, it covered a sufficient proportion of the sediment PCB mass so as to permit the estimation of the remaining inventory.

To estimate the PCB inventories of the areas contained within the Expanded Hot Spot remediation and Hot Spot remediation boundaries, the following procedure was applied.

1. All low resolution sediment cores falling within the target area boundaries were selected. Because the Hot Spot remediation boundaries were contained within the Expanded Hot Spot remediation boundaries, the cores selected for the Hot Spot remediation were a subset of those selected to assess the Expanded Hot Spot remediation.

2. As noted in the LRC, these data were log-normally distributed. Thus log-transform statistics were applied to the data to estimate PCB inventory. Of these, 44 fell within the Expanded Hot Spot remediation boundary, while only 37 fell within the Hot Spot remediation boundary. The geometric mean, the simple arithmetic mean and the Minimum Variance Unbiased Estimate (MVUE) of the arithmetic mean of the MPA data from these locations were calculated according to the formulations given in Gilbert (1987). Because the data are log-normal, the MVUE values were selected as the best estimates of the mean MPA. The MVUE of the selected samples were assumed to represent the average MPA for all unmeasured selected areas in River Section 2 under each removal target area delineation. The MVUE was also calculated within each removal zone based on the data collected within that zone. Thus, PCB inventories for the areas surveyed in 1994 were estimated from the points contained within each removal zone while the MVUE of the MPA for River Section 2 was applied to the removal areas not covered by the 1994 survey.

3. The estimate of the PCB inventory for each delineation was calculated as the sum of mass in the measured target area and mass in the unmeasured (extrapolated) area. The mass in the unmeasured area is the product of the MPA (MVUE) based on selected samples and the total unmeasured area selected. The mass in the measured area is the sum of mass in the hot spots. The mass in the target areas is the product of MPA (MVUE) and the surface area.

4. For Section 3, a parallel approach was used, applying the same steps to the low resolution sediment cores available in this region. Of these, 19 fell within the Hot Spot remediation boundary and 24 fell within the Expanded Hot Spot remediation boundary. However, the MVUE from *Hot Spot* 37 was used for the dredge zones containing no low resolution sediment cores. The other dredge zone area containing low resolution sediment cores in this river section is *Hot Spot* 39. This *hot spot* was unusual in that high PCB concentrations were found a depth indicating a high deposition area. This situation is not likely to be representative of the other target areas in River Section 3, so the cores in *Hot Spot* 39 were not used to estimate the mass in the remaining target areas. Also noteworthy, the MPA of this region was substantially less than that for River Section 2, largely because of the very high inventories found in cores from *Hot Spot* 28 in River Section 2. Table RE-2 contains a summary of MVUE for PCB mass per unit area and removal mass below the TI Dam.

The actual PCB masses estimated for the Expanded Hot Spot remediation and Hot Spot remediation scenarios are given in the main body of the FS for River Sections 2 and 3. For the Full-Section removal in River Section 2, the estimate combines the 1994 data for the Expanded

Hot Spot target areas with the 1977 data for the areas outside the target areas. Because of the uncertainties associated with the 1977 data, (*i.e.*, shallow coring depths and potential sediment inventory changes), one half of the mass estimated from the 1977 data (3.65 of 7.3 metric tons) was used as a part of the lower bound estimate given here. Full-Section removal was not delineated for River Section 3 and, therefore, was not calculated.

Capping with Dredging

Capping with dredging in River Sections 2 and 3 is largely defined on the basis of contaminant depth and water depth, as was done for River Section 1. For the purposes of estimating the PCB mass removed under each capping with dredging target area delineation, a calculation approach different from that used in River Section 1 was applied. Since no complete polygonal declustering coverage is available for these two river sections, it was assumed that all the samples are equally representative of the total PCB mass in this area. Thus, the PCB mass removal in the different capping with dredging target areas can be estimated as a proportion of the total PCB mass associated with the removal target areas described above. For the target areas where only dredging occurs, the removal mass is calculated as:

$$Removal\ Mass_{Dredging\ only} = \frac{Area_D}{Area_t} * Mass_T$$

where:

$Area_D$	=	the surface area of dredging only target areas;
$Area_T$	=	the total capping target area; and
$Mass_T$	=	the total mass of PCB removed, as obtained from the removal calculation

The contamination depth needs to be considered in calculating the removal mass in the capping with dredging target boundaries. All the samples which fell within the target boundaries in River Sections 1 and 2 were selected for different capping with dredging delineations. All the low resolution sediment cores falling within the target boundaries were used to estimate the proportion of area with complete removal and the proportion of area with less-than-complete removal (assigned a value of 50 percent removal). Based on the cores, the percentage (*X*) of samples with a contamination depth greater than 1.5 ft was calculated. The PCB removal mass within the target boundaries was then estimated as follows:

$$Removal\ Mass_{D+C} = \frac{Area_{D+C}}{Area_T} * Mass_t * (1 - X) + \frac{Area_{D+C}}{Area_T} * Mass_t * X * 0.5$$

where:

$Area_{D+C}$	=	the surface area of dredging followed by capping target area;
$Area_T$	=	the total capping target area; and
$Mass_T$	=	the total PCB removal mass obtained from the Full-Section PCB removal delineation.

Again, it is assumed that, for the samples with contamination depth greater than 1.5 ft, 50 percent of inventory is removed by dredging 1.5 ft. As in River Section 1, there was no PCB mass removal in the target areas for which only capping is performed.

References

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Table RE-1
Hot Spot PCB Inventory Below TI Dam

1984 NUS Report		Areas Covered by LRC
Hot Spot No.	PCB Quantity (lbs)	PCB Quantity (lbs)
21	360	
22	600	
23	180	
24	520	
25	2,440	2,440
26	460	
27	340	
28	9,090	9,090
29	220	
30	690	
31	8,150	8,150
32	170	
33	950	
34	12,350	12,350
35	2,090	2,090
36	5,000	
37	11,860	11,860
38	1,300	
39	3,720	3,720
40	3,750	
Total	64,240	49,700
Precentage of Estimated inventory		**77.4**

Table RE-2
MVUE for PCB Mass Per Unit Area and Removal Mass in River Section 2 and 3

	MVUE for PCB Mass per Unit Area	
	3 g/m^2 dredging zone [1]	10 g/m^2 dredging zone [2]
River Section 2		
Hot Spot 25	27.9	39.9
Hot Spot 28	158.8	158.8
Hot Spot 31	12.3	19.9
Hot Spot 34	8.7	11.3
Hot Spot 35	17.8	17.8
River Section 3		
Hot Spot 37	16.1	16.1
Hot Spot 39	34.8	30.3
River Section 2 [3]	53.7	69.9
River Section 3 [4]	16.1	16.1

Mass in 3 g/m^2 dredging zone (kg)

	Measured [5]	Calculated [6]	Total
River Section 2	27,151	4,098	31,248
River Section 3	5,410	5,244	10,655
River Sections 2 and 3	32,561	9,342	41,903

Mass in 10 g/m^2 dredging zone (kg)

	Measured [5]	Calculated [6]	Total
River Section 2	21,491	2,137	23,628
River Section 3	5,410	1,312	6,723
River Sections 2 and 3	26,901	3,450	29,038

Notes:
1. MVUE are calculated based on all the samples within the overlay of *hot spot* (NYSDEC) and 3 g/m^2 dredging area.
2. MVUE are calculated based on all the samples within the overlay of *hot spot* (NYSDEC) and 10 g/m^2dredging area.
3. MVUE for Section 2 is based on the entire set of data points from the *hot spots* in the section.
4. MVUE for River Sections 3 is based on *Hot Spot* 37 only. See text for discussion.
5. Measured mass is contributed by the areas where *hot spots* overlay the dredging zones. The mass is equal to the area of the individual polygon multiplied by the MVUE MPA of corresponding hotspot.
6. Calculated mass is contributed by the dredging areas beyond the hot spots. The mass is equal to the area of the individual polygon mutiplied by the regional MVUE MPA (3 g/m^2 dredging scenario, 70.2 for River Section 2 and 23.3 for River Section 3; 10 g/m^2 dredging scenario, 84.2 for River Section 2 and 26 for River Section 3).

Appendix F

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX F

HABITAT REPLACEMENT PROGRAM DESCRIPTION

APPENDIX F
HABITAT REPLACEMENT

1. INTRODUCTION

This discussion presents conceptual measures intended to mitigate disturbances to aquatic and wildlife habitat resulting from implementation of a remedial alternative. The remedial alternative categories -- No Action, Monitored Natural Attenuation, Removal, and Capping with Dredging -- have been described in detail in this FS. The remedial alternative that would result in habitat disturbance requiring replacement measures are Removal and Capping with Dredging. These alternatives may potentially pose some or all of the following habitat disturbances:

- Removal or capping of substrate used as spawning and foraging habitat by fish and benthic invertebrate species;
- Displacement of benthic organisms;
- Loss of vegetation communities;
- Loss of freshwater wetlands acreage and wetland functional values; and
- Disturbance of riparian habitat and shoreline stability.

The remaining discussion on habitat replacement is organized as follows:

- Section 2 provides a general habitat description of the Upper Hudson River;
- Section 3 focuses on the objectives of the replacement;
- Section 4 presents the replacement concepts and their implementation; and
- Section 5 explores concepts for habitat replacement monitoring, evaluation, and adaptive management to confirm that the replacement objectives are achieved.

2. HABITAT DESCRIPTION

The Upper Hudson River is entirely freshwater and non-tidal and, in the context of this Feasibility Study, extends from the Federal Dam at Troy (RM 153.9) to the former Fort Edward Dam (RM 194.8). This area includes deeper water environments as well as shallower littoral zones characterized by aquatic vegetation and backwaters. Specific habitats include forested shoreline wetlands and transitional uplands, vegetated backwaters (emergent marsh and scrub-shrub wetlands), offshore shoals and channel, rock piles, tailwater, and major tributaries.

The river provides diverse habitats for all trophic levels of the river's ecosystem. Plants, plankton, aquatic invertebrates, fish, amphibians, reptiles, birds, and mammals use the Hudson River for feeding, reproduction, and shelter. In addition to the aquatic communities associated with the river, animals living in riparian, wetland, floodplain, and upland communities are also dependent on the river.

During the August 1992 ecological field sampling effort, a baseline vegetative survey was performed at nine stations in the Upper Hudson River. A plant ecologist conducted the survey by identifying dominant submergent and emergent vegetation observed in intertidal, bank, and upland areas, when possible. A list of species identified throughout the field investigation is provided in Table B-6 of the Baseline Ecological Risk Assessment (USEPA, 1999).

Similar plants were present at the nine Upper Hudson River stations, including nearly all the same dominant submergent plants (*e.g.*, wild celery, water chestnut). The most prevalent aquatic plant noted was water chestnut (*Trapa natans*), which was abundant along nearly the entire river. Water chestnut is an introduced species, whose rosettes of floating leaves crowd together in mats, choking freshwater shallows, limiting boat access, and shading out other submergent vegetation (Stanne *et al.*, 1996). Some locations in the Upper Hudson (*e.g.*, side channel around Griffin Island) were inaccessible due to the thick mats of water chestnut encountered during the ecological sampling. While it is an invasive species, water chestnut beds may harbor large populations of invertebrates and young fish.

Emergent species (*e.g.*, arrow arum, pickerelweed) were located at about half the stations sampled. Generally, areas of the river with reduced flow velocity allow fine-grained sediments to settle out, providing favorable conditions for plant growth. Vegetation observed on the river bank varied, but a majority of locations included silver maple (*Acer saccharinum*) and white ash (*Fraxinus americana*).

As indicated in Table 2-2 of the Revised ERA (USEPA 2000), the dominant macroinvertebrates found in the 1992 ecological sampling were isopods, midges, worms, amphipods, and clams. Vertebrates potentially found in or along the Upper Hudson River are also listed in Section 2 of the Revised ERA. Fish and fish aggregations observed in the Upper Hudson (NYSDEC, 1989) are listed in Tables 2-1 and 2-2. Amphibians, reptiles, birds, and mammals potentially found along the Hudson River are listed in Tables 2-3 to 2-6 of the Revised ERA (USEPA, 2000).

For the purpose of discussing conceptual habitat replacement measures, the physical habitats of the river have been delineated into the following zones:

- **Deep river** - areas of the river that are deeper than the photic zone (*i.e.*, depth to light penetration), defined here as a depths exceeding six feet. The substrate of the deep open river zone is largely characterized as "non-cohesive" and is not vegetated.
- **Shallow river** - open waters of the river that are within the photic zone (*i.e.*, depths less than six feet). A mixture of substrate types (cohesive and non-cohesive) are present in the shallow river.
- **Emergent wetlands** - emergent wetlands that occur in areas of the river with reduced flow velocity (vegetated backwaters) that allow fine-grained sediments to settle out.
- **River bank** - the riverine shoreline or riparian zone (vegetated and non-vegetated).

3. HABITAT REPLACEMENT OBJECTIVES

This section presents specific objectives of the habitat replacement concepts.

3.1 Restore Fish Habitat

The Removal and Capping with Dredging alternatives would disturb the riverine and wetland habitats that fish utilize for spawning, shelter, and foraging. Specific goals of habitat replacement are to provide *substrate* suitable for fish spawning habitat and adequate *cover* to serve as shelter and foraging habitat.

3.1.1 Substrate

The textural composition of the substrate influences the survival and emergence of the embryos of many fish species. Substrate texture affects the pore size and permeablilty of the sediments, which, in turn, regulate intragravel water velocity and oxygen transport to incubating embryos and control intragravel movement of newly hatched fish (Colorado Cooperative Fishery Research Unit, 1984).

The ideal spawning habitat for many species is a combination of certain hydraulic conditions and a complex mixture of sediment sizes. Fish seek substrate that is free of boulders (because nests cannot be formed in them), low in fine (cohesive) sediments (which reduce permeability), and high in gravel (which is permeable and can be moved). Some fine sediments may be important to protect eggs and larvae from predators and high subsurface velocities, and to keep them in the substrate during floods. Substrate type is not so critical to nest builders and guarders (*e.g.*, species of sunfish) as it is to other species that do not guard the eggs but cover them and leave. Many fish species require a vegetation substrate to which eggs stick during embryo development (Colorado Cooperative Fishery Research Unit, 1984).

3.1.2 Cover

Places where fish rest, hide, and feed are cover. Cover serves to visually isolate fish, which increases the number of territories in the same place. Less commonly, cover is defined as vegetation growing over the substrate. Although vegetative cover may not provide concealment, it is necessary for reproduction of some species. Morphological features such as large rocks, pocket pools and deep pools, and undercut banks; and aquatic and overhanging vegetation, riparian communities that provide material for brush piles, and logs define the amount and type of cover (Colorado Cooperative Fishery Research Unit, 1984).

3.2 Replace Benthic Habitat and Encourage Recolonization

A second objective of the habitat replacement concept is to replace substrate that serves as habitat for benthic macroinvertebrates. Benthic macroinvertebrates process organic materials contributing to energy and nutrient recycling but, more importantly, they serve as the foundation in aquatic food chains. The provision of a variety of benthic habitat types (*i.e.*, sand, gravel, and rooted vegetation that epifaunal invertebrates may colonize) would encourage the recolonization of a diverse benthic invertebrate community. Substrate heterogeneity and stability are the key factors in providing for increased abundance and species richness of colonizing benthic invertebrate communities.

3.3 Replace Vegetation Communities

A third objective of the habitat replacement concept is to replace vegetation communities that are disturbed during remediation activities. These communities include rooted and non-rooted aquatic vegetation, as well as shoreline trees. Vegetation is a key component of the riverine environment, being the primary producer and a significant factor in maintaining channel stability. Vegetation fixes solar radiation, making this energy available for a wide range of herbivores including invertebrates, fish, birds, and mammals. The aquatic vegetation can be important in aerating the water, providing shelter, and providing a spawning or egg-laying medium for fish and freshwater invertebrates. Emergent and marginal plants provide shelter and nesting habitat for a variety of fauna including birds and invertebrates. The vegetation is also important in the consolidation of the river bed and banks (Wade, P.M. in Peats and Calow, 1996).

3.4 Replace Wetlands

A fourth objective is to replace wetlands of at least equal value to those disturbed during implementation of a remedy The replaced wetlands would be designed to provide several functions and values; specifically, wildlife habitat, flood control, and water quality improvement at levels equivalent to those currently provided by the existing wetlands.

3.5 Stabilize Shorelines

The final objective of the habitat replacement concept is to provide for bank stability following implementation of remediation activities. Bank stability has an influence on the habitat quality of the river. Bank erosion contributes silt, which reduces light penetration, smothers fish eggs and benthic macroinvertebrates, fills pools, and may cause oxygen depletion in the water column. Slope, substrate type, soil-binding by vegetation roots, bank rock content, and extent of disturbance determine bank stability. Banks with well-developed riparian vegetation are protected from erosion and provide a source of food for small fish (Colorado Cooperative Fishery Research Unit, 1984). Small fish use slower water along margins of rivers and depend on terrestrial organisms from shoreline vegetation for food because most aquatic drift organisms escape them.

4. REPLACEMENT CONCEPTS

Habitat replacement concepts have been formulated for the following four zones typical of the stretch of the Hudson River extending from the Federal Dam to Rogers Island:

- Deep river,
- Shallow river,
- Emergent wetlands, and
- River bank.

Habitat replacement concepts have not been formulated for deep river areas with bottom depths greater than 12 feet. At depths below 12 feet, areas subject to the removal of PCB-contaminated sediments would not be capped or backfilled. For this reason and due to the absence of rooted aquatic vegetation at these depths, opportunities for replacement would be limited, would incur additional costs, and would accrue only marginal ecological benefits. Estimated quantities and costs for planting and seeding replacement are presented in Table F-1.

4.1 Deep River Habitat Replacement

Deep river areas are characterized by bottom depths below the photic zone, the illuminated water column and river bottom to which photosynthesis is restricted. The depth of light penetration in the Upper Hudson River varies on both temporal and spatial scales. However, for the purpose of formulating habitat replacement concepts, the typical depth of the photic zone is assumed to be approximately six feet. Therefore, deep river habitat replacement concepts pertain to river areas with post-backfilling depths ranging between 6 and 12 feet.

Habitat replacement objectives for the deep river zone are to:

- replace fish habitat, and
- replace benthic habitat and encourage recolonization.

Habitat replacement methods applicable to the deep river zone are limited. Due to the absence of sufficient light levels for photosynthesis, establishment of rooted aquatic vegetation is not an option. The need to maintain the navigability of the river, and avoid the creation of obstructions and hazards to boat traffic, precludes the extensive deployment of hard structures. For these reasons, appropriate replacement methods are restricted to the placement of suitable substrate and the limited deployment of boulder clusters.

4.1.1 Backfill Materials and Placement

Most of the remediated area within the deep river zone would be backfilled with a one-half-foot deep layer of gravel over a one-half-foot deep layer of sand. (For the purpose of calculating remediation costs, this backfill cross-section is assumed for all remediation areas in this zone.) The intent is to return the river bottom to a stable, well-sorted substrate, often a critical requirement for fish spawning and secondary production by aquatic insects. Although a gravel substrate would be suitable for most fish species in this zone, the ideal spawning habitat for many species is a complex mixture of sediment sizes. Therefore, a one-foot deep layer of sand would be placed in some locations to create a mosaic of substrates. Backfill comprising fine sediments would not be placed in the deep river zone. However, over time silt and fine sands would be transported into the backfilled areas by currents, gradually increasing the heterogeneity of the substrates.

4.1.2 Boulder Clusters

Clusters of boulders would be placed in selected locations, primarily to provide cover to serve as fish shelter and foraging habitat. In locations with higher average flows, generally those exceeding two feet per second, boulder clusters would also create scour holes and areas of reduced velocity immediately down river from the boulders. Boulder clusters would be placed only on gravel backfill, where they would be most effective; not on sand backfill, where they would tend to be buried by transported sediment. To preclude conflicts with the use of the river for navigation, boulder clusters would be placed within depressions on the river bottom, both natural depressions and those resulting from sediment removal and backfilling operations.

4.2 Shallow River Habitat Replacement

The shallow river zone comprises river areas within the photic zone, generally extending between bottom depths down to six feet and the shoreline, but excludes emergent wetlands and river banks. This zone encompasses both shallow water areas within the main and secondary river channels, and shoals, bars and partially enclosed, sheltered coves adjacent to the channels. It includes both predominantly unvegetated areas, and areas containing rooted submerged or rooted floating aquatic vegetation. (Areas dominated by emergent vegetation comprise the emergent wetland zone; its replacement is discussed in Subsection 4.3, below.)

Habitat replacement objectives for the shallow river zone are to:

- replace fish habitat,
- replace benthic habitat and encourage recolonization, and
- replace vegetation communities.

The availability of sufficient light for photosynthesis enables the employment of habitat replacement methods that require the establishment of rooted aquatic vegetation, to replace vegetation removed during remediation and restore its habitat value. As for the deep river zone, the maintenance of navigation must be considered. The placement of obstructions or hazards to both commercial and recreational craft must be avoided; therefore, the extensive deployment of hard structures is precluded.

4.2.1 Backfill Materials and Placement

The remediated area within the shallow river zone would be backfilled with two substrate cross-sections:

- one-half foot deep layer of gravel over a one-half foot deep layer of sand, and
- a one-foot deep layer of sand.

Alternating patches of the two substrate cross-sections would be placed in the remediation area to form a mosaic of surface substrates, creating a mixture of sediment sizes. The actual location of substrate placement within the shallow river zone would be delimited during the project design phase. (For the purpose of calculating remediation costs, it is assumed that about one-half of the remediation area would be backfilled with a one-half-foot deep layer of gravel over a one-half-foot deep layer of sand, and one-half would be backfilled with a one-foot deep layer of sand.) Although backfill comprising fine sediments would not be placed in this zone, over time silt and fine sands would be transported into the backfilled areas by currents, gradually increasing the heterogeneity of the substrates.

4.2.2 Boulder Clusters

Clusters of boulders would be placed on gravel backfill in selected locations. To preclude conflicts with the use of the river for navigation, boulder clusters would be placed within depressions on the river bottom.

4.2.3 Rooted Aquatic Vegetation

To replace aquatic vegetation communities within the shallow river zone, patches within the remediation area would be planted with rooted aquatic vegetation. River currents in the shallow river zone preclude the establishment of non-rooted vegetation. Species selected would be limited to non-invasive rooted submerged and rooted floating aquatic vegetation, currently occurring in or native to the Upper Hudson River. Species that are valuable to fish and wildlife would be planted and include the following representative candidate species:

- rooted submerged aquatic vegetation such as spatterdock (*Nuphar advena*), long-leaved pond weed (*Potamogeton nodosus*), redhead grass (*P. perfoliatus*), and wild celery (*Vallisneria americana*); and

- rooted floating aquatic vegetation such as fragrant water lily (*Nymphea odorata*), water smartweed (*Polygonum amphibium*), and duck potato (*Sagittaria latifolia*).

Only locations backfilled with the sand substrate cross-section would be planted to rooted aquatic vegetation; gravel surface substrates would not be planted. Planting on sand surface substrates would be implemented to establish a mosaic of vegetation cover, both in terms of species composition and plant cover density. Plant cover densities ranging between 0 and 100 percent would be targeted. Plant materials (species, planting stock, and availability), planting locations, and planting densities would be specified during the project design phase.

4. 3 Emergent Wetland Habitat Replacement

Emergent wetlands are characterized by erect, rooted, herbaceous hydrophytic plants, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. Emergent wetlands occur in areas of the river with reduced flow velocity that allow fine-grained sediments to settle out. While there are forested riparian wetlands adjacent to the river, remediation activities would not occur there and therefore, this habitat replacement concept does not address forested wetlands.

Habitat replacement objectives for emergent wetlands are to:

- replace fish habitat,
- replace benthic habitat and encourage recolonization,
- replace vegetation communities, and
- replace wetlands, specifically:
    - re-establish wetland function and values (habitat, flood control, water quality), and
    - re-create habitat diversity through provision of emergent marsh with interspersed deep water pools, and scrub-shrub wetland habitat.

4.3.1 Emergent Marsh

Following remediation activities, the area would be regraded to achieve pre-remediation elevations. The area would be subsequently revegetated through broadcasting of seed coupled with

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selected plantings as appropriate. Species that are valuable to fish and wildlife would be established and include the following representative candidate species:

- persistent emergents such as cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), saw grass (*Cladium jamaicense*), and sedges (*Carex* spp.);

- broad-leaved emergents such as dock (*Rumex mexicanus*), waterwillow (*Decodon verticillatus*), and many species of smartweeds (*Polygonum* spp.); and

- nonpersistent emergents such as wild rice (*Zizania aquatica*), arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), and arrowheads (*Sagittaria* spp.).

Interspersed within the emergent marsh would be pockets of deep pools of varying size. These pockets would be vegetated with floating vascular plants such as water lettuce (*Pistia stratiotes*), and rooted vascular aquatic plants including horned pondweed (*Zannichellia palustris*), ditch grasses (*Ruppia* spp.), and wild celery (*Vallisneria americana*).

4.3.2 Scrub-Shrub Wetlands

Along the shoreline fringe of the emergent marshes, scrub-shrub wetlands would be established. Shrub-scrub wetlands are dominated by woody vegetation less than 6 m (20 feet) tall. The vegetation includes true shrubs, young trees, and trees or shrubs that are small or stunted because of the hydric conditions. Typical candidate species would include alders (*Alnus* spp.), willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), red osier dogwood (*Cornus stolonifera*), honeycup (*Zenobia pulverulenta*), and young trees of species such as red maple (*Acer rubrum*) or black spruce (*Picea mariana*).

4.4 River Bank Habitat Replacement

River banks immediately adjacent to sediment removal locations may require stabilization to control bank erosion, slumping, and sloughing. Replacement objectives for the river bank zone are to:

- replace vegetation communities, and
- stabilize shorelines.

For the purpose of calculating remediation costs, the stabilization methods employed are assumed to be a function of the depth of sediment removal in the river adjacent to each shoreline segment. Specifically, the following strategy has been applied:

- adjacent to river locations where less than 2 feet of sediment would be removed, no bank stabilization would be employed;

- adjacent to locations where 2 or 2.5 feet of sediment would be removed, dormant mattresses of plant materials would be employed to stabilize the river banks; and

- adjacent to locations where 3 or more feet of sediment would be removed, timber or log revetments in combination with plant material mattresses would be employed.

However, the actual river bank stabilization method to be employed along each shoreline segment will be specified during the project design phase. Both vegetative methods and structural-vegetative methods would be employed, the choice being dependent on the extent of bottom sediment removal in the adjacent river and the magnitude of erosive forces.

4.4.1 Vegetative Methods

Vegetative methods would be employed on river banks adjacent to locations where bottom sediments would be removed to only shallow depths (estimated to be less than approximately three feet), along shorelines subject to low or moderate erosion. Vegetative methods that may be employed are the following (Federal Interagency Stream Restoration Working Group, 1998):

- **Bank shaping and planting** - Regrading river banks to a stable slope, placing topsoil and other materials needed for sustaining plant growth, and selecting, installing, and establishing appropriate plant species.

- **Dormant post plantings** - Plantings of cottonwood, willow, poplar, or other species embedded vertically into river banks to reduce flow velocities near the slope face and trap sediment.

- **Brush mattresses** - Combination of live stakes, live facines, and branch cuttings installed to cover and physically protect river banks; eventually to sprout and establish numerous individual plants.

- **Vegetated geogrids** - Alternating layers of live branch cuttings and compacted soil with natural or synthetic geotextile materials wrapped around each soil lift to rebuild and vegetate eroded river banks.

Where moderate scour by currents or ice is anticipated at the toe of the river bank, vegetative methods (to stabilize the upper bank) would be used in combination with structural-vegetative methods employed as toe protection. Along banks subject to higher magnitudes of toe erosion, vegetative methods may be employed in combination with structural methods (rock riprap or stone toe protection) to protect the toe or lower slope of the river bank.

4.4.2 Structural-Vegetative Methods

Adjacent to locations where bottom sediments would be removed to greater depths (about three feet or greater), structural-vegetative methods would be employed. Structural-vegetative methods also would be employed on river banks adjacent to locations where bottom sediments would be removed to shallow depths, but the shoreline is subject to high erosion. Structural-vegetative methods that may be employed are the following (Federal Interagency Stream Restoration Working Group, 1998):

- **Vegetated gabions** - Wire-mesh, rectangular baskets filled with small to medium size rock and soil and laced together to form a structural toe or sidewall. Live branch cuttings are placed on each consecutive layer between the rock filled baskets to take root, consolidate the structure, and bind it to the slope.

- **Rock riprap with joint plantings** - Live stakes tamped into joints or openings between rocks which have been installed on a slope or while rock is being placed on the slope face.

- **Live cribwalls** - Hollow, box-like interlocking arrangements of untreated log or timber members filled above baseflow with alternate layers of soil material and live branch cuttings that root and gradually take over the structural functions of the wood members.

Where appropriate, structural-vegetative methods would be used in combination with soil bioengineering systems and vegetative plantings to stabilize the upper bank and provide a regenerative source of river bank vegetation.

5. MONITORING AND ADAPTIVE MANAGEMENT CONCEPTS

Habitat replacement monitoring, evaluation, and adaptive management would be undertaken to assess the success of the implemented habitat replacement actions and attainment of the habitat replacement objectives. A monitoring plan will be developed to assess the performance of the habitat replacement actions relative to the replacement objectives, and provide information that can be used to improve the implementation and performance of the actions. Information obtained through monitoring would be evaluated to confirm that the replacement actions are achieving the objectives. Adaptive management would facilitate the identification of problems, selection of corrective actions, and execution of midcourse corrections to the replacement actions during their implementation.

5.1 Monitoring Concepts

Rivers and associated wetland habitats are complex, highly productive systems with diverse and abundant populations of animals and plants. To attempt to measure and understand every component of habitat functioning is beyond the scope of normal operating guidelines. However, early diagnoses of failing ecological functions are difficult to recognize, the most appropriate adjustments are not well understood, and the results of alterations may not be evident for long-time periods. Consequently, a long-term monitoring plan would be essential to develop an information base for continuous comparisons of functional status and biological integrity of the replaced habitats (Hammer, 1992).

The monitoring plan need not be elaborate or lengthy but it must provide clear documentation of monitoring objectives, organizational and technical responsibilities, specific tasks, methods and basic instructions, quality assurance procedures, schedules, reports, and resource requirements (Hammer, 1992). Since the life of the project would span many years and numerous personnel changes, written documentation would be essential so that data sets are at least comparable if collection or analysis procedures change, as would likely happen. A carefully defined monitoring plan should be available to serve as a benchmark for data collection throughout the life of the project (Hammer, 1992).

The monitoring program would include pre-construction baseline monitoring, monitoring during construction, and post-construction long-term monitoring.

5.1.1 Pre-Construction Baseline Monitoring

Biotic inventories (plants, benthic invertebrates, and fish and wildlife species) should be conducted to establish pre-remediation conditions. This baseline monitoring would result in animal species lists, descriptions of the structure of plant communities, and quantitative plant and animal data for selected areas of the river. A community-based Habitat Suitability Index (HSI) model (developed for riverine and riparian systems) could be utilized to provide a quantified assessment of existing wildlife habitat conditions, and a projection of expected conditions for up to 50 years into the future.

5.1.2 Monitoring During Construction

Construction activities would be in progress during the final baseline study sampling period. Plant inventories would be completed prior to implementation of remediation activities. Animal inventories would occur within and outside of impact areas, prior to and during implementation of remediation activities. Further, plantings/seedling survival studies would be conducted at regular intervals. Monitoring would emphasize survival, growth, and species composition. An ecologist would be present during major construction events to ensure that there were no unnecessary impacts to wildlife or other elements of the ecosystem.

5.1.3 Post-Construction Long-term Monitoring

Long-term monitoring and reports on the habitat replacement effort would be prepared annually. Permanent transects and/or sampling sites would be established from which to conduct biotic inventories. As with the baseline studies, community-based HSI models would be used during long-term monitoring to assess the progress of wildlife habitat development. A river habitat quality analysis would be conducted annually. Physical habitat structure would be measured along a series of transects. These measurements would be compared to pre-remediation conditions. Fish and benthic macroinvertebrate samples would be collected within the same sample reaches, and Index of Biotic Integrity (IBI) and Macroinvertebrate Biotic Index (MBI) scores calculated.

5.2 Evaluation and Adaptive Management Concepts

A habitat replacement evaluation and adaptive management program will be formulated during the project design phase, concurrent with formulation of the monitoring plan. Habitat replacement evaluation would determine whether the replacement actions are achieving the specified replacement objectives. This would facilitate the identification of problems before they become prohibitively complex or expensive to correct.

Habitat replacement evaluation and adaptive management in combination would enable the adjustment or redesign of habitat replacement actions, based on their success or failure in one location, before they are executed in other locations later during replacement implementation. Adaptive management would entail adjusting habitat replacement implementation as new information becomes available (Federal Interagency Stream Restoration Working Group, 1998).

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Table F-1
Habitat Replacement Vegetation Seeding/Planting Quantities and Costs
Quantity and Cost Assumptions

Shallow River Habitat Replacement

Planting	Unit	Unit Cost	Planting Cost (per plant)	Spacing (Ft O.C.)	Quantity Per Acre		Per Acre Cost
Deep Pools	Plant	$1.00	$2.00	2	10,890		$32,670

Emergent Wetland Habitat Replacement

Seeding	Unit	Unit Cost	Coverage (SF)	Quantity Per Acre	Materials Cost	Seeding Cost (per acre)	Per Acre Cost
Wetland Rush/Bulrush Mix	pound	$225.00	43,560	1.0	$225	$2,600	$2,825
Wetland Grass Seed Mix	pound	$7.50	2,900	15.0	$113	$2,600	$2,713

Planting	Unit	Unit Cost	Planting Cost (per plant)	Spacing (Ft O.C.)	Quantity Per Acre		Per Acre Cost
Marsh	Plant	$0.50	$2.00	2	10,890		$27,225
Deep Pools	Plant	$1.00	$2.00	2	10,890		$32,670
Scrub-Shrub	Plant	$1.00	$2.00	5	1,742		$5,227

River Bank Restoration

Seeding	Unit	Unit Cost	Coverage (SF)	Quantity Per Acre	Materials Cost	Seeding Cost (per acre)	Per Acre Cost
Erosion Control Mix	pound	$20.00	1,245	35.0	$700	$2,600	$3,300

Planting	Unit	Unit Cost	Planting Cost (per plant)	Spacing (Ft O.C.)	Quantity Per Acre		Per Acre Cost
Shrub Plantings	Plant	$1.00	$2.00	5	1,742		$5,227

Notes:
Ft O.C. - Feet on Center
SF - Square feet

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HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX G

MONITORING PROGRAM DEVELOPMENT

Appendix G

Part A

Monitoring Programs For The Hudson River

G.1 Introduction

An important component of any remedial alternative for the Hudson is the monitoring of river conditions before, during and after the remedial effort. The purpose of the monitoring is primarily to document the improvement in river conditions as a result of the remedial effort as well as to ensure that the remedial effort succeeds in achieving its clean-up goals. Additionally, monitoring can provide assurance that remedial activities do not create unacceptable conditions during the clean-up process itself.

The goals of the monitoring programs described here conform to the purposes described above. Various aspects of the monitoring proposed address the long-term changes in the PCB levels of the sediment, water and fish. Additionally, sediment PCB levels immediately prior to and subsequent to any remedial activity are also to be monitored. Finally, impacts of the remedial activities on water column and fish conditions are addressed. Each of these aspects is covered to a differing degree, depending on the remedial activity selected.

The monitoring scenarios fall into four separate categories as follows:

- Monitored Natural Attenuation
- Design Support
- Construction Monitoring
- Post-Construction Monitoring

The titles of these scenarios are somewhat self-explanatory but are explained in detail below. Note that no monitoring is proposed for the No Action alternative, consistent with USEPA guidelines. In the subsections that follow the basic premise of each of the monitoring scenarios is presented along with a discussion of the monitoring tasks. In several instances, the monitoring scenarios have several tasks in common. In this case, the task is described only in the first scenario in which it appears and simply referenced in subsequent scenario discussions. Additionally, several of the monitoring programs (*e.g.*, design support) have features specific to the remedial scenario chosen. In these instances, the remedial scenario-specific details are discussed as well under the monitoring task.

The length and spatial coverage varies widely among the monitoring scenarios, covering a range from 1 to 25 years and from as little as 30 to as much as 200 river miles. Additionally, there are variations within several of the scenarios that depend upon the exact remedial alternative selected. In particular, the design support, construction and post-construction monitoring are all dependent on the type and extent of remediation selected. Additionally, if No Action or Monitored Natural Attenuation is selected, clearly the other scenarios become superfluous. Figure 5-6 in Chapter 5 of the FS presents a schedule of the various monitoring tasks.

It should be noted that with each of these scenarios there are significant tasks in addition to the sampling effort itself. These tasks include the tallying, reporting and interpretation of the data (*i.e.,* data analysis). These additional tasks involve greater effort for some of the monitoring programs relative to the others. For example, Monitored Natural Attenuation will require more extensive analysis than a removal action, as discussed below. For the purposes of the cost estimates, the reporting and interpretation has been estimate based on a per-sample basis. Monitored Natural Attenuation has the additional effort of incorporating the data collection results into further modeling analysis. This is needed to determine whether the actual data trajectory matches the model forecast. To the extent that there are differences, the model will require adjustment and possibly recalibration to reflect the actual data and make more accurate forecasts. A smaller but similar modeling program is planned for the post-construction monitoring period.

G.2 Monitored Natural Attenuation

Monitored Natural Attenuation involves several large monitoring programs, covering sediment, water and biota. River conditions prompting this alternative are not considered acceptable and thus this alternative involves extensive monitoring to document the occurrence of natural attenuation at a rate similar to or better than that predicted by the Phase 2 modeling analysis. Monitoring under this program replicates and extends the existing long-term sampling programs begun by NYSDEC, GE and others. Water, fish and sediment are to be monitored under this program. Samples in this program are designed to provide integrating information on loads and exposures to PCBs throughout the Hudson. In the event that natural attenuation is not occurring at an acceptable rate, other remedial alternatives for the river may be considered. Additionally, this alternative involves the use of acoustic techniques (*e.g.*, side-scan sonar) to monitor any physical changes in the sediment properties and river bathymetry over time. Changes such as these will have a direct bearing on the issues of sediment resuspension and burial. A final goal of this program is to develop data sets that can be used to validate and further refine the USEPA models. These models will require revision to enhance their accuracy over the long term and correct any differences between the model forecast and the actual measured trends. It is expected that model review and recalibration will occur on a three-to-five cycle to reflect the newest data in the model forecasts. This cycle time also corresponds to the frequency of the major sediment monitoring events. A five-year recalibration has been assumed for cost estimation purposes.

Monitored Natural Attenuation is planned for a thirty-year period. In the event that conditions substantially improve over time, it may be possible to reduce the frequency of monitoring and still achieve a useful record. However, since the timing of such a condition is difficult to estimate, particularly since the model does not predict attainment of the PRGs within the study period. Thus, no allowance has been made to the associated cost estimate.

It should be noted that if a sediment remediation program is selected, it will still be necessary to implement the Monitored Natural Attenuation programs prior to the on-set of remediation.

In this case, the monitoring program provides a baseline for comparison once the remediation is completed. As will be discussed later, the post-construction monitoring program is very similar to the Monitored Natural Attenuation; thus the data collected prior to remediation will be directly comparable to subsequent data collection efforts.

Monitored Natural Attenuation consists of four major programs that are described below.

G.2.1 Surface Water Monitoring

Surface water monitoring under Monitored Natural Attenuation consists of five tasks, two of which are similar in nature to the monitoring work performed by USEPA in 1993, specifically, Upper Hudson water column monitoring and monitoring in the freshwater Lower Hudson. The remaining three tasks under this program are designed to collect data to further enhance the understanding of PCB loads in the Upper Hudson. These tasks involve daily monitoring of suspended solids (program 3) and quarterly float surveys (programs 4 and 5). Table G-1a contains an outline of these programs.

Upper Hudson Monitoring

This program consists of regular time-of-travel surveys of water column conditions in the Upper Hudson. In each time-of-travel survey, sampling stations are occupied in sequence from upstream to downstream while allowing sufficient time for the parcel of water sampled at the previous station to arrive at the next station at the time of sampling. The timing for each event is a function of the flow in the river at that time. For example, during a typical flow condition of 5000 cfs, approximately 12 hours must be allowed between the collection of a sample at Rogers Island and the Thompson Island Dam sample collection. Similar time allowances must be made for the stations down stream of TI Dam.

The purpose of this program is to continue to document PCB loads and concentrations in the Upper Hudson. Under the consent decree for the Post-Construction Monitoring Program for the Remnant Deposits (Administrative Order on Consent II CERCLA 90224), General Electric is required to monitor water column concentrations in the Ft Edward area. This program extends and continues the GE program to build upon the existing data set and further the understanding of PCB transport in the Upper Hudson. Notably, the water column time-of-travel data obtained by USEPA and the weekly monitoring data obtained by GE have proved invaluable in understanding PCB transport in this system. This program will serve to extend these data sets into the future. Additionally, this program will provide data for correlation with the fish and sediment monitoring programs that parallel this effort. As such the water column program provides data for the estimation of fish exposure to PCBs.

The Upper Hudson water-column monitoring program consists of weekly monitoring at seven stations in the Upper Hudson as listed in Table G-1a. Because of the important differences in congener pattern among the various potential PCB sources in the region, congener-specific data are required. Ancillary measurements include suspended solids and the fraction of organic carbon on the suspended solids.

Monitoring in the Freshwater Lower Hudson

This program largely represents an extension of the Upper Hudson program to the lower river. Because the absolute levels, and thus the impacts from PCBs, are substantively lower in this region of the Hudson, sampling will be less frequent. Additionally, tidal fluctuations and mixing serve to reduce the variations in PCB levels found in this region, while tidal mixing in general makes the calculation of water column PCB fluxes problematic. As a result, samples will only be collected once per month in this program, from three Lower Hudson stations plus the Mohawk River. This program is also outlined on Table G-1a.

The timing of these samples will follow sequentially after the Upper Hudson samples so as to make the results directly comparable.

Suspended Solids Monitoring

Monitoring of suspended solids is needed to further refine and improve the existing modeling analysis of solids transport in the Upper Hudson. In particular, suspended solids loads from the tributaries in the Upper Hudson are relatively poorly constrained and can benefit from the additional data. The suspended solids program will involve the automated collection of suspended matter samples at each of 13 locations in the Upper Hudson. These stations will also require the installation of staff gauges and automated flow-monitoring equipment to record daily flow at these locations. The 13 locations include both mainstem and tributary stations in the Upper Hudson.

Float Surveys

The remaining two water-related programs are float survey programs, similar in design to the studies done by GE in 1996 and 1997. The first of the float survey programs covers the TI Pool while the second covers the region from TI Dam to Lock 5. These surveys are focused on the warmer months of the year and are intended to study the processes and the areas responsible for the PCB release from the sediments so clearly documented in the USEPA and GE data. As discussed in Chapter 3 of this report, the shallow regions of the river represent the most likely PCB source to the water column. Each survey consists of 25 to 30 cross-sections wherein samples are collected from the main channel of the river and from the shallow areas to either side. Each cross-section consists of four samples, with one sample in the river channel and three in the shallows. Cross-sections are separated by 0.25-mile intervals. These surveys will be conducted four times a year from mid-May to the end of September. Each survey is expected to represent about a day of sampling per river reach. By observing the evolution of PCB contamination from the sediments to the water, sediment-related PCB source areas can be identified and the magnitudes of their releases estimated.

G.2.2 Fish Monitoring under Monitored Natural Attenuation

NYSDEC has traditionally monitored fish body burdens in the Hudson on a regular basis. Their records for PCBs in fish extend back to at least 1977. In 1997, NYSDEC developed a proposed monitoring program for the Hudson. The proposed plan is included later in this appendix. The proposal describes the basic goals for the sampling program as defined by

NYSDEC. Three of the four goals listed by NYSDEC are also shared by the monitoring programs for the Reassessment RI/FS and are replicated below:

- To assess temporal tends in PCB concentrations in selected resident species;
- To evaluate spatial relationships in Hudson River PCB contamination as reflected by concentration in the fish; [and]
- To ascertain PCB concentrations in the striped bass recreational and commercial fisheries for purposes of providing health advice through the New York State Department of Health and for regulating commercial fisheries when PCB levels exceed the U.S. Food and Drug Administration tolerance level of 2 ppm.

Essentially, the program is intended to further the understanding of PCB uptake in fish while also monitoring to determine when fish levels reach acceptable concentrations for recreational and commercial use.

To accomplish this, fish monitoring will continue as it has for the last several years, with the collection of resident species from both the Upper and Lower Hudson in the spring of each year, followed by collection of young-of-the-year pumpkinseed in the fall. Striped bass collection will take place in both spring and fall with monthly collections at Albany from June to October. These programs were designed by NYSDEC to extend and enhance its fish monitoring program and also satisfy the needs of the Reassessment RI/FS. This program is summarized in Table G-1b. Additional information (*i.e.*, the NYSDEC proposed plan) is provided in part E of this appendix.

G.2.3 Sediment Monitoring under Monitored Natural Attenuation

Sediment monitoring under Monitored Natural Attenuation will involve two main programs that derive from the historical sediment investigations conducted by USEPA and GE in the 1990s. Specifically, the sediment programs will involve the collection of high resolution cores from selected Hudson sites and the collection of low resolution cores (sediment inventory cores) from several documented *hot spots*. The sediment program is outlined in Table G-1c.

<u>Collection of Sediment Cores for Dating and Analysis (High Resolution Coring)</u>

During the Phase 2 investigation, the USEPA made extensive use of the dated sediment cores collected from the Hudson. Dateable cores were successfully obtained from about 14 locations and were used to provide an integrative perspective of long-term PCB transport in the Hudson. The cores documented both the principal source of PCBs to the River (*i.e.*, the GE facilities) as well as the long-term fate of PCBs within the sediments in the absence of resuspension. It is important to the continued understanding of PCB contamination in the Hudson that this program be continued into the future.

These cores document major releases of PCBs to the river along the river's length. Eleven locations on the main stem of the Hudson plus a location in the Mohawk near its confluence with the Hudson will be occupied for this program. The sampling frequency for this program is 5 years for most of the 30 year monitoring period, although cores are collected in years 1 and 4 (three years apart) to examine the initial conditions.

In this program, cores are sliced into thin layers (2 to 4 cm each) and analyzed for PCBs as well as radionuclides. The radionuclides provide the information required to establish the core depositional chronology. PCB analysis is done on a congener-specific basis for this program to provide information on the transformations of the PCB mixtures contained within the sediment over time (*e.g.*, dechlorination). Additionally, congener-specific data can also be used to identify new sources to the river when the source pattern is distinct from that contributed by GE. In this manner, these cores document the long-term response of PCB contamination in the Hudson as well as the introduction of new sources.

Sediment Inventory Monitoring

The sediments of several NYSDEC-identified *hot spots* will be examined approximately every five years to assess the in-place inventory and compare it with prior inventory estimates. Additionally, composite samples similar to those collected by GE and used in the modeling analysis will be generated every five years to track changes in the surface sediment conditions. These results can be directly incorporated into the HUDTOX model as a part of future model refinements anticipated under the Monitored Natural Attenuation alternative. By sampling on this frequency, the results should permit the documentation of changes in sediment PCB inventory and concentration over time. The actual planned sampling years for sediment inventory monitoring include years 1, 4, 9, 14, 19, 24, and 29, the same as those proposed for the high resolution coring program.

For the sediment inventory study, eight *hot spots* will be examined periodically to assess changes in their respective inventories. The *hot spots* selected represent a substantial portion of the sediment PCB mass and thus should represent the general condition of similar *hot spot* areas. Thirty-six cores will be collected per *hot spot* so as to provide a sufficient basis to assess the mean condition and the inherent variability. (The basis for the value of 36 per unit area is presented in subsection G.3.2.) Nominally, five core sections will be obtained per core, similar in design to the low resolution coring program, with the top- and bottom-most slices analyzed for radionuclides and the three main intermediate slices (about 12 inches in length each) analyzed for total PCBs. Unlike the high resolution coring program, PCB analyses from these samples need only represent total PCB mass and not congener-specific levels. Organic carbon will be collected as an ancillary measurement.

For the shallow sediment inventories, sample composites will be produced to represent sediment depths to 25 cm in five 5-cm intervals. Composites will roughly approximate those obtained by GE but a greater thickness of the sediment will be represented and composites will not extend over long distances (*i.e.*, more than 1 mile). These composites will be analyzed for total PCBs as well as radionuclides and organic carbon. The program will consist of the collection of one thousand cores to be sliced into five 5-cm segments. Groups of ten locations will be composited into 5 composite samples, one for each sediment layer, yielding a total of 500 samples per event.

G.2.4 Geophysical Monitoring under Monitored Natural Attenuation

The last monitoring program under this alternative involves the acoustic mapping of sediment properties and river bathymetry. This program is outlined on Table G-1d. The geophysical surveying via acoustic techniques is very similar in style to the Phase 2 efforts completed in 1992. In this instance, side-scan sonar and multibeam sensors will be used to simultaneously collect data on sediment type, sediment thickness (sub-bottom profiling) and bathymetry. Additional coverage of the river bottom for bathymetry, specifically for the purpose of assessing sediment burial or resuspension over time, will be conducted in addition to the regular acoustic survey. The timing for this task is intended to provide a large quantity of data on the sediments and their spatial variability at the beginning of the program followed by more-regular, less frequent monitoring later in the program. Specifically, the acoustic survey will be conducted quarterly in the first year, followed by annual surveys in years 2 to 5, with surveying on five-year intervals during years 6 through 30, matching the frequency of the sediment monitoring program.

Bathymetry

A review of the Fox River studies indicated that river sediment thicknesses vary significantly and seasonally throughout the year. As part of Monitored Natural Attenuation, bathymetric data will be collected to examine this possible occurrence in the Hudson. Bathymetric data for this task will require consistent and accurate vertical control in order that differences in river bottom elevation over time can be discerned. In each survey, bathymetric cross sections will be measured roughly every tenth of a mile from Rogers Island to Lock 5 and in the general vicinity of *hot spots* 36 to 40, downstream. In this fashion an extensive and precise coverage of river bathymetry will be accumulated so as to permit the evaluation of changes in riverbed elevation over time.

Side-Scan Sonar and Multibeam Survey

This task will monitor the properties of the river bottom sediments, updating the USEPA side-scan sonar survey of 1992 on a regular basis. Its purpose is to document the changes in the sediment textures, morphology and thicknesses over time as a basis to evaluate sediment resuspension and deposition. These results will be used in conjunction with the bathymetric data described above.

G.3 Design Support

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Unlike the previous monitoring program, the design support program does not represent a remedial alternative by itself. Rather, this program would be implemented as part of a remedial program involving sediment removal or capping. The purpose of the design support program is to provide current data on river conditions prior to the initiation of sediment remediation. In particular, this program is intended to describe the current sediment contamination levels. These data will form the basis for the final selection of sediments to be remediated whether by dredging or by capping with dredging. Because the information to be gathered on the sediments is needed for both dredging and capping scenarios, the number of samples and the sampling density are the same for both options, given the same level of clean-up. For example, the 0/10/10 clean-up scenario requires the same number of samples for both the dredging option and the capping with dredging option. This is because both programs need to know both the horizontal and vertical extent of contamination since both involve sediment removal.

The design support program involves water, sediment, fish and geophysical sampling during a one-year period. As part of this program, the five water monitoring programs previously described in section G.2, Monitored Natural Attentuation, will be implemented to establish water column conditions prior to remediation (see Table G-2a). Similarly, the fish monitoring program described under Monitored Natural Attenuation will be initiated as part of the design support program. Additional monitoring requirements for fish, sediment and geophysical surveying are described below and are outlined in Tables G-2b, c and d.

G.3.1 Fish Monitoring

In addition to the fish monitoring program described under Monitored Natural Attenuation (see Table G-1b for an outline of the program), the USEPA will implement a caged fish study during the design support program (see Table G-2b). This will establish a baseline of conditions for comparison to caged fish studies planned for the post-construction period. The program itself will consist of caged fish deployed at six stations in the Upper Hudson. Three rounds of sampling will be conducted (spring, summer and fall) with three replicates collected per station. This yields 18 samples per sampling event or 54 samples in total per year. PCB analyses will include Aroclor-based total PCB measurements for all samples and congener-specific measurements for 25 percent of the samples since these analyses will form the baseline for subsequent caged fish studies. The deployments themselves will last 30 days.

G.3.2 Assessment of Sediment Inventory

As discussed elsewhere in this report, several remedial scenarios have been developed which involve varying degrees of sediment removal or capping. Within a given region these can vary from no remediation (monitored natural attenuation) to the removal of all sediment. In between these two extremes are the Expanded Hot Spot removal (sediment inventory greater than 3 g/m^2 or surface concentrations greater than 10 mg/kg) and the Hot Spot removal (sediment inventory greater than 10 g/m^2 or surface concentrations greater than 30 mg/kg). These scenarios have been based on the most current data available to describe the horizontal and vertical extent of contamination but it is unclear that the dredging/capping zones selected by each approach will exactly coincide with the ultimate project goals, that is, the removal of all or nearly all sediment at the respective PCB inventory level. Additionally, given the anticipated cost of sediment removal, it would appear wise to minimize, to the extent possible, the removal of clean sediments. On this basis then the design support program will reassess the sediment PCB inventory of the Upper Hudson. Table G-2c summarizes the sampling needs for the sediment under this program.

Estimation of the number of cores required to assess the sediments is not straightforward, in part because of the need to select a minimum area unit for remediation and, more importantly, because of the inherent variability in the data. To the first issue, a minimum area unit was selected on the basis of the dredge zones defined for the program. For both the Hot Spot remediation and the Expanded Hot Spot remediation scenarios, the nominal median area selected was 5 acres, based on the minimal remedial area selected as shown in Table G-3. This table provides a list of the acreage for each individual remedial zone by remediation scenario for Sections 1 and 2 of the Upper Hudson. Based on the acreage identified, the minimum area for examination in the coring program was set at 5 acres for these remedial scenarios. Note this value is less than half of the mean remediation zone area in both remediation scenarios and thus should provide sufficient resolution for the purposes of classifying areas. For Full-Section remediation, the minimum area unit was doubled to 10 acres simply to limit the number of samples while still providing a useful size for decision making. Thus, based on the sampling programs described below, decisions for the Hot Spot remediation and the Expanded Hot Spot remediation scenarios will be based on 5-acre sampling areas and decisions on Full-Section remediation will be based on 10-acre sampling areas.

Estimation of Sampling Requirements in Remediation Areas

The estimation of the number of cores required per unit area depended on several assumptions as described below. For the selected remediation zones already identified based on the 1984 and 1994 data sets, it was assumed that the major data requirement for these zones was the depth of contamination (*i.e.*, the depth of sediment requiring remediation). It was assumed that these zones did not require recertification as being contaminated. The estimation of the number of cores required for these areas was then based the following discussion and was derived from the existing core depth information.

For those areas selected for remediation, a depth of contamination criteria was set up so as to minimize the residual contamination left behind after dredging to a specific depth. The desired depth in this case is not the mean or median depth of contamination but rather a depth that incorporates about 90 percent of the range of measured depths of contamination. Essentially, the number of cores for each sampling area should provide a 95 percent certainty that less than 10 percent of the sampling area has sediment contamination that extends beyond the cleanup depth. For example, in a previously selected remedial zone, if 90 percent of the area has PCB contamination extending to a depth of 2 ft and ten percent has PCB contamination to a depth of three feet, the remediation program would optimally select a removal/treatment depth of three feet in 95 percent of such instances. In this example, for those instances where removal/treatment to 2 feet (instead of the optimal 3 feet) is selected, approximately 5 percent of the PCB inventory would be left behind, assuming a constant PCB concentration in the entire area. In all likelihood, the actual inventory left behind would probably be less since the maximum contamination tends to lie midway through the zone of contamination and thus within the first 2 feet of sediment.

The actual calculation of the number of cores required to assess the depth of contamination was based on USEPA (1989) and is provided in part B of this appendix. The depth data on the vertical extent of PCB contamination used in the calculation were obtained from the 1994 USEPA low resolution sediment coring results for the Upper Hudson. For these cores, the depth of contamination in each core was defined as the depth to sediment less than 1 mg/kg. These data were selected for this calculation since they were considered most representative of current conditions in fine-grained sediments and they were specifically tested for "completeness" by determining the presence of cesium-137 in the bottom-most core segment. This is discussed at length in USEPA (1998). Notably, the USEPA data yield similar median and mean depths of contamination in all three sections of the Upper Hudson.

These calculations yield a requirement of 40 cores per unit area, which was applied to all selected areas. For 5-acre units, this yields 8 cores per acre with a nodal distance of 80-ft (*i.e.*, 80 ft between sampling locations). For 10-acre units, this represents 4 cores per acre with a nodal distance of 112 ft.

Briefly summarizing the above, Full-Section remediation programs required sampling at 4 cores per acre to establish the depth of contamination on a ten-acre basis. For the Hot Spot and Expanded Hot Spot remediation scenarios, the selected areas require sampling at 8 cores per acre to establish the depth of contamination on a five-acre basis.

<u>Sampling Requirements and Selection of Areas for Screening</u>

The sampling requirements to assess PCB inventory in areas outside the selected remediation areas turned out very similar to that required to establish depth of contamination within the remediation areas, described above. In this instance, however, it was necessary to establish both the number of cores required per sampling area as well as the areas of the Upper Hudson requiring this assessment. The estimation of the number of cores required per unit area is presented first.

The data sets for sediment PCB inventory obtained by NYSDEC and the USEPA have both been shown to best approximate a log-normal distribution (as opposed to a normal distribution (USEPA, 1997; USEPA, 1998). Based on this observation, the sampling requirements were derived assuming a lognormal distribution of the PCB inventory at the proposed time of sampling. The derivation of the sampling requirements for inventory was based on Gilbert, 1987 and are given in part C of this appendix. The criteria were set such that the coring results would yield an estimate of the median PCB concentration with a 95 percent confidence limit of $\pm$50 percent. Based on this analysis, 36 cores were required per sampling area. For 5-acre units, this yields 7.2 cores per acre with a nodal distance of 84 ft.

Like the determination of the sampling requirement itself, the selection of areas of the river requiring screening under the Hot Spot and Expanded Hot Spot remediation scenarios is also based on the observation of a log-normal distribution in the PCB data. Each sediment core or grab sample collected from the Hudson can be thought of as representing the central tendency of the local conditions. Given that the data are log-normally distributed, each sample can be thought of as a best estimate of the local median. Thus, the screening criteria were created to identify those areas of the river bottom outside the selected remediation areas that had at least a 5 percent chance of having a mean inventory greater than 10 g/m^2 or 3 g/m^2, depending on the scenario. These criteria were created assuming that the data to be collected will represent a median condition for the sediments.

The NYSDEC 1984 data set was used to estimate the overall variability of the areas selected under the Hot Spot and Expanded Hot Spot remediation scenarios. The degree of variability was estimated separately for each scenario. This variability was applied to all areas of the Upper Hudson for the purposes of selecting areas to be screened.

Given the high variability of the data, 36 cores per unit area are required to provide a 95 percent confidence limit about the sample median at $\pm$50 percent of the value of the median. Using a minimum-variance-unbiased-estimator (MVUE) of the arithmetic mean assuming a log-normal distribution (Gilbert, 1987), the screening criterion for the Hot Spot remediation scenario (*i.e.*, 10 g/m^2 threshold) is 2 g/m^2. Similarly, the screening criterion for the Expanded Hot Spot remediation scenario (*i.e.*, 3 g/m^2 threshold) is 1.2 g/m^2. Thus all areas above 2 g/m^2 require screening under the Hot Spot remediation scenario and all areas above 1.2 g/m^2 require screening under the Expanded Hot Spot remediation scenario. These areas are summarized in Table G-4. Part D of this appendix contains the derivation of the screening criteria.

Notably under the Expanded Hot Spot remediation scenario in the TI Pool, the area to screened for possible inclusion in the remediation is essentially equal in size to the areas already identified for remediation. Together they cover nearly all areas of the TI Pool. For this reason, the Expanded Hot Spot remediation scenario is assumed to survey the entire TI Pool. By comparison, the Hot Spot remediation scenario covers a much smaller area of the TI Pool but again the selected areas and the screened areas are nearly equal.

Selection of similar areas below TI Dam is problematic due to the lack of appropriate data. The USEPA low resolution cores provide sufficient coverage within the *hot spot* areas but the regions outside these areas are not well represented. The observation that the selected and screened areas matched so closely in the TI Pool was utilized in this program design for the purposes of area estimation. Thus the estimates of the screening areas below TI Dam were assumed to be equal in size to the areas selected for remediation in this region of the river for both scenarios.

Sampling in Other Areas

Sampling in areas of low contamination and therefore low likelihood of remediation was set at 1 core-per-acre between Rogers Island and Lock 5 and 2 cores-per-5-acres below Lock 5. The purpose of this sampling is to provide additional information on the sediment PCB inventory as well as to search for any contaminated zones not already documented.

Sampling Depth

Sampling depth was nominally set at 41 inches, representing three 1-ft core sections for PCB analysis and one 5-inch section at the core bottom for radionuclide analysis. As shown in

Figures G-1 and G-2, which present depth of contamination data for the 1984 and 1994 coring results, a wide range in the depth of contamination has been observed. Thus, coring depth must vary with sampling area. It should be noted that the depth of contamination for the 1984 data is based on slightly different criteria due to its lower sensitivity relative to the 1994 data. Specifically, the depth of contamination for the 1984 cores was defined as the depth to nondetect levels (layers assigned a concentration of zero, thought to represent a detection limit of approximately 1 mg/kg although a strict detection limit was not defined for these data) or as the depth to a second core segment whose screening result was assigned as "cold". In the latter case, the first "cold" segment would be assigned a value of 3.3 mg/kg while the second and all subsequent "cold" segments would be assigned a value of zero, moving from shallow to deeper sediment segments. The handling of the 1984 data is described at length in USEPA (1997).

Summary

The design support sampling program required the incorporation of several data sets in order to properly estimate the sampling density. Sampling density varied with scenario as well as by river region, since most scenarios have different goals in each region. For the areas most likely to be removed under the Hot Spot and Expanded Hot Spot scenarios, 40 cores per 5 acre-units were required to accurately assess sediment depth. For areas with a high probability of sediment contamination at or near the 10 g/m^2 and 3 g/m^2 threshold values, sampling density was estimated at 36 cores per five-acre unit. Finally, low probability areas were sampled at a low density, one core per acre or less. Derivations of the various estimates included in this section are included in parts B, C and D of this appendix. Ultimately, the remedial programs selected for detailed analysis yielded between 4,800 and 7,600 coring sites for the design support sediment sampling program. Table G-5 provides a breakdown of the coring requirements by scenario and area (*e.g.* selected areas, screened areas and other areas). Because of the extensive removal component in any capping scenario, the sampling program was estimated to be the same for both capping and dredging. Cores were nominally estimated at three feet in length consisting of three separate core segments for PCBs plus additional radionuclide analyses.

G.3.3 Design Support Geophysical Surveying

The geophysical survey has two major goals: first, to establish river bathymetry and sediment type prior to the onset of remediation and, second, to re-examine the river bottom in conjunction with the sediment sampling program discussed above as an aid to the final delineation of remediation areas. Table G-2d contains an outline of the geophysical program.

Bathymetry

Under the design support program, the collection of accurate bathymetric data is paramount for the measurement of the actual volume of sediment removed, the depth of cap installed, and achievement of the desired dredging depths. The design support bathymetric survey provides the reference surface for the interpretation of subsequent surveys for the dredged volumes, dredged depths, and cap thicknesses. To this end, the bathymetric cross-sections are to be obtained in a fairly dense coverage in the areas slated for remediation.

Side-Scan Sonar and Multibeam Survey

This task will provide current data on the nature of the river bottom sediments, updating the USEPA side-scan sonar survey of 1992, which will be approximately 10 years old when the design effort begins. This survey will also document the occurrence of debris that may interfere with sediment remediation. Finally and most importantly, this survey will be used in conjunction with the design support coring program to map out dredging/capping boundaries and sediment thicknesses and finalize the remedial design.

G.4 Construction Monitoring

This program is intended to document PCB levels in the Hudson during the remediation of the river sediments. It contains several tasks that specifically address PCB and suspended solids levels in the vicinity of the dredging operations and the resulting downstream impacts. This program also represents the confirmational sampling effort wherein sediment samples will be collected after dredging, backfilling and capping to ascertain the degree of cleanliness achieved. Tables G-6a through G-6d provide an outline of the program. The program is six years long, with the first year consisting of monitoring only while the remedial design is prepared. The latter five years involve monitoring during the remediation period itself. Note that if the Full-Section remediation is selected this program will be 8 years in length, one year prior to implementation plus the anticipated 7 year construction effort. Note as well that this program continues for the entire construction period, whatever its length. A 5-plus-1-year plan has been estimated based on the preferred alternative.

G.4.1 Water Column Monitoring During Construction

This program will continue the weekly time-of-travel monitoring for the Upper Hudson as well as the monthly Lower Hudson water column monitoring begun during the Design Support program (see Table G-6a). These programs are the same as those originally defined under Monitored Natural Attenuation. It is important that these water-column monitoring efforts begin prior to the initiation of remedial operations so as to establish a baseline for subsequent comparisons during and after construction. The monthly monitoring in the Lower Hudson will also examine the impacts of remediation on the Lower Hudson, if any occur.

There are two important water column programs added during construction. The first is the monitoring of suspended solids in the vicinity of the dredging operations. Twice daily measurements of suspended solids via turbidity meter will be made upstream and downstream of each dredge. Approximately 10 percent of the turbidity measurements will be confirmed by a direct suspended solids measurement. These measurements serve to monitor the escape of suspended solids from the dredging operations and will serve to trigger the following program when turbidity exceeds a specific threshold.

When turbidity exceeds a specific level in the downstream measurement, this event will serve to trigger a water column time-of-travel sampling event. These events constitute the last water column program under Construction Monitoring and represent water column sampling in addition to the weekly monitoring. In these events, the water column monitoring will be conducted so as to track the plume of increased turbidity as it travels downstream.

G.4.2 Fish Monitoring During Construction

This program is identical to the fish monitoring program proposed under Monitored Natural Attenuation (compare Tables G-6b and G-1b). In this case, the fish monitoring results will serve to integrate the 6-month to several-year impact of the remedial operation if an impact occurs and is significant enough to be observed. Caged fish studies begun during the Design Support program will be suspended and will recommence during the post-construction monitoring

G.4.3 Confirmational Sediment Sampling

This program is designed to document the degree of cleanup achieved by the remediation activities. Specifically, it consists of sediment core collection in the remediation zones after dredging, backfilling and capping (see Table G-6c). In the case of dredging, core collection will serve to document the removal of the PCB inventory and the attainment of acceptable PCB concentrations. This will be accomplished via a field laboratory, presumably using an immunoassay technique for a threshold PCB concentration. Twenty-five percent of the samples will be sent to a conventional laboratory for PCB, organic carbon and radionuclide (cesium-137) analyses. Sampling to confirm the dredging operation will be fairly dense, until an anticipated success rate and the degree of post-dredging sediment variability can be determined. The task has been estimated assuming that the dredged areas will exhibit the same level of variability as seen in the historical data. Thus the requirement of 36 cores per 5-acre unit as derived in part C of this appendix was used in the estimate. It is estimated that 90 percent of the cores will be sampled to a depth of 4 inches. Ten percent will be analyzed to a depth of 24 inches. These percentages will likely require adjustment after the remediation begins and the true success rate and degree of homogeneity are known.

Confirmational sampling for the backfill program will be implemented to document an acceptable PCB level in the backfill as well as a sufficient thickness of material. Since this material will be essentially pristine prior to its placement on the river bottom, a lower rate of sampling is proposed, 15 cores per 5-acre unit. Like the dredging area sampling, the ultimate rate of sampling will need to be adjusted once the success rate and degree of homogeneity has been tested during the remediation itself.

The capping-plus-selective-removal scenarios will also require confirmational sampling. In those areas slated only for dredging, the sampling density will be the same as that for the regular dredging program. For all areas to be capped, confirmational coring is only required once the cap is in place. Areas to be partially dredged do not require post-dredge sampling since the sediment removal in these areas is only designed to permit the emplacement of the cap. Sampling density for the capped areas is estimated to be the same as the backfill scenario. Although the capping material is expected to be self-healing (*i.e.*, minor damage to the cap should be corrected by horizontal displacement of undamaged materials), core depths will be generally limited to 4 inches since the main point of this effort is to confirm acceptable PCB levels in the backfill material overlaying the cap.

G.4.3 Geophysical Surveying During Construction

This program is designed to document the physical volume of sediment removed and the backfill or capping material installed on the river bottom. This will be done via simple bathymetry as well as via acoustic imaging of the sediment type and thickness (side-scan sonar and multibeam). Table G-6d contains an outline of the program.

Bathymetry

Bathymetric surveys will be required for all areas of sediment removal to assess the degree of success in sediment removal. It is expected that bathymetric surveying will be completed prior to any confirmational sediment core collection. For the purposes of the cost estimate, a nominal survey unit of 10 acres has been assumed. The survey itself will consist of both cross-sectional and longitudinal sweeps so as to provide net-like coverage of the removal areas. Some manual bathymetric surveying will be required in very shallow water where access by the survey boat is limited.

Bathymetric surveys will also be performed to confirm the volume and thicknesses of backfill and capping material. For dredged areas, this represents a single additional survey after the backfill material has been installed. For the capped areas, two bathymetric surveys will be required. The first follows the emplacement of the cap itself to assess the success of the installation and the thickness installed. A second survey will be required after the backfill has been installed, to confirm that an appropriate thickness has been installed.

Side-Scan Sonar and Multibeam Surveys

This program has essentially the same goals as the bathymetric surveys. In this instance, however, the program will examine the changes in sediment texture as a basis for affirmation of a successful removal and installation. This survey also permits the review of the conditions in between the lines of the bathymetric coverage "net" and thus can identify additional areas where the removal, capping or backfill may have been incomplete. These surveys will be conducted from the same survey boat as the bathymetry and it is expected that a single provider will conduct both surveys. A side-scan sonar/multibeam survey will be completed with each of the bathymetric surveys described above. In all cases, both the bathymetric and side-scan sonar surveys will be conducted prior to confirmational core collection. It is expected that the geophysical data collected will assist in the selection of some coring locations. Both the bathymetric and side-scan sonar/multibeam surveys will use the design support geophysical surveys as a reference baseline in determining removal and capping success.

G.5 Post-Construction Monitoring

This program is viewed as a monitored natural attenuation program initiated after the remediation. Thus, it involves nearly all aspects of the monitored natural attenuation program. The program extends for 25 years after the completion of the construction period. Initially, the frequency of data collection is quite similar to that of the Monitored Natural Attenuation. Unlike Monitored Natural Attenuation however, it is anticipated that the need for frequent monitoring will decline several years after the remediation is completed. The anticipated rate of decline is based in part on the degree of expected PCB removal or isolation. The anticipated rate of decline is reflected in the planned duration of the scenario-specific monitoring programs. The programs are discussed by matrix below.

The purpose of the post-construction monitoring program is to document the success of the remedial measures in reducing PCB levels in the water, sediments and fish of the Hudson River. Thus this program involves the sampling of all three media. TablesG-7a through G-7d provide an outline of the program.

G.5.1 Surface Water Monitoring for Post-Construction

The design of the post-construction water-column program is identical to that of Monitored Natural Attenuation (compare Table G-7a with Table G-1a). In this instance, however, the results will document the impact of the remediation. Additionally, with the removal of PCBs from the Hudson, the monitoring required for PCBs in the water column should decline over time. It is expected that the monitoring requirements would decrease as the amount of PCB removed increases. Thus, for all removal scenarios, weekly water column and float survey studies are implemented for only the first 10 years following dredging. Note that due to the inherently less secure nature of the capping programs, the water column programs are continued throughout the 25 year post-construction period for these scenarios.

For the removal scenarios after the initial, intense ten-year monitoring period, monitoring decreases to quarterly time-of-travel monitoring and the float surveys are discontinued. Water column monitoring of suspended solids also declines from daily measurements to monthly. In each instance the decision to decrease the rate of monitoring will be made at the appropriate time. The periods specified above are best estimates needed for cost estimation.

G.5.2 Fish Monitoring for Post-Construction

The fish monitoring program for the post-construction period is identical to that of Monitored Natural Attenuation (compare Tables G-7b and G-1b) with the one exception discussed below. The purpose here is to closely monitor fish body burdens throughout the Hudson as they respond to the remedial efforts. These results will serve to document the anticipated decline in fish body burdens and provide the data needed by the NYSDEC to regulate and eventually reopen the Hudson fishery when appropriate. Because the recovery of fish body burdens is expected to take as much as a decade or more despite the remediation, the monitoring program was estimated for the entire 25-year period.

In addition to the regular fish monitoring described above, caged fish will also be deployed and collected in the post-construction period to monitor the impacts of water-column exposures to fish after construction. These data provide a basis for establishing the impact of the upstream dredging efforts on downstream fish exposure. This program will be implemented for 10 years.

G.5.3 Sediment Monitoring for Post-Construction

The sediment monitoring program consists of two tasks, the first designed to document the long-term response of the river to the remediation and the second to monitor changes in the remediation areas themselves. The first task is the collection of dated sediment cores, which has been previously discussed. Here the integrating nature of these cores will document the long-term recovery of the Hudson. The duration of this task for all removal scenarios extends nine years with coring events in years 1, 4, and 9. For capping scenarios, the program duration is 25 years, with coring events in years 1, 4, 9, 14, 19, and 24.

The second task involves the monitoring of the remediation areas to document the changes, if any, in the thicknesses of the backfill material and its level of contamination. It will also document any recontamination of surface sediments. Specific to the capping scenarios, this sampling should also verify that the integrity of the caps by showing that the capping material has not been exposed from under the backfill material. Thus the sediment sampling program is substantially larger and more frequent for the capping alternatives than for the dredging alternatives. Specifically, for the removal scenarios, 250 sites will be occupied on three separate occasions, years 1, 4 and 9 of the post-construction period. For the capping scenarios, the caps will be sampled approximately every five years at 500 locations throughout the post-construction period. This frequency is approximately the same as proposed under the Monitored Natural Attenuation scenario, *i.e.*, years 1, 4, 9, 14, 19, and 24 (see Table G-7b).

G.5.4 Geophysical Surveying for Post-Construction

Geophysical surveys will be conducted on a routine basis to monitor changes in the installed backfill and capping material and identify areas undergoing scour or deposition. These data will be particularly important to the capping option since they can be used to assess the integrity of the cap over time. The program is similar in structure to the geophysical survey planned for the construction monitoring program and will use the geophysical survey data from the construction monitoring program as a baseline for comparison. The frequency of sampling is the same as the sediment monitoring program. This program will be completed just prior to the sediment sampling as an aid in the selection of coring sites.

<u>Bathymetry</u>

Bathymetric surveys will be required for all areas of sediment remediation to assess the degree of change in installed materials. For the purposes of the cost estimate, a nominal survey unit of 10 acres has been assumed. The survey itself will consist of both cross-sectional and longitudinal sweeps so as to provide "net-like" coverage of the removal areas. Some manual bathymetric surveying will be required in very shallow water where access by the survey boat is limited.

Bathymetric surveys will be performed to monitor the elevation of the sediment-water interface in areas of backfill and capping. For the dredging scenarios, surveying is scheduled for the three years of sediment inventory coring described above since the contaminated sediments have largely been removed. The capping plus select removal scenarios will require more frequent surveying to ensure that the caps remain intact. Thus the geophysical surveying will be done once every three years coinciding with the sediment coring program for the capping scenarios.

Side-Scan Sonar /Multibeam Survey

This program has essentially the same goals as the bathymetric surveys. In this instance, however, the program will examine in the changes in sediment texture primarily as a basis to assess cap integrity. This survey also permits the review of the conditions in between the lines of the bathymetric coverage net and thus can identify additional areas where the cap integrity may be compromised. A multibeam survey will be completed with each of the bathymetric surveys described above. In all cases, both the bathymetric and side-scan sonar surveys will be conducted prior to sediment inventory core collection. It is expected that the geophysical data collected will assist in the selection of some coring location

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Table G-1a
Monitoring Program for Monitored Natural Attenuation Alternative
(Water Program)

Monitored Natural Attenuation

Duration 30 Yrs

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBS -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater Waterford, and Troy.	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12 / yr	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	Suspended Solids Monitoring	daily	13	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Fort Miller[1] Schuylerville Stillwater Waterford Moses Kill Snook Kill Batten Kill Fish Creek Hoosic River	13	-Total Suspended solids -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy. -Flow[3] on all major tributaries -Fraction organic carbon on TSS (20 times/yr)	Permanent monitoring stations at each station to continously measure flow and to collect daily TSS samples *to be done on 10% of the samples*	Establish solids balance for the Upper Hudson Determine whether each reach is net depositional Monitor variation in nature of suspended solids.
	TI Pool Float Survey[4]	4 / yr	25 cross-sections	Every 0.25 miles from Rogers Island to TI Dam plus Snook Kill Moses Kill	4 samples per cross-section = 100 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward. -Flow[3] on all TI Pool tributaries	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.
	TI Dam to Lock 5 Float Survey[4]	4 / yr	30 cross-sections	Every 0.25 miles from TI Dam to Lock 5	4 samples per cross-section = 120 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward. -Flow[3] at Schuylerville -Flow[3] on tributaries Moses Kill Snook Kill Batten Kill	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the *mechanism*.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.

Notes:

1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Float survey entails sampling by drifting raft. Raft should be made to follow river flow. Water column samples include two from center channel (one at thalweg, one near-bottom) plus one in each of the shoals to either side of center.

Table G-1b
Monitoring Program for Monitored Natural Attenuation Alternative
(Fish Program)

Monitored Natural Attenuation

Duration 30 Yrs

Fish	Program	Frequency of Sampling (per year)	No. of Locations	Descriptions	Species per Station (spring/fall)	Samples Per Species	No of Samples/Year	Subtotal	Analytes	Objective
	Resident	2	5 (Fall)	NYSDEC Stations:					-Aroclor total PCBs	Examine long-term trends
	Species		8 (Spring)	Above Feeder Dam*	4/1	20	100		-Congener-specific	in PCB levels in fish
				TI Pool*	4/1	20	100		total PCBs	throughout Hudson and
				Stillwater*	4/1	20	100		-Lipid content	assure that fish levels do
				Albany/Troy*	4/1	20	100			not exceed unacceptable
				Catskill	3/0	20	60			concentrations.
				Poughkeepsie	2/0	20	40			
				Newburgh*	2/1	20	60			
				Tappan Zee	2/0	20	40	600		
	Striped Ba	2		Albany/Troy**	30/20	1	50		-Aroclor total PCBs	Examine long-term trends
				Catskill	20/20	1	40		-Congener-specific	in PCB levels in striped
				Poughkeepsie	20/20	1	40		total PCBs	bass throughout Hudson
				Stony Point	40/40	1	80		-Lipid content	
				Tappan Zee	40/40	1	80			Monitor for possible
				George Washington B	260	1	40			reopening of commercial
								330		fishery

Notes:

1. Add 5% additional samples per event for quality assurance.

* Fall stations for Young-of-year pumpkinseed

** Monthly sampling from June through October, 10 samples per month

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Table G-1c
Monitoring Program for Monitored Natural Attenuation Alternative
(Sediment Program)

Monitored Natural Attenuation

Duration 30 Yrs

Sediment	Program	Frequency of Sampling	No. of Locations	Descriptions	No. of Stations/Zone	No of Samples/Station	No of Samples/Event	Analytes	Objectives
	Dated Cores	Years 1, 4, 9, 14, 19, 24, 29	12	Above Feeder Dam-RM 203 TI Pool RM 188.6 Schuylerville-RM 185.4 Stillwater-RM 177.6 Waterford-RM 168 Albany-RM 145.3 Stockport Flats-RM 124 Kingston-RM 88.6 Lents Cove-RM 44.6 Tappan Zee-RM 30 NYC Harbor-RM -1.7 Mohawk R -near Cohoes	1	25	300	Total PCBs-congener-specific Cesium-137 Berylium-7 Organic carbon	Monitor trend in sediment to assure that levels remain below unacceptable criteria. Montior to support or refute the lack of substantive dechlorination rates in PCB-contaminated sediments.
	Sediment Inventory	Every Five Years	8	Hot Spots/Dredge Zones 8, 14, 16, 25, 28, 34, 37, 39	260	5[2]	1440	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor trend in entire sediment inventory in several important areas to establish rates of change.
	Shallow Sediment Inventory	Every Five Years	1,000	Roughly replicate GE composite locations plus add additional composites	1	5 (0-5, 5-10, 10-15, 15-20, 20-25 cm)[3]	500	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor trend in shallow sediment inventory in several important areas to establish rates of change.

Notes:

1. Add 5% additional samples per event for quality assurance.
2. Be-7 in top 2 cm only. Cs-137 in bottom core segment PCBs done on three main one-foot intervals.
3. 100 composite of 10 points each

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Table G-1d
Monitoring Program for Monitored Natural Attenuation Alternative
(Geophysical Program)

Monitored Natural Attenuation

Duration 30 Yrs

Geophysical	Program	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Event	Analytes
	Bathymetry	Year 1 - quarterly Year 2-5 annually Year 6-30 every 5 years	Main contamination zones of the Upper Hudson from Rogers Island to Lock 2.	Bathymetric cross-sections of the river must be collected in identified areas of contamination to directly measure sediment accumulation or scour. Bathymetric survey must have sufficient control to be able to resolve a few centimeters of change between sampling events.	200 cross sections per event. Cross sections should be collected every 0.1 river miles to closely and accurately monitor changes in sediment bed elevation. To be completed prior to sediment surveys.	None
	Side-Scan Sonar / Multibeam Survey	Year 1 - quarterly Year 2-5 annually Year 6-30 every 5 years	Main contamination zones of the Upper Hudson from Rogers Island to Lock 2.	Side-scan sonar to document change in sediment elevation and changes in sediment texture over time.	Multibeam survey should cover roughly 260 To be completed prior to sediment surveys.	None

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Table G-2a
Monitoring Program for Design Support
(Water Program)

Design Support

Duration 1 Yrs

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBS -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater Waterford, and Troy.	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12 / yr	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	Suspended Solids Monitoring	daily	13	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Fort Miller[1] Schuylerville Stillwater Waterford	13	-Total Suspended solids -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy. -Flow[3] on all major tributaries	Permanent monitoring stations at each station to continously measure flow and to collect daily TSS samples	Establish solids balance for the Upper Hudson Determine whether each reach is net depositional
				Moses Kill Snook Kill Batten Kill Fish Creek Hoosic River		-Fraction organic carbon on TSS (20 times/yr)	*to be done on 10% of the samples*	Monitor variation in nature of suspended solids.
	TI Pool Float Survey[4]	4 / yr	25 cross-sections	Every 0.25 miles from Rogers Island to TI Dam plus Snook Kill Moses Kill	4 samples per cross-section = 100 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward. -Flow[3] on all TI Pool tributaries	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.
	TI Dam to Lock 5 Float Survey[4]	4 / yr	30 cross-sections	Every 0.25 miles from TI Dam to Lock 5	4 samples per cross-section = 120 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward. -Flow[3] at Schuylerville -Flow[3] on tributaries Moses Kill Snook Kill Batten Kill	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possible the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments.

Notes:

1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Float survey entails sampling by drifting raft. Raft should be made to follow river flow. Water column samples include two from center channel (one at thalwig, one near-bottom) plus one in each of the shoals to either side of center.

Table G-2b
Monitoring Program for Design Support
(Fish Program)[1]

Design Support

Duration 1 Yr

Fish	Program	Frequency of Sampling (per year)	No. of Locations [3]	Descriptions	Species per Station	Samples Per Species	No of Samples/Year	Total Samples per Year [2]	Analytes	Objective
	Caged Fish	3	6	Upper Hudson only:					-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Establish baseline condition for this test to assist in its application during post-construction monitoring.
				Above Feeder Dam	1	3	9			
				TI Pool-north end	1	3	9			
				TI Pool-south end	1	3	9			
				Schuylerville	1	3	9			
				Stillwater	1	3	9			
				Waterford	1	3	9	54		

Notes:
1. Also included the fish monitoring program outlined in Table G-1b.
2. Add 5% additional samples per event for quality assurance.
3. Thiry day deployments, spring, summer and fall.

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Table G-2c
Monitoring Program for Design Support
(Sediment Program)

Design Support

Duration 1 Yr

Note: Water column and fish sampling programs for monitored natural attentuation must begin prior to the remedial operation itself
This program is simply intended to define sediment areas for remediation

Sediment	Program	No. of Locations Program	Number[4]	Comments	Samples/Station	Analytes[4, 7]	Objectives
	Sediment	0/0/3[1]	7,531	• Samples set into one of 5 grids	5[7]	Total PCBs	Establish current
	Inventory	0/10/10[2]	5,502	(0.4 to 8 cores per acre)		Cesium-137	sediment inventory to
		0/10/MNA[1]	4,807	for selected remediation zones		Berylium-7	allow for final selection
		3/10/10[2]	7,565	plus an additional areas		Organic carbon	of sediment zones for
		0/3/MNA[1]	5,214	meeting screening criteria[5, 6]			remediation via dredging
				• Sampling for excluded areas			or capping
				at 2 cores per 5 acre unit below Lock 5		Cation Exchange	Assess general degeree
				and 5 samples per 5 arce unit above Lock 5.		Capacity	of contamination and
				• Sampling for scenarios requiring			properties relating to
				complete removal based on			treatment.
				depth information needs only.			(10 percent of samples)
				These regions set to 40 cores			
				per 10 acre-unit. (Nodal			
				distance of 112 ft.)			

Notes:
1. Dredging only scenario
2. Dredging or capping scenario
3. Capping only scenario
4. Includes five percent additional samples for quality assurance.
5. Smallest area unit is 5 acres.
6. Preselected areas sampled at 40 cores per 5 acres to establish contaminated sediment depth.
   Screened areas sampled at 36 cores per 5 acres to establish sediment concentrations.
   Areas of low potential for contamination sampled at 5 cores per five acres for the areas between Rogers Island and Lock 5.
   Areas of low potential for contamination sampled at 2 cores per five acres below lock 5.
   Sampling for full section dredging performed at 40 cores per ten acres
7. PCB sampling intervals at 1 ft for a total of three feet of core
   Portion of top 2 cm sent for Be-7 analysis. Five inch segment below bottom PCB segment sent for Cs-137

Remediation Areas Dredge	Area (acres)	Cap	Unmodified Area (acres)	Total Area (acres)
0/0/3	938		2,966	3,904
0/10/10	608	0/10/10	3,297	
0/10/MNA	562		3,343	
3/10/10	389	3/10/10	3,515	
	603	0/3/MNA	3,301	

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TAMS

Table G-2d
Monitoring Program for Design Support
(Geophysical Program)

Design Support

Duration 1 Yr

Geophysical	Program	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	No of Samples/Event	Analytes
	Side-Scan Sonar / Multibeam Survey - Dredging	One extensive survey prior to onset of remedial operations.	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and effectivenes of dredge	One survey per 10 acres	Total area for survey varies by dredge scenario. Geophysical surveys must cover at least 25 percent more area than is slated for removal. Bathymetric cross-sections needed every 50 yards in areas slated for removal	None
	-Capping w/SM	One extensive survey prior to onset of remedial operations.	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Total area for survey varies by dredge scenario. Geophysical surveys must cover at least 25 percent more area than is slated for removal. Bathymetric cross-sections needed every 50 yards in areas slated for capping	None

Remediation Areas

Dredge	Area (acres)	Cap
0/0/3	938	
0/10/10	608	0/10/10
0/10/MNA	562	
3/10/10	389	3/10/10
	603	0/3/MNA

401967

Table G-3

Proposed Dredge Zone Areas for Expanded Hot Spot and Hot Spot Remediation Scenarios (Rogers Island to Lock 5)

Individual Dredge Zone Areas (acres)	Exp. *Hot Spot* Areas	*Hot Spot* Areas
TI Pool	12.5	11.7
	58.6	29.8
	5.1	2.4
	1.7	1.7
	5.2	5.2
	121.5	26.0
	0.4	39.6
	3.9	2.0
	3.5	3.1
	4.8	3.3
	9.6	7.9
	5.3	17.6
	12.4	
	25.1	
Mean Number of Acres per Area	19.3	12.5
Count	14	12
Median	5.3	6.55
TI Dam to Lock 5	37.5	29.7
	5.2	4.7
	19.5	13.8
	23.1	3.6
	6.1	6.1
	4.8	4.8
	0.9	2.7
	2.7	3.5
	5.5	4.9
	8.3	
	1.7	
Mean Number of Acres per Area	10.5	8.2
Count	11	9
Median	5.5	4.8
Combined Areas		
Mean Number of Acres per Area	15.1	10.6
Count	28	24
Median	5.4	5.65

Table G-4
Potential Remediation Areas of Upper Hudson

		TIP	TID-Lk5	Below Lk5
Selected Area (40 cores/5 acres)	Exp. *Hot Spot*	271	115	134
	Hot Spot	145	74	46
Screened (36 cores/5 acres)	Exp. *Hot Spot*	241 [1]	115 [2]	134 [2]
	Hot Spot	146	74 [2]	46 [2]

Notes:

1. Includes 25 acres which do not meet criteria. Because of its location, this area was considered too small to be excluded from screening.
2. Screened area estimate is set equal to selected area value, based on relationship seen in TI Pool, wherein the total screening area is approximately equal to the area selected for remediation.
   Screened areas below TI Dam will include areas adjacent to selected areas as well as others to be identified by side-scan sonar surveys to be completed under Design Support monitoring.

Table G-5
Details of Design Support Sediment Sample Program [1]

		River Section + Remediation Scenario							
		TI Pool (section 1)		TI Dam to Lock 5 (section 2)			Below Lock 5 (section 3)		
	Area Type	Full Section	Exp. Hot Spot	Full Section	Exp. Hot Spot	Hot Spot	Exp. Hot Spot	Hot Spot	MNA
Selected for Remediation	Area (acres)	534	270	488	115	74	134	46	
	Density of Sample Locations (cores per unit area)	40	40	40	40	40	40	40	
	Area unit (acre)	10	5	10	5	5	5	5	
	No. of Cores [2]	2242	2266	2052	620	620	1126	386	
	No. of PCB Samples [3]	6726	6798	6156	1857	1857	3379	1159	
Screened Areas	Area (acres)	NA	270	NA	115	74	134	46	
	Density of Sample Locations (cores per unit area)		36		36	36	36	36	
	Area unit (acre)		5		5	5	5	5	
	No. of Cores [2]		2039		870	557	1013	348	
	No. of PCB Samples [3]		6118		2610	1671	3039	1043	
Low Level Area (Outside)	Area (acres)	NA	0	NA	258	169	2614	2790	2882
	Density of Sample Locations (cores per unit area)		5		5	5	2	2	2
	Area unit (acre)		5		5	5	5	5	5
	No. of Cores [2]		0		271	177	1098	1172	1211
	No. of PCB Samples [3]		0		813	531	3294	3515	3630

Note:

1. These totals are summed to estimate the total samplng need for a given cleaning scenario. For Example, the 0/10/10 scenario requires a total of

section 1	section 2	section 3	
2242 +	(620+657+177) +	(386+348+1172)	=5502

For each scenario and river section, the preselected plus screended plus outside areas must be summed.

2. Includes an additional 5% QC samples
3. 3 PCB segments per core

401970

Table G-6a
Monitoring Program for Construction
(Water Program)

Construction Monitoring

Duration 5+1 Yrs

Use the Monitored Natural Attenuation program prior to 2004, including the completion of one float survey.

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly[4]	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBS -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy.	Time-of-travel style sampling only (i.e. sample collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are not increasing above expected levels.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12 / yr	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e. samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	On-site Turbidity Monitoring	Twice per day per dredge[5]	5 dredges	Upstream and downstream	20 samples per day	Turbidity at several depths at each station	Each dredge will be monitored twice per day by sampling upstream and downstream of the dredging area. Measurements will be obtained from at least three depths each time. Ten percent of samples to be nalyzed for Total Suspended Solids.	Monitor suspended solids releases and effectiveness of solids controls during remedial operations.
	Event-based PCB Water Column Monitoring	When required[5]	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBs PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy.	Time-of-travel style sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess impacts of spill or leakage events. A total of 50 events, 10 per year of operation, are assumed

Notes:

1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Years 1 through 6
5. Years 2 through 6

Table G-6b
Monitoring Program for Construction
(Fish Program)

Construction Monitoring

Duration 5+1 Yrs

Fish	Program	Frequency of Sampling (per year)	No of Locations	Descriptions	Species per Station (spring/fall)	Samples Per Species	No of Samples/Year[1]	Subtotal	Analytes	Objective
	Resident Species	2[2]	5 (Fall) 8 (spring)	NYSDEC Stations:					-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Examine long-term trends in PCB levels in fish throughout Hudson and assure that fish levels do not exceed unacceptable concentrations.
				Above Feeder Dam*	4/1	20	100			
				TI Pool*	4/1	20	100			
				Stillwater*	4/1	20	100			
				Albany/Troy*	4/1	20	100			
				Catskill	3/0	20	60			
				Poughkeepsie	2/0	20	40			
				Newburgh*	2/1	20	60			
				Tappan Zee	2/0	20	40	600		
	Striped Bass	2[2]		Albany/Troy**	30/20	1	50		-Aroclor total PCBs -Congener-specific total PCBs -Lipid content	Examine long-term trends in PCB levels in striped bass throughout Hudson Monitor for possible reopening of commercial fishery
				Catskill	20/20	1	40			
				Poughkeepsie	20/20	1	40			
				Stony Point	40/40	1	80			
				Tappan Zee	40/40	1	80			
				George Washington B	20/20	1	40			
								330		

Notes:

1. Add 5% additional samples per event for quality assurance.
2. Years 1 through 6

* Fall stations for Young-of-year pumpkinseed

** Monthly sampling from June through October. 10 samples per month

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Table G-6c
Monitoring Program for Construction
(Sediment Program)

Construction Monitoring
Duration 5+1 Yrs

Sediment	Program	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	No of Samples/Event[3]		Analytes
	Confirmational Core collection -Dredging	As necessary to demonstrate compliance with dredging residual criteria.	36 cores per unit remediated[2] Grabs only as a last resort	These samples to be placed in remediation zones. For five-acre units, samples set into an 84 ft grid (1 sample per 6,050 sq ft).	90% @ 1 sample per station (0-4 in) 10% @ 3 samples per station (0-4, 4-12, 12-24 in)	Depends on scenario 0/0/3 => 0/10/10 => 0/10/MNA=> 3/10/10 =>	 7,430 4,813 4,449 3,085	Total PCBs by immunoassay or field lab. 25% by conventional method for total PCBs cesium-137 and organic carbon.
	-Backfill	As necessary to demonstrate compliance with backfill residual criteria.	3 cores per acre remediated	These samples to be placed in remediation zones. 1 sample/14,500 sq ft	90% @ 1 sample per station (0-4 in) 10% @ 3 samples per station (0-4, 4-12, 12-24 in)	Depends on scenario 0/0/3 => 0/10/10 => 0/10/MNA=> 3/10/10 =>	 - - - -	Total PCBs by immunoassay or field lab. 25% by conventional method for total PCBs and organic carbon.
	-Capping w/SM	As necessary to demonstrate compliance with capping+backfill residual criteria.	3 cores per acre remediated	These samples to be placed in remediation zones. 1 sample/14,500 sq ft	100% at 1 sample per station (0-4 in)	Depends on scenario 0/10/10 => 3/10/10 => 0/3/MNA =>	 - - -	Total PCBs by immunoassay or field lab. 25% by conventional method for total PCBs and organic carbon.

Notes:
1. Add 5% additional samples per event for quality assurance.
2. Sampling density derived from same basis as design sampling.
3. Number of samples based on pre-selected areas plus 10 percent to allow for the additional of other areas for removal based on the design monitoring program.
Number also based on a 5 acre unit area as applied in other programs.

Table G-6d
Monitoring Program for Construction
(Geophysical Program)

Construction Monitoring

Duration 5+1 Yrs [1]

Geophysical	Program	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	No of Samples/Event	Analytes
	Side-Scan Sonar / Multibeam Survey - Dredging	As necessary to demonstrate compliance with dredging goals	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and effectiveness of dredge	One survey per 10 acres	Assume 5 percent will need resurveying after re-dredging operation Total area for survey varies by dredge scenario	None
	- Backfill	As necessary to demonstrate compliance with backfill goals	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Assume 5 percent will need resurveying after re-backfill operation Total area for survey varies by dredge scenario	None
	- Capping w/SM	As necessary to demonstrate compliance with capping+backfill goals	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Assume 5 percent will need resurveying after re-backfill operation Total area for survey varies by capping scenario	None

Note:
1. Years 2 through 6 only

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Table G-7a
Monitoring Program for Post-Construction Period
(Water Program)

Post-Construction Monitoring

Duration 25 Yrs

Water	Program	Frequency of Sampling	No. of Locations	Station Descriptions	No of Samples/Event	Analytes	Comments	Objective
	PCB Water Column Monitoring -Upper Hudson	Weekly[5]	7	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Schuylerville Stillwater Waterford	7[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater Waterford, and Troy.	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	PCB Water Column Monitoring -Freshwater Lower Hudson	12/yr[5]	4	RM142[1] RM100[1] Poughkeepsie[1] Mohawk at Cohoes	4[2]	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] on Mohawk at Cohoes	Time-of-travel sampling only (i.e., samples collected sequentially from upstream to downstream in accordance with the flow of the river)	Monitor PCB Levels in water to asess that levels are declining toward acceptable levels at an acceptable rate.
	Suspended Solids Monitoring	4/yr[7]	13	Bakers Falls Rogers Island TI D-West TID-PRW2[1] Fort Miller[1] Schuylerville Stillwater Waterford Moses Kill Snook Kill Batten Kill Fish Creek Hoosic River	260	-Total Suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward, Schuylerville, Stillwater, Waterford, and Troy. -Flow[3] on all major tributaries	4 twenty-day sampling events, one event for each season, consisting of daily composite suspended matter samples. Spring event to correspond to peak flow event *This program will require at least five to seven years to simply begin to satisfy the objectives.*	Establish solids balance for the Upper Hudson Determine whether each reach is net depositional
	TI Pool Float Survey[4]	4/yr[6]	25 cross-sections	Every 0.25 miles from Rogers Island to TI Dam plus Snook Kill Moses Kill	4 samples per cross-section = 100 samples per event	-Congener-specific PCbs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward. -Flow[3] on all TI Pool tributaries	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possibly the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments after remediation.
	TI Dam to Lock 5 Float Survey[4]	4/yr[6]	30 cross-sections	Every 0.25 miles from TI Dam to Lock 5	4 samples per cross-section = 120 samples per event	-Congener-specific PCBs -Total suspended solids -Fraction organic carbon on TSS -Flow[3] at Ft. Edward. -Flow[3] at Schuylerville -Flow[3] on tributaries Moses Kill Snook Kill Batten Kill	The frequency of this program could decrease to once per year after 10 years of study Congener fingerprint should clarify nature of source and possibly the mechanism.	Establish a data set sufficient to determine the sediment-to-water transfer coefficient for near-shore and center-channel sediments after remediation.

Notes:

1. Special access needs (boat)
2. Add 10% additional samples per event for quality assurance.
3. Year-round monitoring of flow at each station.
4. Float survey entails sampling by drifting raft. Raft should be made to follow river flow. Water column samples include two from center channel (one at thalwig, one near-bottom) plus one in each of the shoals to either side of center.
5. Decreases to quarterly monitoring after 5 years for 0/0/3 scenairo and after 10 years for all other removal scenarios.
6. Discountinued after 5 years for 0/0/3 scenario and after 10 years for all other removal scenarios.
7. Decrease to monthly sampling after 5 years for 0/0/3 scenario a, J after 10 years for all other removal scenarios.

Table G-7b
Monitoring Program for Post-Construction Period
(Fish Program)

Post-Construction Monitoring

Duration 25 Yrs

Fish	Program	Frequency of Sampling (per year)	No. of Locations	Descriptions	Species per Station (spring/fall)	Samples Per Species	No of Samples/Year	Subtotal	Analytes	Objective
	Resident	2	5 (Fall)	NYSDEC Stations:					-Aroclor total PCBs	Examine long-term trends
	Species		8 (Spring)	Above Feeder Dam*	4/1	20	100		-Congener-specific	in PCB levels in fish
				TI Pool*	4/1	20	100		total PCBs	throughout Hudson and
				Stillwater*	4/1	20	100		-Lipid content	assure that fish levels do
				Albany/Troy*	4/1	20	100			not exceed unacceptable
				Catskill	3/0	20	60			concentrations.
				Poughkeepsie	2/0	20	40			
				Newburgh*	2/1	20	60			
				Tappan Zee	2/0	20	40	600		
	Striped Bass	2		Albany/Troy**	30/20	1	50		-Aroclor total PCBs	Examine long-term trends
				Catskill	20/20	1	40		-Congener-specific	in PCB levels in striped
				Poughkeepsie	20/20	1	40		total PCBs	bass throughout Hudson
				Stony Point	40/40	1	80		-Lipid content	
				Tappan Zee	40/40	1	80			Monitor for possible
				George Washington Br	20/20	1	40	330		reopening of commercial
										fishery
	Caged Fish[2]	3	6	Upper Hudson Only:					-Aroclor total PCBs	Monitor for impacts of
				Above Feeder Dam	1	3	9		-Congener-specific	remedial activities on
				TI Pool-north end	1	3	9		total PCBs	fish after construction
				TI Pool-south end	1	3	9		-Lipid content	is complete.
				Schuylerville	1	3	9			
				Stillwater	1	3	9			
				Waterford	1	3	9	54		

Notes:
1. Add 5% additional samples per event for quality assurance.
* Fall stations for Young-of-year pumpkinseed
** Monthly sampling from June through October, 10 samples per month
2. This program is run for 10 years.

Table G-7c
Monitoring Program for Post-Construction Period
(Sediment Program)

Post-Construction Monitoring

Duration 25 Yrs for capping alternatives
10 Yrs for removal alternatives

Sediment	Program	Frequency of Sampling	No. of Locations	Descriptions	No. of Stations/Zone	No of Samples/Station	No of Samples/Event[1]	Analytes	Objectives
	Dated Cores	Years 1, 4, 9, 14, 19, 24 for all CAP alternatives Years 1, 4, 9 for REM alternatives 3/10/10 0/10/MNA 0/10/10 0/0/3	12	Above Feeder Dam-RM 203 TI Pool RM 188.6 Schuylerville-RM 185.4 Stillwater-RM 177.6 Waterford-RM 168 Albany-RM 145.3 Stockport Flats-RM 124 Kingston-RM 88.6 Lents Cove-RM 44.6 Tappan Zee-RM 30 NYC Harbor-RM -1.7 Mohawk R -near Cohoes	1	25	300	Total PCBs-congener-specific Cesium-137 Berylium-7 Organic carbon	Monitor trend in sediment to assure that levels remain below unacceptable criteria. Montior to support or refute the lack of substantive dechlorination rates in PCB-contaminated sediment.
	Shallow Sediment Inventory -Removal only	Year 1,4,9	250	Examine shallowest of sediments only.		2 (0-5, 5-10 cm)	500	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor trend in shallow sediment inventory in several important areas to establish rates of change and impact of remediation.
	-Capping	Every three years for 25 capping	500	Examine shallowest of sediments only.		2 (0-5, 5-10 cm)	1000	Total PCBs Cesium-137 Berylium-7 Organic carbon	Monitor cap/backfill integrity

Notes:
1. Add 5% additional samples per event for quality assurance.

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Table G-7d
Monitoring Program for Post-Construction Period
(Geophysical Program)

Post-Construction Monitoring

Duration 25 Yrs for capping alternatives
10 Yrs for removal alternatives

Geophysical	Program	Frequency of Sampling	No. of Locations	Descriptions	No of Samples/Station	Comment	Analytes
	Bathymetry Survey						
	- Dredging[1]	Year 1, 4, 9	Equal to number of dredge zones	Bathymetry to document change in sediment elevation with time.	One survey per 10 acres	Total area for survey varies by dredge scenario	None
	- Capping[2]	Years 1,4,9,14,19, 24, 29	Equal to number of dredge zones	Bathymetry to document change in sediment elevation and integrity of backfill plus cap	One survey per 10 acres	Total area for survey varies by capping scenario	None
	Side-Scan Sonar / Multibean Survey						None
	- Dredging[1]	Year 1, 4, 9	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and integrity of backfill plus cap	One survey per 10 acres	Total area for survey varies by dredge scenario	
	- Capping[2]	Years 1,4,9,14,19, 24, 29	Equal to number of dredge zones	Bathymetry plus side-scan sonar to document change in sediment elevation and completeness of backfill	One survey per 10 acres	Total area for survey varies by capping scenario	None

Notes:
1. Program ends after 9 years.
2. Program continues for entire period.

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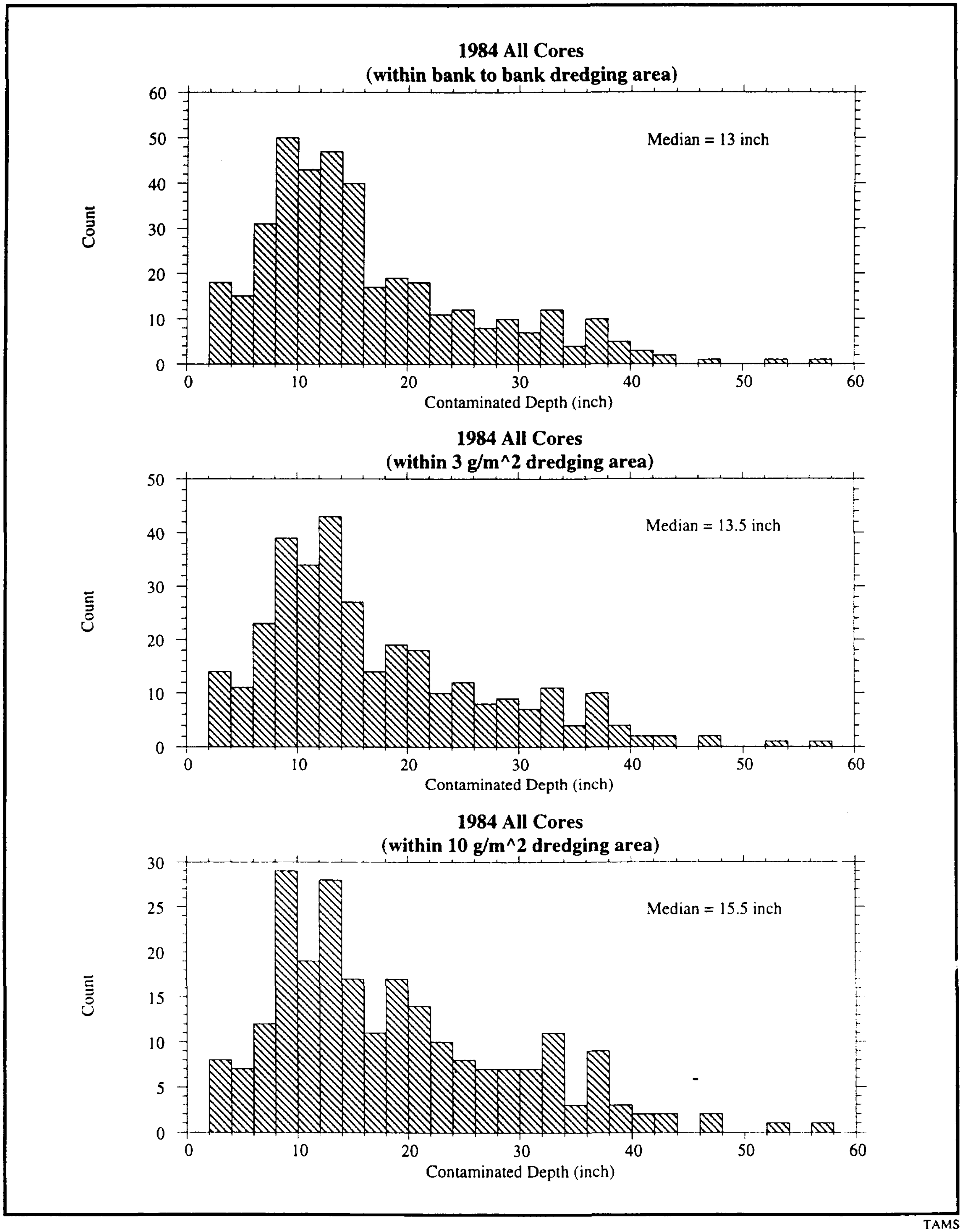

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Figure G-1
Depth of Contamination in Selected Sediment within TI Pool
(NYSDEC 1984 Results)

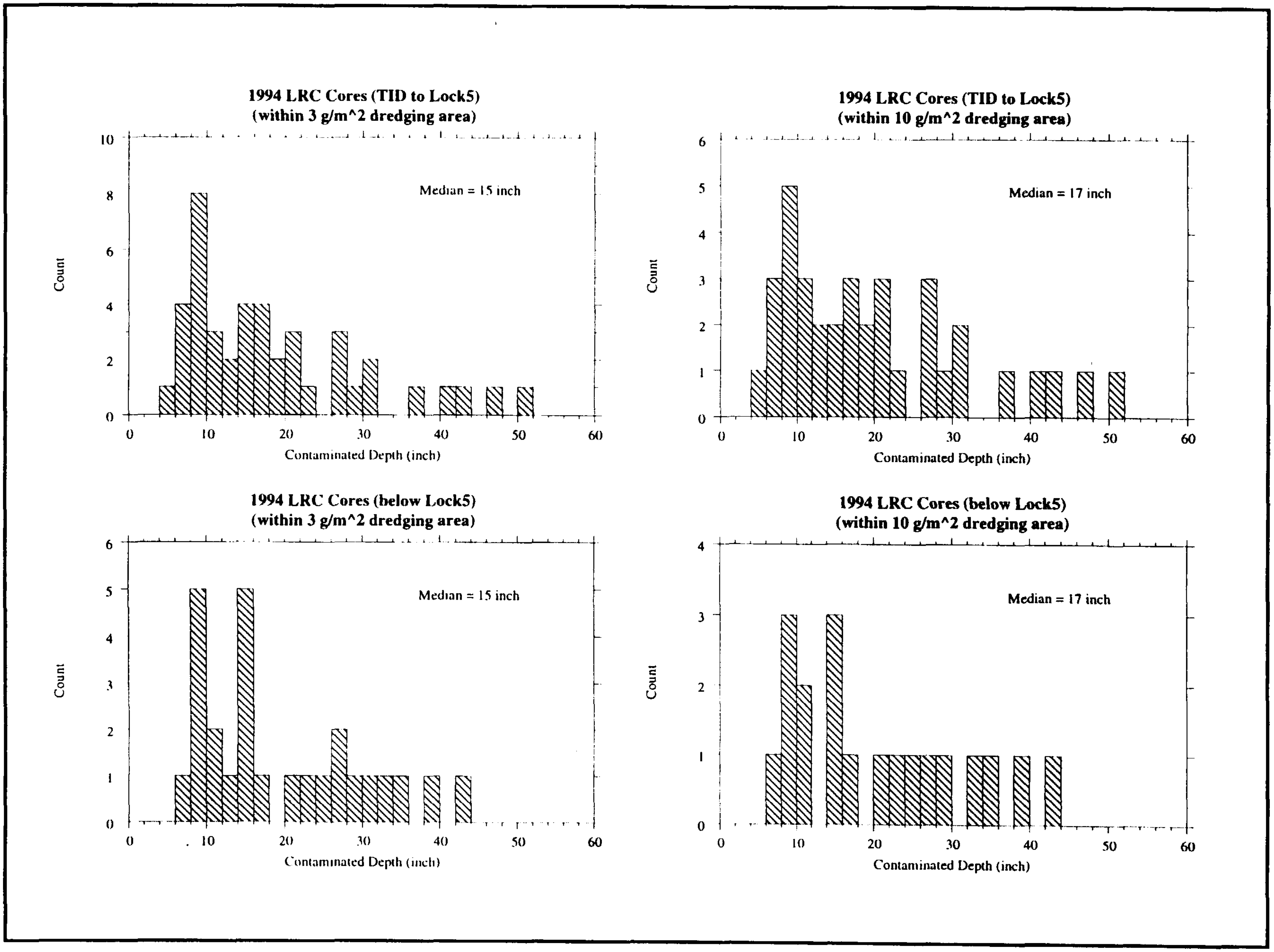

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Figure G-2
Depth of Contamination in Selected Sediments Below TI Dam
(USEPA 1994 Results)

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Appendix G

Part B

Determination of Sampling Requirements to Assess Depth of Sediment Removal

1. Introduction

Depths of sediment removal have been estimated as part of this report for the purposes of estimating costs and selecting removal equipment. To this end, the various sediment surveys, particularly the 1976-1978 NYSDEC, the 1984 NYSDEC and the 1994 USEPA surveys have provided a useful basis for these estimates. In actuality, however, the processes internal to the river, deposition, scour, bed load transport and others may modify the local conditions and change the thickness of contamination at given location. For this reason, it will be necessary to sample the areas selected for removal prior to remediation, as part of the design support program.

The data requirements to determine removal depth depend upon the desired outcome. As noted in the main report in the removal zones, it is USEPA's intention to minimize the residual sediment PCB contamination after removal. For this reason, it will be necessary to estimate a upper limit (*i.e.,* maximum depth) on the vertical extent of contamination, and not the mean or median as is more typical. In estimating a removal depth for an area, this value will provide the desired degree of certainty that the majority of the PCB inventory has been removed.

2. Calculation of the Number of Cores for Determination of Sediment Removal Depth

The estimation of the sampling requirements to determine removal depth is derived from the sediment contamination depth information available in the USEPA low resolution core results. For the low resolution cores, the depth of contamination was defined as the depth to a PCB concentration less than 1 mg/kg. These data are summarized below:

Statistics on Low Resolution Cores Depth of Contamination

	TI Pool	TI Dam to Lock 5	Below Lock 5
Mean (inch)	14.5	17.5	18.5
Median (inch)	15.0	13.5	15.0
Upper 10% (inch)	22.8	37.4	37.6
Upper 5 % (inch)	26.5	32.2	43.8
N	71	48	40
Min	5	5	6
Max	30	51	47
Depth of 2 ft capture	94%	80%	76%

From these data it is evident that sediment contamination is shallower in the TI Pool than in areas downstream. It is unlikely that these differences are due to sampling site selection since the LRC program was intended to characterize contamination in areas of fine-grained sediment both in the TI Pool and downstream of the TI Dam.

The importance of the selection of an accurate removal depth is evident in the following calculation. Given a 100 ft^2 area with 95 percent of its surface underlain by 2 ft of contamination and 5 percent underlain by 3 ft, setting the removal depth to 2 ft yields the following:

Dredge volume	= 100 ft^2 * 2 ft	= 200 ft^3
	= (95 ft^2 at 2 ft and 5 ft^2 at 3 ft thick but only 2 ft of removal)	
Residual volume	= 5 ft^2 * 1 ft	= 5 ft^3
Total volume	= 200 + 5	= 205 ft^3
Volume fraction left behind	= 5/205	= 2.4%

If the PCBs are assumed to be equally distributed throughout the sediment, then 2.4 percent of the PCB mass would remain as well. On the resolution of 1 ft intervals, the assumption of a constant concentration is not overly conservative since deeper cores tend to have higher average concentrations.

If 75 percent of the 100 ft^2 area is contaminated to 2 ft and 25 percent extends to 3ft, the following is obtained:

Dredge volume	= 100 * 2	= 200 ft^3
Remaining Volume	= 25 *1	= 25
Fraction Remaining	= 25/225	= 11%

As evident in the summary table above, a removal depth of 2 ft in the TI Pool would leave behind PCB-bearing sediments in about 6 percent of the coring sites. If the sediment mass is proportional to PCB mass, this would leave roughly 3 percent of the PCB inventory. A similar depth downstream would yield a residual of about 10 percent of the PCB inventory in removal zones below TI Dam.

To minimize this occurrence, the USEPA's design support program will characterize sediment depths throughout the areas selected for removal. In this fashion, the most appropriate depth of removal will be applied to each removal zone, minimizing the residual PCB inventory and avoiding unnecessary sediment removal.

The derivation of the number of samples required is based on USEPA (1989). The desired number of samples (n_d)to determine whether a specific proportion of an exceeds some threshold is given by

$$n_d = \left\{ \frac{z_{1-\beta}\sqrt{P_1(1-P)_1} + z_{1-\alpha}\sqrt{P_0(1-P_0)}}{P_0 - P_1} \right\}^2$$

Where:

n_d	The desired samples size for the statistical calculations.
α	The desired false positive rate for the statistical test to be used. The false positive rate for the statistical procedure is the probability that the depth of contamination in the study area will be declared to be at a specified depth when in fact it is deeper.
β	The false negative rate for the statistical procedure is the probability that the depth of contamination in the study area will be declared to be at a specified depth when in fact it is shallower and the true mean is P1. The desired sample size n_d is elected so that the statistical procedure has a false negative rate of β at P_1.
$z_{1-\beta}$ and $z_{1-\alpha}$	The critical values for the normal distribution with probabilities of 1- β and 1- α..
P_0	The criterion for defining whether the depth of contamination is above or below a given depth. According to the attainment objectives, the study area depth of contamination is declared to be less than the specified removal depth if the proportion of the study area with depth of contamination greater than the specified removal depth is less than P_0 (*i.e.,* the proposed removal depth is correct is correct if $P<P_0$).
P_1	The value of P under the alternative hypothesis for which a specified false negative rate is to be controlled. Think of P_1 as the value less than P_0 ($P_1 < P_0$) that designates a very shallow area that must, with great certainty, be designated as less than or equal to the proposed removal depth by the statistical test.

For the application to the TI Pool, it was assumed that α=0.05 and β=0.2. Additionally, the target probablilities were taken as:

$P_0 = 0.1$ (10% > 2ft)	A specified removal depth would be acceptable if less than 10 percent of the study area exceeded that depth.
$P_1 = 0.01$	A specified removal depth must be selected if less than 1 percent of the study area exceeds that depth.

Based on α =0.05 and β=0.2, $z_{1-\alpha}$= 1.645, $z_{1-\beta}$= 0.842.

Inserting these values into the equation above yields a requirement of

$$n_d = 41.4 \text{ samples}$$

Thus 41.4 or nominally 40 cores are required per study area to accurately assess the sediment removal depth. At this level of sampling, there is less than a 5 percent chance that more than 10 percent of the study area exceeds the removal depth. The value of 40 was applied to all identified removal zones in estimating the design support sampling requirements. For the Hot Spot remediation and Expanded Hot Spot remediation scenarios, this value was used on a 5-acre-unit basis. For the Full-Section, this value was applied on a 10-acre-unit basis.

REFERENCES

USEPA. 1989. Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media, Report No. PB89-234959. Prepared for the USEPA, Statistical Policy Branch (PM-223), Office of Policy, Planning, and Evaluation. February 1989.

Appendix G

Part C

Determination of the Sampling Requirements to Estimate the Median Tri+ Mass per Unit Area (MPA)

1. Introduction

As noted in the main body of this report, large areas of the Upper Hudson sediments have a reasonable possibility of containing relatively high levels of PCBs. The basis for selecting these areas for screening is described in a subsequent section of this appendix. Once selected, these areas need to be assessed via sampling in order to determine whether they do exceed the threshold criteria selected by the USEPA (*e.g.*, 3 g/m^2). The size of the target areas for the Hot Spot remediation and Expanded Hot Spot remediation sceanrios have been identified in Appendix G as part of the monitoring discussion. The estimation of the number of samples required per unit area is described below and was estimated from statistics derived from the 1984 NYSDEC survey of the TI Pool. These numbers were applied to all areas of potential sampling.

The analysis of the 1984 data showed the results to be log-normally distributed. As a result, the tests for meeting or exceeding the criteria are based on the geometric mean of the data since this parameter is a good estimate of the central tendency of the data (as opposed to the arithmetic mean). The following calculations are based on Gilbert (1987).

2. Sample Requirement Estimation

To estimate the true median of log-normal distributions, the number of independent observations, n, required from a population (*i.e.*, the number of cores from an area of study) is equal to

$$n = \frac{Z_{1-\alpha}^2 \quad S_y^2}{[\ln(d+1)]^2 + Z_{1-\alpha}^2 \quad S_y^2 / N}$$

where:	S_y^2	=	The variance of the data
	Z	=	The Z-score based on α
	α	=	Defined such that $100*(1-\alpha)$ is the confidence limit required
	N	=	The total population
	d	=	The error in the median which can be tolerated

Since the calculation is only concerned with exceedance of a threshold, a one-sided test is used.

For all 1984 samples falling in Expanded Hot Spot remediation areas, the variance of the PCB Tri+ mass per unit area (MPA) is:

$$S_y^2 = 2.144$$

The folllowing assumptions were made in the calculation:

1. Assume one-side upper 95% confidence limit
   Z = 1.65 (from Table A1)
2. Assume d = 0.5, *i.e.*, a 50 percent error in the estimate of the median is tolerable
3. Since N represents all possible cores from a study area (5 acres), N is very large and approaches infinity.

This yields:

$$n = \frac{1.65^2 * 2.144}{[\ln(0.5+1)]^2} = 35.5 \approx 36$$

Thus 36 cores are required per study area (5 acre unit) in order to estimate the median value of the Tri+ MPA to $\pm$50 percent with a 95 percent confidence level that the true median will not exceed the median plus 50 percent of its value.

REFERENCES

Gilbert, R.O. 1987. *Statistical Methods of Environmental Pollution Monitoring.* Van Nostrand Reinhold, New York.

Appendix G

Part D

Determination of the Screening Criteria for the Selection of Target Areas on the Basis of the Total PCB Mass per Unit Area (MPA)

1. Introduction

As noted in the main body of this report, large areas of the Upper Hudson sediments have a reasonable possibility of containing relatively high levels of PCBs. The basis for selecting these areas for removal or capping is derived from the remediation criteria selected by USEPA. Essentially, two of the three possible criteria described in this Feasibility Study use the PCB mass-per-unit-area (MPA) as a basis for the selection of an area for treatment. The following discussion relates the sampling results to be obtained from the design study to the cleanup criteria. That is, study areas (*i.e.,* 5-acre study areas) whose geometric mean values exceed these criteria have a real probability of an arithmetic mean that exceeds the clean-up criteria.. These values were also used as a basis for the selection of areas outside of the proposed remediation zones for screening via sampling as part of the design study. This analysis, combined with the data from the 1984 survey, provides the basis for the estimate of the total number of acres of river bottom to be screened during the design study. These areas were included in the estimates of sediment coring requirements for the Expanded Hot Spot and Hot Spot remediation scenarios.

As discussed earlier in this appendix, the number of samples required per unit area was estimated from statistics derived from the 1984 NYSDEC survey of the TI Pool. These numbers were applied to all areas of potential sampling. The analysis of the 1984 data showed the results to be log-normally distributed. As a result, the tests for meeting or exceeding the criteria are based on the geometric mean of the data. This parameter is a surrogate for the median of the population and is a good estimate of the central tendency of the data under a log-normal distribution (as opposed to the arithmetic mean). Since the sediment data are log-normally distributed, the individual measurements can be thought of as estimates of the geometric mean. The existing 1984 data can be used to identify the areas for screening by comparing the measured MPA values to the screening criterion since they are both related to the central tendency of the population. The following calculations are based on Gilbert (1987).

2. Screening Value Estimation

The goal of this calculation is to derive a threshold value for the median MPA for an area of study so as to define it as meeting or exceeding the USEPA cleanup standard with a predetermined degree of confidence. The screening values vary with the threshold standard (*e.g.,* 10 g/m^2) and must be calculated separately. Additionally, the selection of a screening criterion must take into account the fact that the MPA data are log-normally distributed. The screening value must also consider the uncertainties associated with the proposed sampling requirements described previously in this appendix.

Screening Criterion for the Hot Spot Remediation Scenario

The data to estimate a screening criterion for this scenario were obtained from the total PCB MPA values of 1984 samples falling in the Expanded Hot Spot remediation areas. This represents a larger data set than that for the Hot Spot remediation alone (approximately corresponding to the 10 g/m^2 threshold) since the larger sample set was considered more representative of the general nature of PCB contamination in the TI Pool in sediments requiring remediation. These samples yielded the following summary statistics:

$$\text{Mean } Log_{10}(MPA)\ \ \overline{Y} = 1.4903$$

$$\text{Variance } Log_{10}(MPA)\ \ S_y^2 = 2.1441$$

$$\text{StandardDeviation } Log_{10}(MPA)\ \ S_y = 1.4643$$

$$\text{Coefficient of Variation } S_y/\overline{Y} = 0.9825$$

Given that the underlying distribution is log-normal, then the best estimate of the mean for the population is given by the minimum variance unbiased estimator (MVUE) as defined in Gilbert (1987). For the purposes of screening, it is desired to certify that the upper confidence limit on the MVUE does not exceed the clean-up criterion. The upper one-sided $100(1-\alpha)\%$ confidence limit on the MVUE is given by (Gilbert 1987):

$$UL_{1-\alpha} = \exp(\overline{Y} + 0.5S_y^2 + \frac{S_y H_{1-\alpha}}{\sqrt{n-1}})$$

where

$\overline{Y},\ S_y^2,\ and\ S_y$ are defined as above,

n	=	the number of locations in the sample (*i.e.*, cores per study area)
$H_{1\text{-}\alpha}$	=	a statistic for log-normal distribution, somewhat equavalent to the t-statitistic for a normal distribution
$UL_{1\text{-}\alpha}$	=	the value of the upper confidence limit on the arithmetic mean of the population.

To determine a screening value for the Hot Spot remediation scenario, the value of 10 g/m^2, the MPA target value for this scenario, is substituted for the upper confidence limit on the arithmetic mean of the population ($UL_{1\text{-}\alpha}$). Additionally, the product of the coefficient of variation and the mean log is substituted for the standard deviation as

$$S_y = Y * \text{Coeff.Var.}$$
$$S_y = Y * 0.9825$$
$$S_y^2 = Y^2 * 0.9825^2$$

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In this fashion, the relationship between the standard deviation of the logs of the population and the mean log of the population (*i.e.*, the coefficient of variation) is preserved in the calculation. The equation is solved for Y, the value of the log of the geometric mean of the population:

$$10 = \exp(\bar{Y} + 0.5 * (0.9825)^2 \cdot \bar{Y}^2 + \frac{0.9825\bar{Y}H_{1-\alpha}}{\sqrt{36-1}})$$

$$0.4827\bar{Y}^2 + (1 + 0.1661H_{1-\alpha})\bar{Y} - 2.3 = 0$$

$$H_{1-\alpha} = 2.562$$

The value for $H_{1-\alpha}$ is obtained from Gilbert (1987) and n is taken as 36, as derived from the discussion on the estimation of the median MPA, given previously in this appendix. This yields:

$$\bar{Y} = 1.587$$

$$S_y = 1.38$$

Geometric Mean MPA (g/m^2) = $e^{(1.58675)}$ = 3.2 g/m^2

This calculation is based on knowing the true geometric mean of the population. The calculation also needs to recognize that the geometric mean determined from the design sampling will have a uncertainty of $\pm$ 50 percent. Thus, the geometric mean value of the sample group (*i.e.*, the set of 36 cores) must be less than 3.2 g/m^2 by 50 percent and is given by:

$$\hat{Y} + 0.5 * \hat{Y} = 3.2$$

$$\hat{Y} = 2.1$$

where $\hat{Y}$ is the geometric mean of the sample group.

Thus the screening level for the Hot Spot remediation scenario is 2.1 g/m^2.

Screening Criterion for the Expanded Hot Spot Remediation Scenario

The data to estimate the screening criterion for this scenario were again obtained from the total PCB MPA values of 1984 samples falling in the Expanded Hot Spot remediation areas. Repeating the calculation for the MPA target value of 3 g/m^2 for this scenario:

$$3 = \exp(\bar{Y} + 0.5 * (0.9825)^2 * \bar{Y}^2 + \frac{0.9825\bar{Y} * H_{1-\alpha}}{\sqrt{36-1}})$$

$$0.4827\bar{Y}^2 + (1 + 0.1661H_{1-\alpha})\bar{Y} - 1.1 = 0$$

$$H = 2.040$$

The value for $H_{1,\alpha}$ is obtained from Gilbert (1987). This yields the following value for the mean log MPA and its standard deviation:

$$\bar{Y} = 0.6630$$

$$S_y = 0.6514$$

$$\text{Geometric Mean MPA (g/m}^2) = e^{(0.6630)} = 1.94 \text{ g/m}^2$$

Correcting for the design sampling uncertainty of ± 50 percent, the geometric mean value of the sample group (*i.e.*, the set of 36 cores) is given by:

$$\hat{Y} + 0.5 * \hat{Y} = 1.94$$

$$\hat{Y} = 1.3$$

Thus the screening level for the Expanded Hot Spot remediation scenario is 1.3 g/m^2

3. Screening Values for the Tri+ MPA

An approximate estimate of the Tri+ threshold criteria for screening can be obtained by applying the correction factor for the 1984 NYSDEC sediment data (0.944) derived in Phase 2 (USEPA, 1999).

Hot Spot remediation	2.1*0.944 = **2.0** g/m^2
Expanded Hot Spot remediation	1.3*0.944 = **1.2** g/m^2

Notably, this approach is not as accurate as applying the correction before the calculation of the criteria, but this is likely to represent only a very minor adjustment to the screening values.

4. Selection of Areas to be Screened

The above calculation provides values for selection of areas for removal/capping under the Expanded Hot Spot remediation and Hot Spot remediation scenarios. These values apply to all areas of sampling, both those pre-selected for removal as well as those being screened for possible removal. As discussed above, these criteria were also used as a basis to identify those areas to undergo screening. While this is not a completely correct application, it is likely that this approach will identify all likely areas of sufficient contamination and minimize the number of contaminated areas left unaddressed. Applying these criteria to the Upper Hudson substantially increased the overall area requiring sampling during the design support program relative to the pre-selected areas alone. The discussion on the monitoring program contained in this appendix provides the details concerning the actual number of acres to be screened in each section under each scenario.

REFERENCES

Gilbert, R.O. 1987. *Statistical Methods of Environmental Pollution Monitoring.* Van Nostrand Reinhold, New York

USEPA. 1999. Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS and TetraTech, Inc. February 1999.

Appendix G

Part E

NYSDEC Fish Monitoring Program

LONG TERM HUDSON RIVER

PCB ANALYSIS PROJECT

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Project Leader ________________________
Ronald J. Sloan, Ph.D.

Project Quality Assurance Officer: ________________ 9/2/97
Robert W. Bauer

Date: Revised August 27, 1997
Revised October 22, 1997

1. Project Name: Long-Term Hudson River PCB Analysis Project

2. Revised Project Requested By: Ronald J. Sloan

3. Date of Request: December 19,1996

4. Date of Original Project Initiation: 1977

5. Project Leader: Ronald J. Sloan, Ph.D.

6. Quality Assurance Officer: Robert W. Bauer

7. Project Description:

A. Objective and Scope:

Since 1977 with the implementation of the Settlement Agreement between the General Electric Company and DEC, long-term monitoring of PCB in the Hudson River system was initiated. Major fish species, either resident or migratory, to the system were slated for annual monitoring. That effort has continued largely unchanged through 1996 with modifications subject to available funding and personnel. An intensive sampling of the upper Hudson River fish in 1991 and 1992 showed that PCB concentrations in fish were sensitive to perturbations of source conditions.
The finding and defining of PCB sources in the upper Hudson River (O'Brien and Gere 1994a, 1994b) were simultaneously coupled with an intense interest in the potential for changes in managing the recreational fishery. At the same time, PCB concentrations in portions of the river, particularly in the lower section below Poughkeepsie and specifically in striped bass, reflected levels that might signal considerations for the eventual re-opening of the commercial fishery for striped bass (Sloan et al. 1995). In keeping with the New York State policies on contaminants in fish (Horn and Skinner 1985, Kim 1990), a long-term monitoring strategy is defined herein commencing with the 1997 sampling year. It is anticipated that the General Electric Company will meet most analytical and a portion of sampling costs beginning in 1997.

Attention to the contminant conditions in the Hudson River has focused almost entirely on PCBs. It is recognized that other xenobiotics also exist and persist in the system but the available data are limited and are not up-to-date. Occasionally, it is desirable and necessary to evaluate these other materials, but to still recognize that PCBs are the dominant concern.

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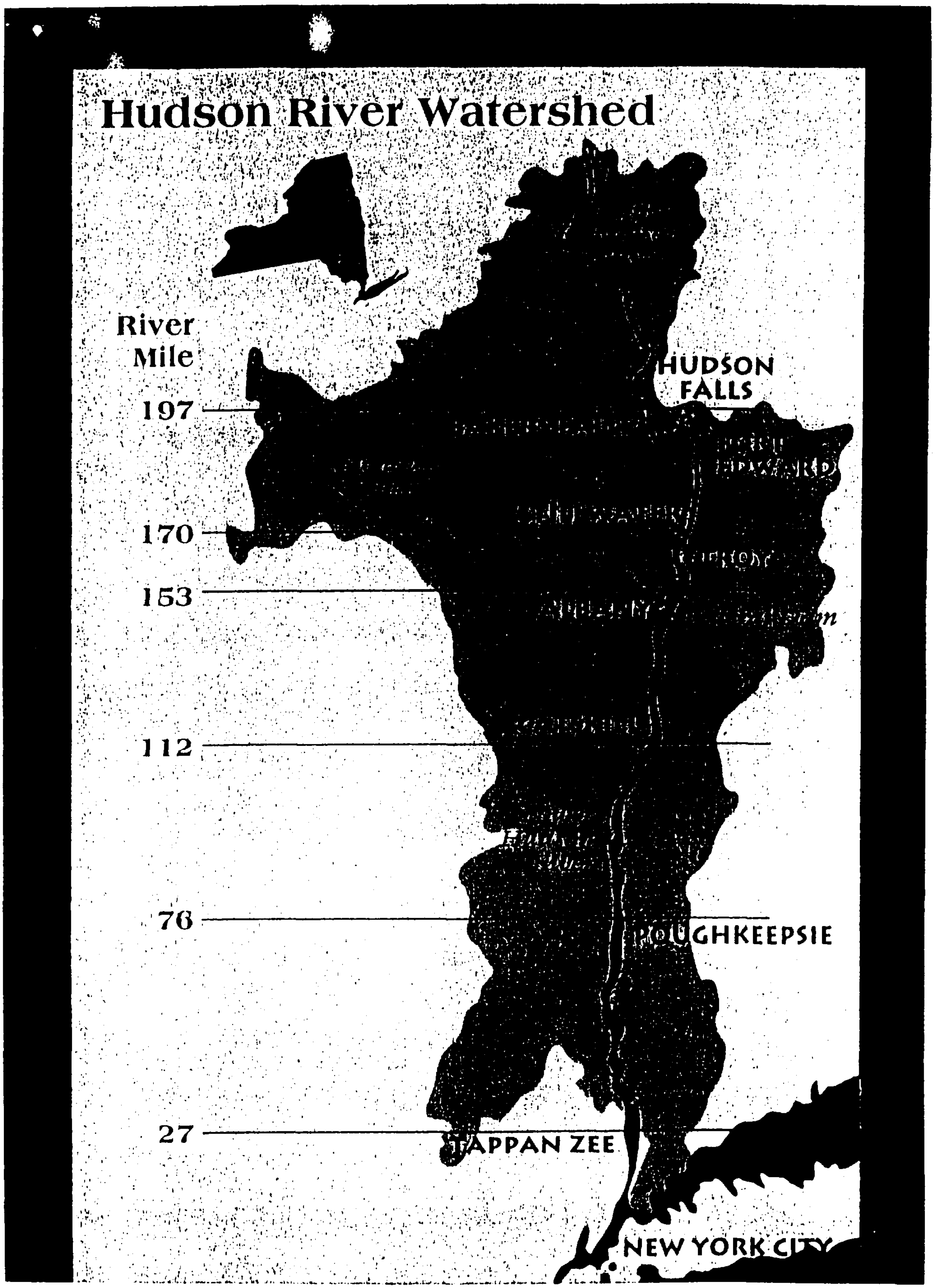

Figure 1. Locations and geographic reference points for the Hudson River used in the collection of fish for PCB analysis.

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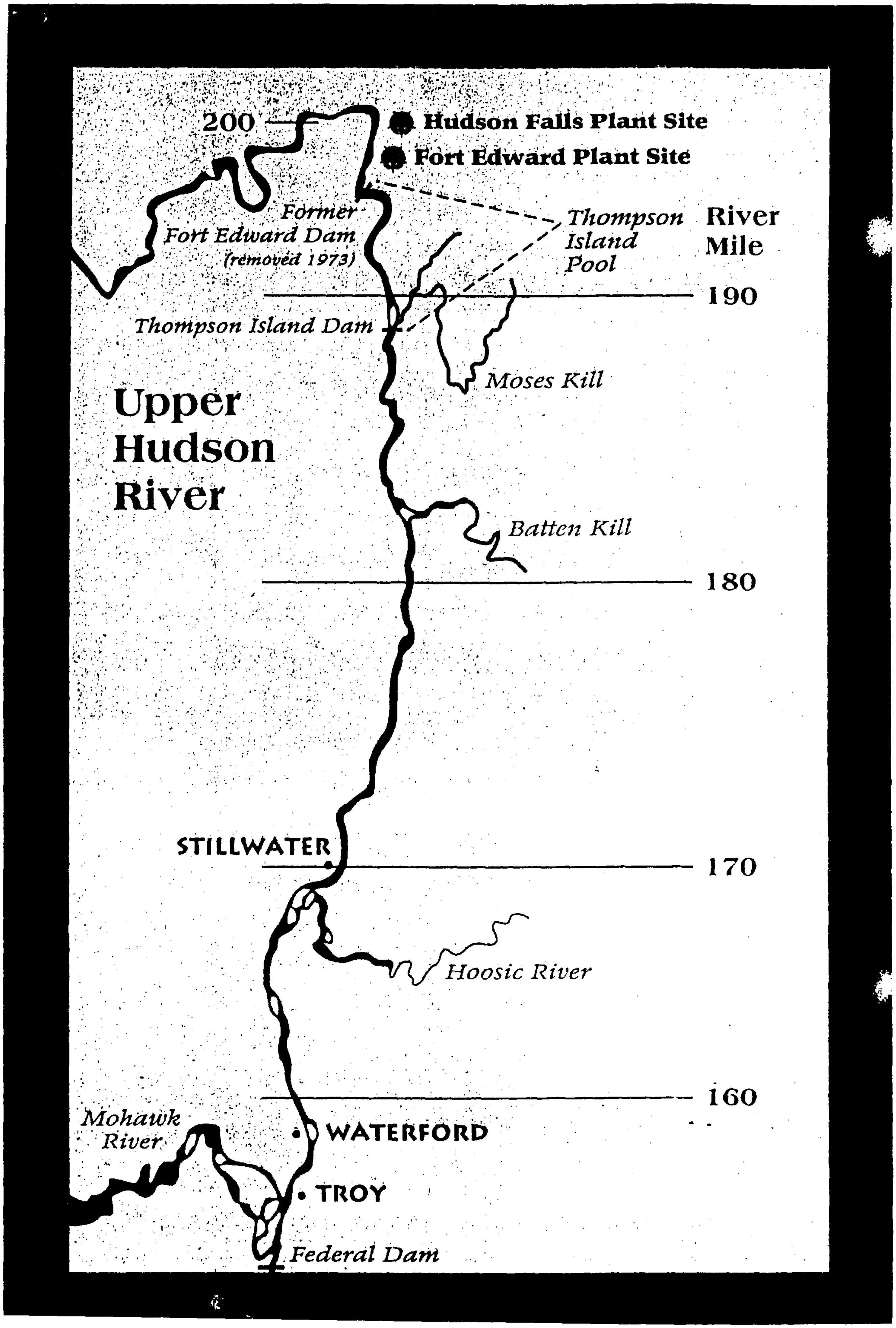

200
Hudson Falls Plant Site
Fort Edward Plant Site
Former
Fort Edward Dam
(removed 1973)
Thompson
Island
Pool
River
Mile
190
Thompson Island Dam
Moses Kill
Upper
Hudson
River
Batten Kill
180
STILLWATER
170
Hoosic River
160
Mohawk
River
WATERFORD
TROY
Federal Dam

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The principal objectives are:

1. to assess temporal trends in PCB concentrations in selected resident species;

2. to evaluate spatial relationships in Hudson River PCB contamination as reflected by concentrations in the fish;

3. to ascertain PCB concentrations in the striped bass recreational and commercial fisheries for purposes of providing health advice through the New York State Department of Health and for regulating commercial fisheries when PCB levels exceed the accepted U.S. Food and Drug Administration tolerance level of 2 ppm;

4. to determine the current status of other chemical contaminants in the fishery resources of the Hudson River.

In 1988 the project plan was revised to specifically reflect three study segments since funding sources and the level of funding had varied so widely during the course of the project. Each segment was considered scientifically sound when used as an entity. The approach beginning in 1997 is to expand on these basic three segments. The expansion in 1997 is oriented toward specific questions -- better delineation of spatial and temporal gradients, a wider array of contaminants, and modifications of fishery management options. In future years, presumably by 1999, depending upon the results obtained, monitoring plans would revert to the pre-1997 effort.

B. Data usage:

The data for Segments I and II (below) are used to measure the effectiveness of PCB remedial activities and respond to the first two objectives of this project. In addition, Segment II data are useful for triggering re-evaluation of PCB in recreationally available resident fish species when levels decline significantly in key species at several locations. Segment II data are also used for health advisory assessments by the Department of Health. Segment III information is directed at evaluations for the reopening of the closed commercial striped bass fishery and relaxation of restrictive health advisories.

In addition, the data are used for reporting to state and federal agencies, interested public sectors (e.g. New York State Commercial Fishermen's Association and environmental groups), and scientific/technical groups including representatives of the General Electric Company.

C. Monitoring network design and rationale:

Over the course of the project, the species desired for collection, the numbers to be sampled, and the locations involved were updated to best reflect current estimates required for effective sample sizes, advisory needs, questions on commercial fisheries, and other resource concerns (e.g. species or sizes on which data were lacking). Major collection areas and geographic reference points pertinent to sampling are depicted in Figure 1. For 1997, all three segments are to be completed according to the activity schedules for each segment. A major change in segments I and II is the deletion of a reference (control) location above Corinth used in 1995 and 1996 since the source condition in the Sherman Island Pool was remediated in 1996 and the fish have apparently responded already with significant declines in PCB concentrations (Engineering Science 1996). Sampling above Corinth is also contraindicated since the habitat is not suitable for supporting an abundant, diverse fish community. Sampling in the pool above the Feeder Dam is once again envisioned as a "reference" location for Hudson River fish PCB conditions above Hudson Falls. A brief description highlighting each segment is presented as follows:

Segment I - Yearling Pumpkinseed

Yearling pumpkinseed are the primary indicators of PCB contamination in specific reaches of the Hudson River. This aspect of evaluating PCB contamination in the Hudson River was first implemented in 1979 to provide annual data that would indicate relatively short-term responses to perturbations in the system, and would generate suitable information for temporal and spatial trend purposes, yet would require relatively small sample sizes by utilizing a species available throughout the freshwater reaches of the river (Sloan et al. 1984). The established spatial gradient was oriented toward the predominant Hudson River PCB source located in the Ft. Edward/Hudson Falls area. Unlike other fish species sampled in the past and included in Segments II and III, the fish are relatively locally oriented in their behavior, thus are a good indicator of local PCB contamination. Any significant change in biologically available PCB will be most readily discerned by this species. Hence, in the event of limited funds for the three study segments in any sampling year, the yearling pumpkinseed were to receive first priority. Yearling pumpkinseed will maximize the amount of information gained per dollar expenditure.

Age 1+ pumpkinseed are collected at five locations:

DEC Region	Hudson River Location
5	Above Feeder Dam in West Glens Falls
5	Thompson Island Pool
5	Stillwater
4	Albany/Troy
3	Newburgh

Collect up to 25 (a target minimum of 15) yearling pumpkinseed from each location.

Originally, seventy-five (75) fish were to be collected at each location within a two week period surrounding September 30th of each collection year. Chemical analyses were to be conducted on whole fish composites (25 composites of three fish per composite from each location per year). The use of young, single-aged fish of a species having a limited home range and the use of composite sample analyses restricted data variability thereby permitting use of small numbers of sample groups to obtain spatial and temporal variability information for determining the eventual fate of PCB in the Hudson River with or without remediation measures being undertaken. In recent years, however, there was a marked decrease in pumpkinseed availability.

It is not clear whether the populations were reduced by annual sampling in restricted habitats or whether habitat conditions changed. In any event, adjusted sample size calculations based on the 1988 data indicate that 15 individual analyses for each location are sufficient to detect a 25 percent change in PCB concentrations. In the event variability is high enough that sample sizes greater than 15 are necessary, collection efforts and analytical budgets are established for a maximum of 25 fish from each location.

Sampling will occur annually. Sampling may be modified or incorporated into the monitoring requirements as part of remediation of hazardous waste site(s).

Scheduled tasks include:

Activity	Time
Sampling	September
Sample preparation	October
Transport to lab	October
Chemical analysis	November-December
Data analysis and reporting	January of year following sampling

In 1997, all samples will receive the standard PCB analysis, plus ten fish from each site will undergo mercury and cadmium analysis.

Segment II - Resident Species

Three species of fish monitored historically provide reliable indications of spatial and temporal trend information which supplement and substantiate yearling pumpkinseed data. Although their abundances have changed over the years, they have remained relatively available. In some situations, however, collection locations and methods require modification to obtain adequate numbers. These species, i.e. largemouth bass, brown bullhead, white perch plus goldfish/carp, are also species to which the public can readily relate and the data supplied will most directly affect potential modifications of fisheries use restrictions. Goldfish and carp were dropped in recent years as indicator species due to their general unavailability in the river. Reasons for their population declines are not clear but they may be related to improvements in water quality.

The recommended sampling regime is indicated in Table 1. A reference area is being added in 1997 above the Feeder Dam at West Glens Falls. This site is to replace the Corinth control location. Additionally other locations principally targeting white perch, white catfish and American eel are being added in 1997 to better correlate with the striped bass collections and their sampling locations. American eel may not be retained in the sampling plan in subsequent years if they are not readily available for sampling in 1997. Part of the rationale for the species selected is to provide commonality of species across locations so that major discontinuities in the spatial gradient do not occur.

Currently, the sampling frequency for Segment II is annual, since major changes in PCBs entering the river are anticipated, primarily reflecting ongoing and potential remedial efforts.

Scheduled tasks include:

Activity	Time
Sampling	June
Sample preparation	July
Transport to lab	August
Chemical analyses	August - October
Data analysis and reporting	January of year following collection

As conditions change in the river and it is deemed worthwhile, additional samples for other species from various locations will be considered for analysis. Examples of species for consideration may include, but are not limited to, American shad, blue crab, bluefish, blueback herring and alewife. Health advisories and fish management considerations are considered in modifying the sampling plan.

Scheduled tasks include:

Activity	Time
Sampling	
--Spring collections	April - June
--Summer collections	July - August
--Fall collections	October - November
Sample preparation	
--Spring collections	July - August
--Summer collections	September - October
--Fall collections	November - December
Transportation to lab	
--Spring collections	July - August
--Summer collections	September - October
--Fall collections	November - December
Chemical analysis	
--Spring collections	August - November
--Summer collections	September - December
--Fall collections	December - January of year following collection
Data analysis and reporting	January - February of year following collection

D. Monitoring parameters and frequency of collection:

The actual data items to be gathered and tabulated for purposes of computerization and/or producing hard copy records include: laboratory entry numbers; tag numbers; species; date collected; location of collection; collectors; method of collection; preservation method; age, sex and reproductive condition where possible and appropriate; total length; and weight.

Scales and the impressions therefrom,taken for the purposes of aging, are to become the property of the New York State Department of Environmental Conservation, Hudson River Fisheries Unit, New Paltz, NY upon the completion of the project or at the conclusion of the annual sampling period.

The analytical laboratory, in addition to supplying laboratory entry numbers, must indicate: PCB concentrations in parts per million on a wet weight basis for a range of Aroclors- 1242, 1248, 1254 and 1260, separately and as appropriate; organochlorine pesticides including the DDT complex, several compounds in the chlordane group, and dieldrin; hexachlorobenzene; the lipid content in the sample in percent; mercury and cadmium (as totals for each); and specimen tag numbers for purposes of cross-reference to DEC collection records. A recommended frequency of 10 percent for additional analyses on congeneric PCBs, dioxins, dibenzofurans and PAHs. General guidelines for collecting fish and the handling of specimens are provided in Appendix I. For this project, the general field collection procedures are applicable. Preparation methods for standard fillets and whole fish are also found in Appendix I.

The Data Dictionary, adopted and developed by the Bureau of Environmental Protection, for compiling data in a dBase or FoxPro format is detailed in Appendix III.

Table 1: Sampling design for resident fish species of the Hudson River. Species and collection numbers in bold type represent expanded efforts for long-term monitoring beginning in 1997.

Location	Region	Species[a]	Collection Numbers	Date ± 2 Weeks	Sizes (mm)	Remarks
Above Feeder Dam (reference area)	5	**Largemouth bass[bm]**	**20**	6/16	>305	
		Yellow perch*[cm]	**20**	6/16	>170	
		Brown bullhead[m]	**20**	6/16	>200	
		Goldfish/carp	**10**	6/16	>200	
Thompson Island Pool	5	Largemouth bass[bm]	20	6/16	>305	
		Brown bullhead[m]	20	6/16	>200	
		Goldfish/carp[b]	20	6/16	>200	May be mixed sample
		Yellow perch*[cm]	**20**	6/16	>170	
Stillwater	5	Largemouth bass[bm]	20	6/16	>305	
		Brown bullhead	20	6/16	>200	
		Goldfish/carp	20	6/16	>200	May be mixed sample
		Yellow perch*[cm]	**20**	6/16	>170	
Albany/Troy	4	White perch*[bm]	20	5/26	>160	
		Yellow perch*[cm]	**20**	5/26	>170	
		Largemouth bass[bm]	20	5/26	>305	
		Brown bullhead[m]	20	5/26	>200	
Catskill	4	White perch[bm]	20	5/26	>160	
		Largemouth bass[bm]	20	5/26	>305	
		American eel[m]	**10**	5/26	>150	
		White catfish[m]	**20**	5/26	>356	
Poughkeepsie	3	**White perch[bm]**	**20**	6/16	>160	
		White catfish[m]	**20**	6/16	>356	

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Newburgh	3	**White perch**[bm] **White catfish**[m]	**20** **20**	6/16 6/16	>160 >356	
Tappan Zee	3	**White perch**[bm] **American eel**[m] **White catfish**[m]	**20** **10** **20**	6/16 6/16 6/16	>160 >150 >356	

*** Perch (White or Yellow) are listed due to lack of brown bullhead at Albany and goldfish/carp at Stillwater and the Thompson Island pool.**

[a] All samples are targeted for PCBs, and ½ the samples for organochlorine pesticides (largest sized individuals regardless of sex).

[b] Analyses expanded to include cadmium, polychlorinated dibenzodioxins and dibenzofurans, polycyclic aromatic hydrocarbons (PAHs), and congeneric PCBs for 1/4 of the targeted collection (largest sized specimens).

[c] Same as footnote "a" plus congeneric PCBs for 1/4 of the targeted collection (largest sized specimens).

[m] Samples also targeted for mercury.

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Segment III - Striped Bass

Striped bass is the subject of one of the important commercial fisheries which has been closed due to Hudson River PCB contamination. They are also part of a growing recreational fishery which is clouded by the health advisory on limiting fish consumption due to excessive PCB concentrations. Due to their migratory nature, striped bass usually cannot be considered a good indicator of local PCB contamination, but through use of large sample sizes to counteract significant data variability, striped bass may be an indicator of relatively large scale spatial and temporal patterns of PCB contamination. Recent evaluations, however, provide some perspective on the capability of this species , even though migratory, to reflect localized source situations (Sloan et al. 1995, Skinner et al. 1996). However, the primary focus of contaminant analysis for this species has been to provide information for the proper regulation of commercial fisheries.

PCB concentrations in striped bass tend to be higher with increased distance upstream (i.e. closer proximity to the major PCB sources). A summary of results from 1994 are included herein which illustrate this point - (Table 2). In addition, there may be seasonal variations in PCB content of striped bass which also require evaluation. Therefore, any reopening of the commercial fishery will be phased in, based on data obtained for several years, seasons and locales.

Spring and Fall collections of striped bass (Table 3) are recommended annually from several locations (Figure 1). From the most recent data, 1996 and in particular 1997, the status of PCB contamination in the fish will be closely examined with regard to the possibility of managing a commercial fishery in the Hudson River. Consideration for and certification of the reopening of a once contaminated fishery is the responsibility of the New York State Department of Health under ECL 11-0325 and the "Final Environmental Impact Statement for Policy on Contaminants in Fish" (Horn and Skinner 1985). The N.Y.S. Department of Health criteria for considering the reopening of a commercial fishery are discussed in Appendix II. Any actions would also necessitate the establishment of the appropriate regulations and require the endorsement of the Atlantic States Marine Fisheries Commission.

Modifications for 1997 reflect an incresed sampling at Catskill. Further modifications will occur as necessary dependent upon the 1997 results.

Table 2. PCB concentrations in striped bass from the Hudson River in 1994.

Location	Month Collected	No. of Fish	Length (mm) Ave.	Length (mm) Min.-Max.	Weight (g) Ave.	Weight (g) Min.-Max.	Lipid (%) Ave.	Lipid (%) Min.-Max.	Lower-Cl (ppm) Ave.	Lower-Cl (ppm) Min.-Max.	Higher-Cl (ppm) Ave.	Higher-Cl (ppm) Min.-Max.	Total PCB (ppm) Ave.	Total PCB (ppm) Min.-Max.
Albany/Troy (RM 153)	August	19	599	418 - 950	2392	680 - 8890	2.90	0.89 - 6.64	2.31	0.26 - 4.80	3.86	0.37- 6.60	6.17	0.63 -10.50
	October	10	589	492 - 730	2215	1200 - 4120	2.77	1.00 - 5.09	2.80	0.99 - 6.20	4.06	1.70- 7.40	6.86	2.82 -13.60
	All Dates	29	596	418 - 950	2331	680 - 8890	2.86	0.89 - 6.64	2.48	0.26 - 6.20	3.93	0.37- 7.40	6.41	0.63 -13.60
Catskill (RM 112)	May	21	659	470 - 960	3644	1100 - 9540	3.04	0.52 - 7.76	0.45	<0.05 - 2.20	2.60	0.52-11.60	3.05	0.59 -13.80
Poughkeepsie (RM 76)	April	33	666	550 - 908	3293	1560 - 8940	4.97	1.53 - 9.88	0.39	<0.05 - 3.70	2.32	0.39-11.70	2.71	0.41 -15.40
	May	10	669	597 - 880	3090	2040 - 7260	5.62	2.64 - 8.57	0.30	<0.05 - 0.70	1.70	0.72- 4.80	1.99	0.91 - 5.50
	All Dates	43	667	550 - 908	3246	1560 - 8940	5.12	1.53 - 9.88	0.37	<0.05 - 3.70	2.18	0.39-11.70	2.54	0.41 -15.40
Croton Pt. (RM 40)	April	18	653	557 - 710	2887	1640 - 3900	4.32	2.41 - 6.54	0.18	<0.05 - 0.49	1.67	0.46- 3.90	1.85	0.48 - 4.39
	May	25	679	489 - 904	3452	1120 - 8560	4.47	1.41 - 7.58	0.20	<0.05 - 2.20	1.53	0.15- 7.00	1.73	0.20 - 9.20
	All Dates	43	668	489 - 904	3215	1120 - 8560	4.41	1.41 - 7.58	0.19	<0.05 - 2.20	1.59	0.15- 7.00	1.78	0.20 - 9.20
Tappan Zee Bridge (RM 27)	April	20	650	548 - 910	2981	1720 - 8760	4.49	1.43 - 7.34	0.24	<0.05 - 1.60	1.67	0.33- 6.30	1.91	0.38 - 7.90
	May	20	654	536 - 976	2997	1380 -10660	4.06	1.30 - 7.06	0.12	<0.05 - 0.62	1.07	0.31- 3.33	1.19	0.37 - 3.95
	All Dates	40	652	536 - 976	2989	1380 -10660	4.27	1.30 - 7.34	0.18	<0.05 - 1.60	1.37	0.31- 6.30	1.55	0.37 - 7.90
Lower Estuary (RM 12-76)	Spring	126	663	489 - 976	3154	1120 -10660	4.61	1.30 - 9.88	0.25	<0.05 - 3.70	1.72	0.15-11.70	1.97	0.20 -15.40
Haverstraw Bay/Tappan Zee(RM27-33)	November	46	646	495 - 820	3321	1400 - 6700	5.82	1.05 - 9.67	0.44	<0.05 - 1.40	1.92	0.44- 5.00	2.36	0.47 - 6.40
	December	53	628	514 - 865	2841	1500 - 5200	5.55	1.35 - 9.66	0.24	<0.05 - 1.70	1.15	0.31- 3.66	1.39	0.36 - 5.36
	All Dates	99	636	495 - 865	3064	1400 - 6700	5.67	1.05 - 9.67	0.33	<0.05 - 1.70	1.50	0.31- 5.00	1.84	0.36 - 6.40

Table 3: Sampling design for striped bass from the Hudson River. Seasons and collection numbers in bold type represent an expanded effort beginning in 1997.

Season	River-mile	Location	Collection[a] Numbers	Date (month)	Sizes[a] (mm)	Remarks
Spring - Fall	152	Albany/Troy	10[b]	June	>457	
			10	July	>457	
			10	August	>457	
			10	September	>457	
			10[b]	October	>457	
Spring (April, May & June only)	112	"Catskill" area	20	Early run	>457	----
			20[b]	Late run	>457	Collect 2 to 4 weeks after first collection
Spring	76	Poughkeepsie	20	Early run	>457	----
			20[b]	Late run	>457	Collect 2 to 4 weeks after first collection
Spring	40	Stony Point area	20	Early run	>457	----
			20	Late run	>457	Collect 2 to 4 weeks after first collection
Fall			20	~10/15	>457	----
			20	~11/15	>457	Collect 2 to 4 weeks after first collection
Spring	27	Tappan Zee Bridge	20	Early run	>457	----
			20[b]	Late run	>457	Collect 2 to 4 weeks after first collection
Fall			20	~10/15	>457	----
			20[b]	~11/15	>457	Collect 2 to 4 weeks after first collection
Spring	12	George Washington Bridge	20	Early run	>457	----
			20[b]	Late run	>457	Collect 2 to 4 weeks after first collection
TOTALS		Riverwide				
Sprg/Summer			250		>457	
Fall			80		>457	
All			330		>457	

*** Sizes are measured as total length (TL) in millimeters; 1/3 of total striped bass sample from each location should measure 24 inches TL (610 mm) or more; at least 10% of each sampling should be targeted to be over 33 inches TL (838 mm).**

[a] All samples targeted for PCBs and mercury; and ½ the samples for organochlorine pesticides (select the males largest to smallest; fill in with females if males are not available).
[b] Analyses expanded to include cadmium, polychlorinated dioxins and dibenzofurans, polycyclic aromatic hydrocarbons (PAHs) and congeneric PCBs for 1/4 of the targeted collection (largest males only; use females if males are not available).

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E. Parameter Table:

For 1997, the maximum numbers of samples to be analyzed are 510 fillets from resident species, 330 fillets of striped bass, and 125 whole pumpkinseed. This is a maximum of 965 samples. The parameters being analyzed and pertinent analytical methods for fish preserved through freezing at -18°C or colder for a holding time of one year are:

Analyte	**Method**
Aroclor PCBs	Modified EPA 8080
Congener PCBs	ITS Environmental SOP (Modify to separate co-planar congeners;suggest procedure of Schwartz et al. 1993)
PAHs	Modified EPA 8310 (Method development might follow lines of some of the procedures reviewed by Howard and Fazio 1993)
Chlorinated dioxins/furans	EPA 8280/8290
Mercury	Modified EPA 7470
Cadmium	Modified EPA 7131
Lipid Content	En Chem SOP

Examples of general laboratory procedures using SOPs of the NYSDEC Hale creek Field Station are provided in Appendix IV.

Table 4 . Data Quality Requirement and Assessments for fish tissue. A minimum of 5% of samples analyzed shall be quality assurance for spiked recoveries. A minimum of 10% of the samples analyzed shall be quality assurance for duplicates and standards.

Parameter	Detection Limit	Quantitation Limit	Estimated* Accuracy	Estimated** Precision (ppm)
Mercury	10 ng/g	50 ng/g	± 30%	0.063
Cadmium	10 ng/g	50 ng/g	± 30%	0.100
alpha-hexachlorocyclohexane (HCH)	1 ng/g	10 ng/g	± 24%	0.050
beta-HCH	1 ng/g	10 ng/g	± 24%	0.050
gamma-HCH (Lindane)	1 ng/g	10 ng/g	± 24%	0.050
delta-HCH	1 ng/g	10 ng/g	± 24%	0.050
cis-chlordane	1 ng/g	10 ng/g	± 24%	0.050
trans-nonachlor	1 ng/g	10 ng/g	± 24%	0.050
Oxychlordane	1 ng/g	10 ng/g	± 24%	0.050
p,p'-DDT	5 ng/g	10 ng/g	± 24%	0.033
p,p'-DDE	5 ng/g	10 ng/g	± 24%	0.033
p,p'-DDD	5 ng/g	10 ng/g	± 24%	0.033
Dieldrin	1 ng/g	10 ng/g	± 24%	0.050
Endrin	1 ng/g	10 ng/g	± 24%	0.050
Hexachlorobenzene (HCB)	1 ng/g	10 ng/g	± 24%	0.050
Heptachlor epoxide	1 ng/g	10 ng/g	± 24%	0.050
Mirex	5 ng/g	10 ng/g	± 24%	0.050
Oxychlordane	2 ng/g	10 ng/g	± 24%	0.050

PCB total	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1242	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1248	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1254	10 ng/g	50 ng/g	± 30%	0.649
Aroclor 1260	10 ng/g	50 ng/g	± 30%	0.649
Lipid	0.01 percent	0.01 percent	not applicable	0.10 %
2,3,7,8-TCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8-PeCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,7,8-HxCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,6,7,8-HxCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8,9-HxCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,6,7,8-HpCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,6,7,8,9-OCDD	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
2,3,7,8-TCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8-PeCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
2,3,4,7,8-PeCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,7,8-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,6,7,8-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
2,3,4,6,7,8-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,7,8,9-HxCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,6,7,8-HpCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
1,2,3,4,7,8,9-HpCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g

1,2,3,4,6,7,8,9-OCDF	0.001 ng/g	0.001 ng/g	± 30%	0.010 ng/g
Acenaphthene	50 ng/g	50 ng/g	to be determined	to be determined
Acenaphthylene	50 ng/g	50 ng/g	to be determined	to be determined
Anthracene	50 ng/g	50 ng/g	to be determined	to be determined
Benzidine	250 ng/g	250 ng/g	to be determined	to be determined
Benzo (a) anthracene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (a) pyrene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (a) fluoranthene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (g,h,i) perylene	50 ng/g	50 ng/g	to be determined	to be determined
Benzo (k) fluoranthene	50 ng/g	50 ng/g	to be determined	to be determined
Chrysene	50 ng/g	50 ng/g	to be determined	to be determined
Dibenzo (a,h) anthracene	50 ng/g	50 ng/g	to be determined	to be determined
Fluoranthene	50 ng/g	50 ng/g	to be determined	to be determined
Fluorene	50 ng/g	50 ng/g	to be determined	to be determined
Indeno (1,2,3-cd) pyrene	50 ng/g	50 ng/g	to be determined	to be determined
Naphthalene	50 ng/g	50 ng/g	to be determined	to be determined
Phenanthrene	50 ng/g	50 ng/g	to be determined	to be determined
Pyrene	50 ng/g	50 ng/g	to be determined	to be determined

* Accuracy is based on analysis of spiked samples. Spikes should be representative of the analyte concentration range expected in the fish samples.

In the dioxin and dibenzofuran groups, accuracy is estimated by use of selected radio-isotopes of internal, surrogate and alternate standards for each sample analyzed. Acceptance of specific results are measured against USEPA Method 8290 requirements.

** Precision is based on analysis of duplicate samples from the same specimen. If quantified values are greater than specified estimated precision than any duplicate analyses should be within ± 20 percent.

8. Project Organization and Responsibility:

Region 3 - Hudson River Fisheries Unit A. Kahnle - 914-256-3072 Region 4 - W. Keller - 607-652-7364 Region 5 - L. Strait - 518-891-1370	Sampling, storage, transportation and QC
Independent contractor - to be arranged	Sampling, storage, shipment prep, data management and QC
Suggested laboratories: En Chem, Inc. formerly Hazleton Environmental Services, Inc. Madison WI T. Noltmeyer 608-232-3310 (PCBs, organochlorine pesticides, mercury, cadmium, PAHs, lipids) ITS Environmental formerly Inchcape Testing Colchester VT (congeneric PCBs) Triangle Laboratories Research Triangle Park NC (Chlorinated dioxins and dibenzofurans)	Analyses, raw data management and reporting, billing and QC
Ronald J. Sloan, Ph.D. Project Leader 518-457-0756	Data processing and QC, laboratory data quality review, data management, data quality review, performance and system auditing
Robert W. Bauer 716-226-2466	Overall quality assurance
Ronald J. Sloan, Ph.D.	Overall project coordination
General Electric Company and other parties as needed	Fiscal resources for fish collections, technician services, laboratory analyses and project review

9. Data Quality Requirements and Assessments:

See Table 4 for analytical specifications.

Data representativeness: Fish samples shall consist of edible sizes or ages specified in the text and tables for each study segment.

Data comparability: Analyses will be performed for all fish with the exception of yearling pumpkinseed on a standard fillet. Comparisons will be made on both wet weight and lipid bases.

Data completeness: Data will be considered complete within any given study segment when all of the samples are collected dependent upon fish availability and all results are returned from the laboratory.

10. Sampling procedures:

Sampling will be by standard techniques of netting, electrofishing or angling. Fish must be of sizes or ages specified in the study segment descriptions. Yearling pumpkinseed are prepared and analyzed whole. Other species are analyzed as standard fillets. Collection data are to be recorded on the Fish/Wildlife Collection Record (Appendix I).

11. Sample custody procedures:

The Chain-of-Custody form (Appendix I) must accompany all samples to any temporary storage facility and to the Hale Creek Field Station for sample preparation and shipment. En Chem Chain-of-Custody Record and Analysis Request forms (Appendix I), only, accompany all samples shipped frozen via priority air freight to En Chem. The Analysis Request forms must be double checked for accuracy and to ensure that the shipment contents are properly accounted. Similar chain-of-custody procedures are followed when split samples are sent to other laboratories for special analyses (e.g., subsamples going to Triangle Laboratories for dioxin analyses).

12. Calibration procedures and preventive maintenance:

Normal operating procedures call for twice daily inspection of: chemical assay procedures and validation, reagent preparation and labelling, controls and standards, instrument calibration and maintenance, analytical results, data recording and analysis and archiving of data. An Internal Operating Procedure (IOP) manual detailing use, calibration and maintenance is kept with each item of analytical equipment.

13. Documentation, Data Reduction and Reporting:

A. Documentation: Raw laboratory data are stored in computer files at the laboratory. All results are generated electronically onto diskette and along with a hard copy report sheet are sent to Ronald Sloan for review and reporting. All data are checked for possible errors. As soon as data are error checked, they are provided to the General Electric Company via John Haggard, G.E. Project Manager, in hard copy and electronic format.

B. Data Reduction and Reporting: Raw data are compiled, using the DEC data dictionary format (Appendix III), tabulated, subjected to statistical analyses and reported as appropriate, usually with explanatory text. Information releases are coordinated with the General Electric Company as per the agreement between the NYSDEC and GE dated Oct. ,1997. A draft copy is attached as Appendix V.

14. Data validation:

All data, plus data from spiked recoveries, duplicates and blanks are reviewed by Ronald Sloan. Every 17 unknown samples are followed by one spiked recovery, one duplicate analysis selected at random and one blank.

15. Performance and System Audits:

The laboratories participate in performance evaluation studies conducted by the New York State Department of Environmental Conservation.

16. Corrective Action:

When a QC sample falls outside the control limits, the QC sample is rerun [if an error in calculation or reporting is not found]. If the QC sample is still outside the control limits, that segment of 17 unknown samples is voided and the samples rerun.

17. Reports:

The findings from this project will be reported in several public colloquia and as subjects of various scientific/technical manuscripts. The New York State Department of Environmental Conservation reserves the right to publish the results and findings in peer reviewed articles and publications.

18. Estimated Project Fiscal and Staff Requirements:

The following tables for each of the study segments and the overall project costs reflect the 1997 level of effort if DEC was to fully implement the plan.

Table I: SEGMENT I - YEARLING PUMPKINSEED - BUDGET PORTION FOR FY 1997 - 1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT.

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	8	$ 1,288
Research Scientist	8	1,840
Technicians	94	8,859
Fringe benefits (29.21% of personnel costs)		3,163
Subtotal personnel & fringe		15,150
Supplies and materials (s&m)		400
Travel		300
Subtotal s&m, travel		700
Total Sampling		$15,850

B. Contractual laboratory services		
PCBs, lipids -includes preparation, lipid analyses & shipping $155/sample X 125 samples		19,375
Quality Assurance $155/sample X 22 samples		3,410
PCB analyses subtotal		$22,785
Mercury $50/sample X 50 samples		2,500
Quality Assurance $50/sample X 9 samples		450
Cadmium $45/sample X 50 samples		2,250
Quality Assurance $45/sample X 9 samples		405
Metals analyses subtotal		5,605
Total analytical costs		28,390
C. Project oversight, data management and		
reporting	26	5,980
Research Scientist	3	616
QA Officer	3	682
Supervising Ecologist	3	255
Keyboard Specialist		
		7,533
Subtotal oversight		
		2,200
Fringe Benefits (29.21% of personnel)		
		9,733
Total Project oversight		
D. Indirect costs (31.2% of Department personnel costs)		7,764
TOTAL (A + B + C + D)		61,737

Table II: SEGMENT II - RESIDENT SPECIES - BUDGET PORTION FOR FY 1997-1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT.

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	8	$ 1,288
Research Scientist	8	1,840
Technicians	68	6,392
Fringe benefits (29.21% of personnel costs)		2,781
Subtotal personnel & fringe		12,301
Supplies and materials (s&m)		900
Travel		700
Subtotal s&m, travel		1,600
Total Sampling		13,901

B. Contractual laboratory services			
PCBs,lipids -includes preparation, lipid analyses & shipping $155/sample X 255 samples			39,525
Quality Assurance $155/sample X 45 samples			6,975
PCBs, organochlorine pesticides, lipids -includes preparation, lipid analyses & shipping $316/sample X 255 samples			80,580
Quality Assurance $316/sample X 45 samples			14,220
Mercury $50/sample X 440 samples			22,000
Quality Assurance $50/sample X 78 samples			3,900
Cadmium $45/sample X 55 samples			2,475
Quality Assurance $45/sample X 10 samples			450
Chlorinated Dioxins and Dibenzofurans - quality assurance is built into the analyses and is included in the data package $1250/sample X 55 samples			68,750
Polycyclic Aromatic Hydrocarbons (PAHs) $190/sample X 55 samples			10,450
Quality Assurance $190/sample X 10 samples			1,900
Congeneric PCBs - quality assurance is built into the analytical package $825/sample X 75 samples			61,875
Total analytical costs			313,100

C. Project oversight, data management and reporting		
Research Scientist	20	4,600
QA Officer	2	410
Supervising Ecologist	2	455
Keyboard Specialist	2	170
Subtotal oversight		5,635
Fringe Benefits (29.21% of personnel)		1,646
Total Project oversight		7,281
D. Indirect costs (31.2% of Department personnel costs)		6,110
TOTAL (A + B + C + D)		340,392

Table III. SEGMENT III - STRIPED BASS - BUDGET PORTION FOR FY 1997- 1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT.

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	15	$ 2,415
Research Scientist	15	3,450
Technicians	150	14,137
Fringe benefits (29.21% of personnel costs)		5,843
Subtotal personnel & fringe		25,845
Supplies and materials (s& m)		1,400
Travel		1,000
Subtotal s&m, travel		2,400
Total Sampling		$28,245

B. Contractual laboratory services		
PCBs, lipids -includes preparation, lipid analyses & shipping $155/sample X 165 samples		25,575
Quality Assurance $155/sample X 30 samples		4,650
PCBs, organochlorine pesticides, lipids -includes preparation, lipid analyses & shipping $316/sample X 165 samples		52,140
Quality Assurance $316/sample X 30 samples		9,480
Mercury $50/sample X 330 samples		16,500
Quality Assurance $50/sample X 60 samples		3,000
Cadmium $45/sample X 30 samples		1,350
Quality Assurance $45/sample X 6 samples		270
Chlorinated dioxins and dibenzofurans - quality assurance is built into the analyses and is included in the data package $1250/sample X 30 samples		37,500
Polycyclic Aromatic Hydrocarbons (PAHs) $190/sample X 30 samples		5,700
Quality Assurance $190/sample X 6 samples		1,140
Congeneric PCBs - quality assurance is built into the analytical package $825/sample X 30 samples		24,750
Total analytical costs		182,055

C. Project oversight, data management and reporting		
Research Scientist	43	$ 9,890
QA Officer	13	2,670
Supervising Ecologist	16	3,632
Keyboard Specialist	16	1,360
Subtotal oversight		17,552
Fringe Benefits (29.21% of personnel)		5,127
Total Project oversight		$22,679
D. Indirect costs (31.2% of Department personnel costs)		15,139
TOTAL (A + B + C + D)		248,118

Table IV. BUDGET FOR ALL STUDY SEGMENTS COMBINED FOR FY 1997-1998 OF THE LONG-TERM HUDSON RIVER FISH PCB ANALYSIS PROJECT - YEARLING PUMPKINSEED, RESIDENT SPECIES, AND STRIPED BASS

	Staff days	Amount
A. Sampling, processing and transportation		
Personnel		
Conservation biologists	31	$ 4,991
Research Scientist	31	7,130
Technicians	312	29,388
Fringe benefits (29.21% of personnel costs)		11,787
Subtotal personnel & fringe		53,296
Supplies and materials (s& m)		2,700
Travel		2,000
Subtotal s&m, travel		4,700
Total Sampling		$ 57,996

B. Contractual laboratory services		
PCBs, lipids -includes preparation, lipid analyses & shipping $155/sample X 545 samples		84,475
Quality Assurance $155/sample X 97 samples		15,035
PCBs, organochlorine pesticides, lipids -includes preparation, lipid analyses & shipping $316/sample X 420 samples		132,720
Quality Assurance $316/sample X 75 samples		23,700
Mercury $50/sample X 820 samples		41,000
Quality Assurance $50/sample X 147 samples		7,350
Cadmium $45/sample X 135 samples		6,075
Quality Assurance $45/sample X 25 samples		1,125
Chlorinated Dioxins and Dibenzofurans - quality assurance is included in the analytical package $1250/sample X 85 samples		106,250
Polycyclic Aromatic Hydrocarbons (PAHs) $190/sample X 85 samples		16,150
Quality Assurance $190/sample X 16 samples		3,040
Congeneric PCBs - quality assurance is built into the analytical package $825/sample X 105 samples		86,625
Total analytical costs		$ 523,545

C.	Project oversight, data management and reporting		
	Research Scientist	89	$ 20,470
	QA Officer	18	3,696
	Supervising Ecologist	21	4,769
	Keyboard Specialist	21	1,785
	Subtotal oversight		30,720
	Fringe Benefits (29.21% of personnel)		8,973
	Total Project oversight		$ 39,693
D.	Indirect costs (31.2% of Department personnel costs)		29,013
	TOTAL (A + B + C + D)		$ 650,247

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Appendix H

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX H

HYDRAULIC DREDGING REPORT AND DEBRIS SURVEY

HUDSON RIVER PCBs REASSESSMENT FS

APPENDIX H

HYDRAULIC DREDGING REPORT AND DEBRIS SURVEY

H.1 Hydraulic Dredging Report

HYDRAULIC DREDGING CONCEPT DEVELOPMENT

For the Hudson River PCBs Site Reassessment Feasibility study

Prepared By

Gahagan and Bryant Associates, Inc.
9008-O Yellow Brick Road
Baltimore MD, 21237

Prepared for:
TAMS Consultants, Inc.

November 2000

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SUMMARY

Cost elements are presented for the hydraulic dredging concept portion of the Hudson River Feasibility Study. Alternatives REM-3/10/Select and REM-0/0/3 are evaluated in this report. For each alternative examined it is judged that hydraulic dredging is infeasible for Section 3 (areas downstream of Lock 5) due to the long pumping distances involved to reach the northern processing site. A combination of hydraulic dredging loading scows with transport to a point closer to the northern processing site may be feasible but has not been examined in this report.

Alternative REM-3/10/Select provides for the removal of areas in the Thompson Island Pool greater than 3 g/m^2 and the removal of areas greater than 10 g/m^2 in the Lock 6 and Lock 5 Pools. Dredging will take place over a river distance of 12 miles. The total required dredging volumes are 1.6 million cy in the Thompson Island Pool and 0.05 and 0.46 million cy respectively in the Lock 6 and Lock 5 Pools for a total required dredging volume of 2.1 million cy. No additional volume for the practical minimum dredging depth of 2 ft since all polygons are greater than 2 ft in depth. Access dredging which might be required to reach shallow-water dredge zones is not required under this alternative. Tolerance dredging which would be excavated in order to assure removal to the required depth is also not required due to the conservative method used to estimate the required depth of dredging. The total cut volume that must be dredged, transported to the northern processing site for water and solids separation, solids dewatering and rail transport to a permitted (drop) landfill is equal to the required dredging volume.

Alternative REM-0/0/3 provides for the "full section" dredging of the Thompson Island and Lock 6 and Lock 5 Pools. Dredging will take place over a river distance of 12 miles. The total required dredging volumes are 2.0 million cy in the Thompson Island Pool and 0.33 million cy in the Lock 6 Pool and 0.78 million cy in the Lock 5 Pool for a total required dredging volume of 3.1 million cy. An additional volume of 90 thousand cy must be added to account for the practical minimum dredging depth of 2 ft. Access dredging which might be required to reach shallow-water dredge zones is not required under this alternative. Tolerance dredging which would be excavated in order to assure removal to the required depth is also not required due to the conservative method used to estimate the required depth of dredging. This results in a total cut volume of dredging of 3.2 million cy that must be transported to the processing site for water and solids separation, solids stabilization and rail transport to an industrial landfill.

The dredging system evaluated includes; a 12-in. Hydraulic Dredge pipeline and up to six Booster Pumps with a maximum pumping distance of approximately 53,000 ft. Solids and water processing and rail car loading takes place at the Northern Processing Site. The principal solids and water processing elements are; (a) Primary Solids Separation (Trash rack, screens and hydrocyclone separation), (b) Water Treatment (surge storage, coagulation, flocculation, sedimentation, dual media filtration and granular activated carbon filtration), (c) Solids dewatering, (d) Transport of Stabilized Solids by rail to industrial landfill(s). For Alternative REM-3/10/Select hydraulic dredging can be completed in three 6.5-month dredging seasons. For Alternative REM-0/0/3 hydraulic dredging will be carried out over the maximum five dredging seasons allowed.

This report defines costing elements only. Cost estimates for the concept systems are to be prepared by the U. S. Army, Corps of Engineers. Data in this report is the basis for a conceptual analysis only and is not be used for additional planning or design purposes without review. Additional detailed studies and investigations will be required to refine the technical details and the estimated costs of the processes described in this report.

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1. INTRODUCTION

1.1 Description of the Project

The Hudson River Feasibility Study (HRFS) is the most recent of a number of feasibility and design studies carried out in recent years. The first analysis of the feasibility of removal of PCB-contaminated materials from the bed of the Hudson River above the Federal Lock and Dam at Troy, New York was prepared for the NY State, Department of Environmental Conservation in 1978 (MPI 1980a). Several additional studies and design efforts were completed prior to the current effort.

Cost elements are presented for the hydraulic dredging concept portion of the Hudson River Feasibility Study. Alternatives REM-3/10/Select and REM-0/0/3 are evaluated in this report. Reference maps depicting the alternative dredging areas discussed in this report are available in the Feasibility Study; REM 3/10/Select - Pl. 17; and REM 0/0/3 – Pl. 18. For each alternative examined it is judged that hydraulic dredging is unfeasible for Section 3 (areas below Lock 5) due to the long pumping distances involved to reach the northern processing site. A combination of hydraulic dredging loading scows with transport to a point closer to the northern processing site may be feasible but has not been examined.

Alternative REM-3/10/Select provides for the removal of areas in the Thompson Island Pool greater than 3 g/m^2 and the removal of areas greater than 10 g/m^2 in the Lock 6 and Lock 5 Pools. Dredging will take place over a river distance of 12 miles. The total required dredging volumes are 1.6 million cy in the Thompson Island Pool and 0.05 and 0.46 million cy respectively in the Lock 6 and Lock 5 Pools for a total required dredging volume of 2.1 million cy. No additional volume for the practical minimum dredging depth of 2 ft since all polygons are greater than 2 ft in depth. Access dredging which might be required to reach shallow-water dredge zones is not required under this alternative. Tolerance dredging which would be excavated in order to assure removal to the required depth is also not required due to the conservative method used to estimate the required depth of dredging. The total cut volume that must be dredged, transported to the northern processing site for water and solids separation, solids stabilization and rail transport to an permitted landfill is equal to the required dredging volume.

Alternative REM-0/0/3 provides for the "full section" dredging of the Thompson Island and Lock 6 and Lock 5 Pools. Dredging will take place over a river distance of 12 miles. The total required dredging volumes are 2.0 million cy in the Thompson Island Pool and 0.33 million cy in the Lock 6 Pool and 0.78 million cy in the Lock 5 Pool for a total required dredging volume of 3.1 million cy. An additional volume of 90 thousand cy must be added to account for the practical minimum dredging depth of 2 ft. Access dredging which might be required to reach shallow-water dredge zones is not required under this alternative. Tolerance dredging which would be excavated in order to assure removal to the required depth is also not required due to the conservative method used to estimate the required depth of dredging. This results in a total cut volume of dredging of 3.2

million cy that must be transported to the processing site for water and solids separation, solids dewatering and rail transport to an permitted landfill.

1.2 Geographical Locations

The hydraulic dredging and material processing areas are located along the Upper Hudson River between Fort Edward and Northumberland, New York a river distance of approximately 12 miles. The Dredge Zones have been identified and described by TAMS and supplied to GBA for determination of dredging requirements (TAMS 2000). Dredge slurry solids and water separation and rail car loading of processed solids will take place at the Northern Site. A second Rail Loading Site outside the river reach to be dredged is located at the southern part of the river. As part of the HRFS the Upper Hudson River has been divided into three sections as indicated in Table 1-1.

TABLE 1-1, HRFS RIVER SECTIONS

Section	Reach	RM us	RM ds	Length, st mi	Length, naut mi	Remarks *(1)*
1	Thompson Island Pool	194.5	188.5	6.0	5.4	Some non-navigable
2	Lock 6 Pool	188.5	186.2	2.3	2.0	Some non-navigable
2	Lock 5 Pool	186.2	182.6	3.6	3.1	Some non-navigable
3	Lock 4 Pool	182.6	168.2	14.4	12.5	Some non-navigable
3	Lock 3 Pool	168.2	166.0	2.2	1.9	Some non-navigable
3	Lock 2 Pool	166.0	163.5	2.5	2.2	
3	Lock 1 Pool	163.5				
3	Federal Dam Pool					Some non-navigable

RM us, ds - upstream and downstream river miles
st mi - statute miles
naut mi - nautical miles
(1) Some portions of the Canal are in land cut. This may require remobilization of the dredging system into non-navigable portions of the river in order to access Dredge Zones.

Details of the dredging and site locations used in the dredging production analysis are given in Section 3 and Appendix A.

1.3 Scope of Work

This report was prepared under the direction of Richard F. Thomas, PE, Vice President and with the review of J. Franklin Bryant, PE, Principal, both of Gahagan & Bryant Associates, Inc. This report defines costing elements only. Cost estimates for the concept systems presented are to be prepared by the U. S. Army, Corps of Engineers.

1.4 Disclaimer

Data in this report is the basis for a conceptual analysis only and is not be used for additional planning or design purposes without review. Additional detailed studies and investigations will be required to refine the technical details and the estimated costs of the processes described in this report.

2. DREDGE ZONES AND MATERIAL ANALYSIS

2.1 Dredge Zones

Characteristics of areas to be dredged (Dredge Zones) have been described and supplied to GBA by TAMS. The Dredge Zones identification (ID), location (River Mile), surface area, required depth of dredging, required dredging volume and typical depth of water for the two alternatives examined are contained in appendix A and the Feasibility Study; Plates 17 and 18. These characteristics are summarized in Table 2-1a and 2-1b.

TABLE 2-1A, CHARACTERISTICS OF DREDGING AREAS, ALTERNATIVE REM-3/10/SELECT*(1)*

Characteristic	Thompson Island Pool	Lock 6 Pool	Lock 5 Pool	Totals
River Miles (RM)	194.3 - 188.5	188.5 - 186.2	186.2 - 182.6	194.5 – 182.6
Distance, miles	6.0	2.3	3.6	11.9
Area to be dredged, 1,000 sq ft	12,316	482	2,822	15,619
Area to be dredged, acres	283	11	65	359
Required average removal depth, ft	2.9 - 4.4	3.0	3.1 - 5.1	2.9 - 5.1
Required removal volume, cy *(2)*	1,620,000	55,300	463,800	2,139,000
Minimum Dredging volume, cy *(2)*	0	0	0	0
Tolerance dredging, cy *(2)*	0	0	0	0
Access dredging, cy *(2)*	0	0	0	0
Total cut volume, cy *(2)*	1,620,000	55,300	463,800	2,139,000

Values rounded
(1) Section 3 is not dredged hydraulically. Mechanical dredging of Section 3 is to be evaluated by TAMS
(2) See Section 3 and Appendix A for definition of these terms.

TABLE 2-1B, CHARACTERISTICS OF DREDGING AREAS, ALTERNATIVE REM-0/0/3*(1)*

Characteristic	Thompson Island Pool	Lock 6 Pool	Lock 5 Pool	Totals
River Miles (RM)	194.5 - 188.5	188.5 - 186.2	186.2 - 182.6	194.5 - 182.6
Distance, miles	6.0	2.3	3.6	11.9
Area to be dredged, 1,000 sq ft	20,569	5,459	8,425	34,454
Area to be dredged, acres	472	125	193	791
Required average removal depth, ft	1.6 - 3.4	1.6 – 2.1	1.9 – 4.1	1.6 – 4.1
Required removal volume, cy *(2)*	2,018,000	328,000	780,500	3,127,000
Minimum Dredging volume, cy *(2)*	23,000	60,000	7,000	90,000
Tolerance dredging, cy *(2)*	0	0	0	0
Access dredging, cy *(2)*	0	0	0	0
Total cut volume, cy *(2)*	2,041,000	388,000	788,000	3,217,000

Values rounded
(1) Section 3 is not dredged hydraulically. Mechanical dredging of Section 3 is to be evaluated by TAMS
(2) See Section 3 and Appendix A for definition of these terms.

2.2 Materials Analysis

The grain-size distribution of the materials to be dredged are described in a memorandum prepared by TAMS (TAMS 1999). Materials are divided into coarse and fine-grained sizes in the two river reaches examined in this report; Thompson Island Pool and the Lock 6 and Lock 5 Pools. The average of these four distributions are shown in Figure 2-1.

These data show that about 80 percent of the coarse-grained materials have, on average, a particle size greater than 0.1 mm and are coarser than fine sand. Even in the fine-grained materials about 40 percent of the materials are coarser than fine sand.

These results may have significant implications for the project. The classification of the sand-sized materials as non-contaminated and therefore available for beneficial uses may be a possibility. In any event, the mechanical separation of coarse materials as proposed in this alternative (Section 3.4) will offer the possibility of reduced material stabilization, transport and containment costs.

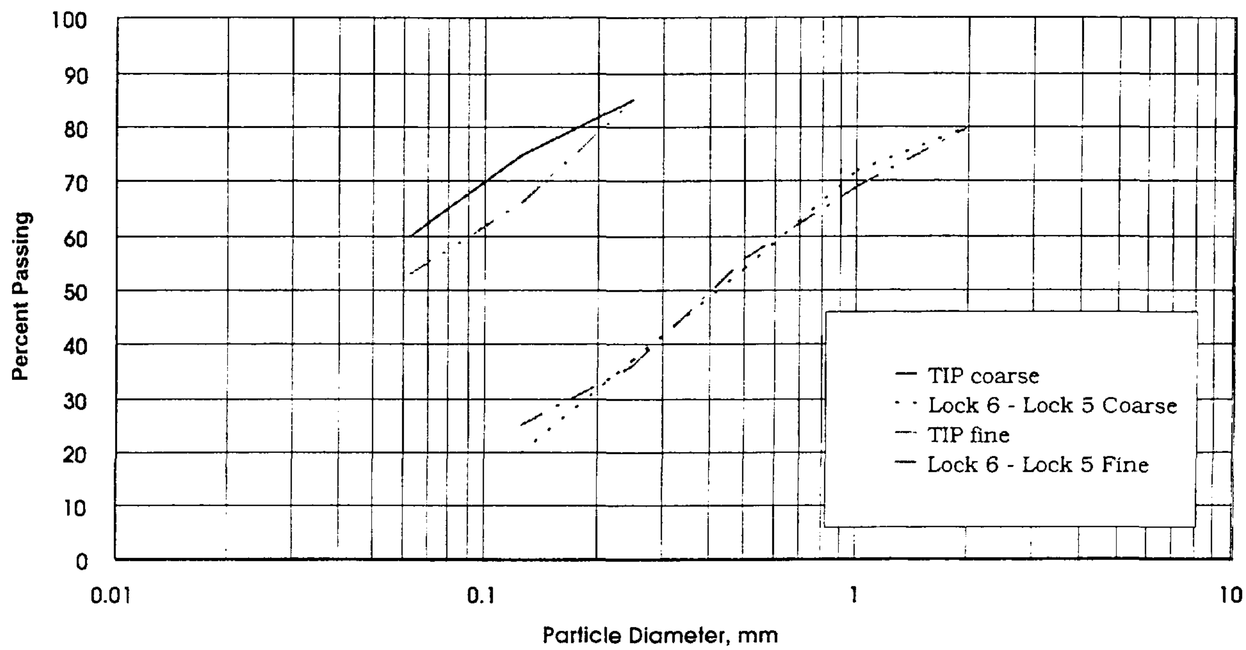

FIGURE 2-1, GRAIN SIZE DISTRIBUTIONS IN THOMPSON ISLAND, LOCK 6 AND LOCK 5 POOLS

The grain-size distribution of the materials to be dredged are described in a memorandum prepared by TAMS (TAMS 1999). Materials are divided into coarse and fine-grained sizes in two river reaches; Thompson Island Pool and the Lock 6 and Lock 5 Pools. The average values of these four distributions are shown in this figure. The pair of curves at the upper left are the fine-grained material size distributions for the two pool reaches. Those at the lower right are the coarse-grained distributions. These data show that the about 80 percent coarse-grained materials are, on the average, coarser than 0.1 mm or coarser than fine sand. Even in the fine-grained materials about 40 percent of the materials are coarser than fine sand.

These results may have significant implications for the project. The treatment of the sand-sized materials as non-contaminated and therefore available for beneficial uses may be a possibility. In any event, the mechanical separation of coarse materials as proposed in this alternative (Section 3.4) will offer the possibility of reduced material stabilization, transport and containment costs.

Results of a debris survey in the project area can found in Capital Feasibility Study Appendix H. The purpose of that investigation carried out in November 1999 was to identify debris within the river, its relative amount, and discuss the impact that the debris might have on remedial activities being studied for the river. The dredge proposed for this conceptual study, with proper operating care, can accommodate or work around the debris described.

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3. DREDGING SYSTEM DESCRIPTION (DRG)

3.1 Introduction

The dredging system evaluated includes; a 12-in. Hydraulic Dredge and pipeline and up to six Booster Pumps as needed. Solids and water processing and rail loading takes place at the Northern Processing Site. A second rail loading site at The Southern Site is required to meet rail car loading requirements. Dewatered solids from the Northern Site will be barged to the Southern Rail Transfer Site. The principal solids and water processing elements at The Northern Site are; (a) Primary Solids Separation (trash rack, screens and hydrocyclone separation), (b) Water Treatment (surge storage, coagulation, flocculation, sedimentation, dual media filtration and granular activated carbon filtration). (c) Solids Dewatering (d) Processed Solids Transport by rail to permitted landfill(s). Dredging is to be carried out over a maximum of five dredging seasons. The dredging system described in this report can accomplish the required removal in three or possibly four dredging seasons. A further description of this system presented below. A schematic diagram of the overall hydraulic dredging concept is presented in Figure 3-1.

GBA judges that pumping approximately 54,000 ft with six booster pumps is at the practical limit under HRFS project conditions. We are aware of a dredging project pumping about ten miles but do not have specific information on the project. Advances in equipment reliability and instrumentation in recent years contribute to the feasibility of such a system. Careful planning and operational controls will be required in the work.

3.2 Dredging Seasons

In consideration of traffic and ice conditions on the Upper Hudson the New York Barge Canal is normally operated from early May to mid-November. Therefore, mobilization of floating equipment and dredging operations are limited to about 6.5 months each year. Dredging operations are limited to five dredging seasons in the development of the hydraulic dredging concept.

3.3 Dredge and Pipeline

It should be emphasized that although it is feasible to use essentially conventional hydraulic dredging equipment with some modifications, a project such as this cannot be approached as a traditional dredging project. It is imperative that careful field engineering and equipment and data management on a real-time basis be applied to insure that design expectations are being met and to make any necessary adjustments to maintain design and environmental requirements.

3.3.1 Dredge and Pipeline General Description

The hydraulic dredge and ancillary equipment are readily available from various dredging contractors. As noted, however, some equipment modifications are desirable and will need to be addressed in the detailed planning and design phases of project implementation. A general description of the equipment evaluated is presented in the following sections. All dimensions are approximate.

a. Dredge – 12-in. hydraulic cutterhead dredge with a 600 HP main pump and 200 HP auxiliaries. A typical dredge of this size has hull dimensions of 60 ft x 28 ft x 4 ft. Its overall length to the end of the cutterhead is about 100 ft. The draft of the dredge is about 2.5 to 3 ft. The dredge advances by alternately raising and lowering spuds located at the rear of the hull. Other dredge cutterhead configurations and swing procedures should be evaluated in the detailed planning and design phases of project implementation (see Section 3.4).

The dredge should not advance (make an upset) more than the length of the cutterhead being used. The actual length of the "upset" will depend on how the material reacts with the cutter being used and the depth of the bank being excavated. An upset (moving the spud on the center line ahead) is made by swinging the dredge off the center line to the starboard the desired number of degrees and then changing spuds (dropping the port spud and raising the starboard digging spud) and then swinging back to the port so that the starboard spud is again on the center line, and again changing spuds, dropping the starboard spud and raising the port spud.

The cutterhead for a typical 12-in. dredge will be about 40-in. in diameter by about 42-in. in length. Modification of the dredge ladder and suction intake arrangements is proposed in order to optimize conditions for a 2 ft cut or face of material, or other appropriate face, in order to minimize losses of material at the dredge cutterhead.

b. Skimmer/Debris Collector - This will be a standard vessel utilized to collect debris and floating materials which may accumulate on the surface and near surface of the river during dredging operations. Collected materials will be periodically transferred at collection points, and transported to the Northern Processing Site for processing. This vessel will be powered by a 200 HP engine and will be about 25 ft in length, 10 ft in beam and draw about 2 ft of water. It will operate in conjunction with any devices found feasible for deployment at the dredge.

c. Pipeline - The dredging system described utilizes a 16 in. High Density Polyethylene (HDPE) pipeline with a maximum length of about 53,000 ft. Three types of pipeline will be employed:

Pontoon Line - Typically 2,000 ft in length will be used immediately behind the dredge. This line provides flexibility for maneuvering the dredge along the various dredge cuts. The pipeline can be either HDPE or steel. If the steel pipeline is used, the connections between the joints could be either hoses or ball joints. Hoses are preferred.

Submerged Line - Will vary from a few hundred to about 50,000 ft in length. Additional pipe is added periodically as the dredge advances along the river. Submerged line presents minimum interference with river traffic.

Shoreline - Short sections of shoreline will be installed as necessary to carry the pipeline over land at locations such as the Thompson Island and Lock 6 dams.

d. Booster Pumps with 1,000 HP pump and 200 HP auxiliaries mounted on barges, or possibly on shore, will be added as necessary. Booster barge dimensions will be typically 45 ft x 30 ft x 5 ft with about a 3 ft draft. The distance between booster barges will be on the order of 10,000 ft. Shore Boosters may also be utilized. System characteristics are summarized in Table 3-1.

TABLE 3-1, DREDGING SYSTEM CHARACTERISTICS

	Hull Dimensions, ft			Length		Horsepower	
Unit	Length	Beam	Depth	Overall, ft	Draft, ft	Main	Auxiliary
12-in. Hydraulic Cutterhead Dredge	60	28	4	100	2.5-3	600	200
Skimmer/Debris Collector	25	10	---	---	2	200	---
16-in. Booster	45	30	5	---	3	1,000	200

Dredging system production rates are discussed in Section 4.

3.4 Dredging System Design Considerations

During the detailed planning and design phase of project implementation several aspects of dredging system design and operation should be considered. They are; (1) alternative cutterhead types, e.g. wheel, "goose neck" and auger types, (2) Swinging-ladder dredge that would avoid use of anchors, (3) evaluation of Dredge Zones located in non-navigable portions of the river which may preclude use of floating equipment or require remobilization of the dredge.

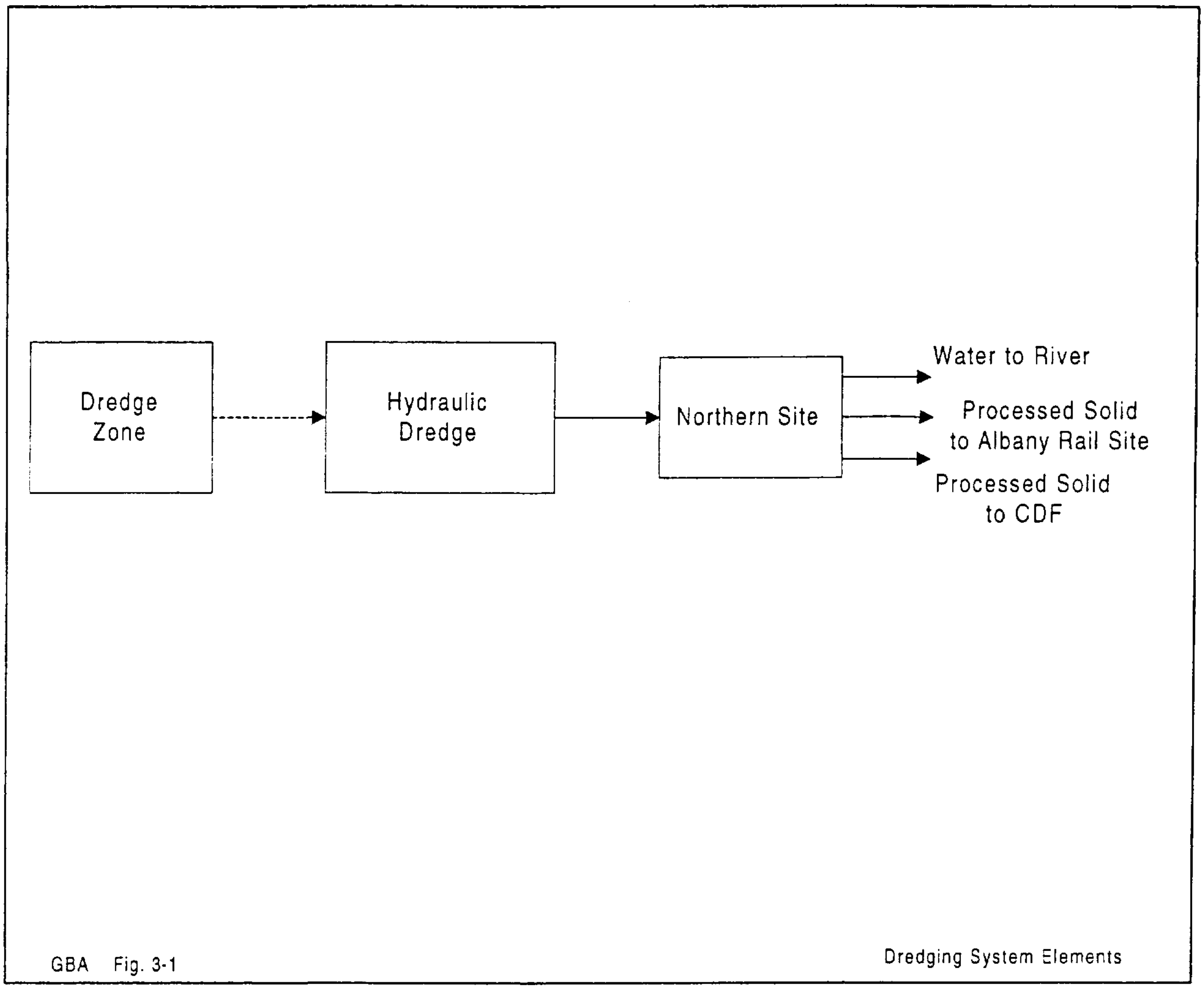

FIGURE 3-1, HYDRAULIC DREDGING SYSTEM (DRG) SCHEMATIC DIAGRAM

The dredging system evaluated includes; a 12-in. Hydraulic Dredge with a 16-in. Pipeline and up to six Booster Pumps as needed. Solids and water processing and rail loading takes place at the Northern Processing Site. A second rail loading site at The Southern Site is required to meet rail-car loading requirements. Processed solids from the Northern Site will be barged to the Southern Rail Transfer Site. The principal solids and water processing elements at The Northern Site are; (a) Primary Solids Separation (trash rack, screens and hydrocyclone separation), (b) Water Treatment (surge storage, coagulation, flocculation, sedimentation, dual media filtration and granular activated carbon filtration). (c) Solids Dewatering. (d) Processed Solids Transport by rail to permitted landfill(s). Dredging is to be carried out over a maximum of five dredging seasons.

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3.5 Northern Processing Site (NPS)

3.5.1 Introduction

A processing site is required to provide for dredged solids processing and railcar loading, treatment of slurry water and barge transport of dewatered solids to a second rail site for loading and haul to an industrial landfill(s). The principal solids and water processing elements at a transfer site are; (a) Primary Solids Separation (PSS) (screening and hydrocyclone separation), (b) Water Treatment Plant (WTP) (roughing and storage, coagulation, flocculation, sedimentation, dual media filtration and granular activated carbon filtration). (c) Secondary Dewatering, (d) Barge transport of stabilized solids to a second rail site (not evaluated in this report). A schematic diagram of the processing site is presented in Figure3-2. A conceptual layout of the site is presented in Figure 3-3. Rail car loading has been analyzed by TAMS and is not evaluated in this report.

Detailed design studies are required to optimize the integration of the solids and water processing systems described in this report.

3.5.2 Primary Solids Separation (PSS)

Consideration was give to conventional gravity settling of the dredge slurry to remove the coarse-grained fraction of the dredged material. It was determined however that the resultant ponds would require the use of some tens of acres of land that may not otherwise be available. The selected system utilizes a "separator" tower containing a set of trash racks and vibrating screens to remove debris down to about 20 mm. These materials will travel down vibrating chutes to a conveyor for stockpiling (Figure 3-4). The remaining slurry will travel vertically through a series of hydrocyclones to remove coarse, medium and fine sands. These sands will be carried on vibrating chutes to a stockpile. Each stockpile will have an underdrain to collect drainage water for treatment.

A separator tower has a slurry flow capacity of approximately 3 mgd. Typical dredge flows will be about 8 mgd. Four towers will provide for about 9 mgd with one tower for backup purposes. A tower will be about 75 ft in height with a 35 ft square cross section. The trash rack and screens will be mounted at the top with the three hydrocyclones mounted on the sides of the tower at approximately 16 ft intervals to provide adequate velocity head to the units. Solids collected from each of the screening and hydrocyclone units may be kept separate or mixed according to processing requirements.

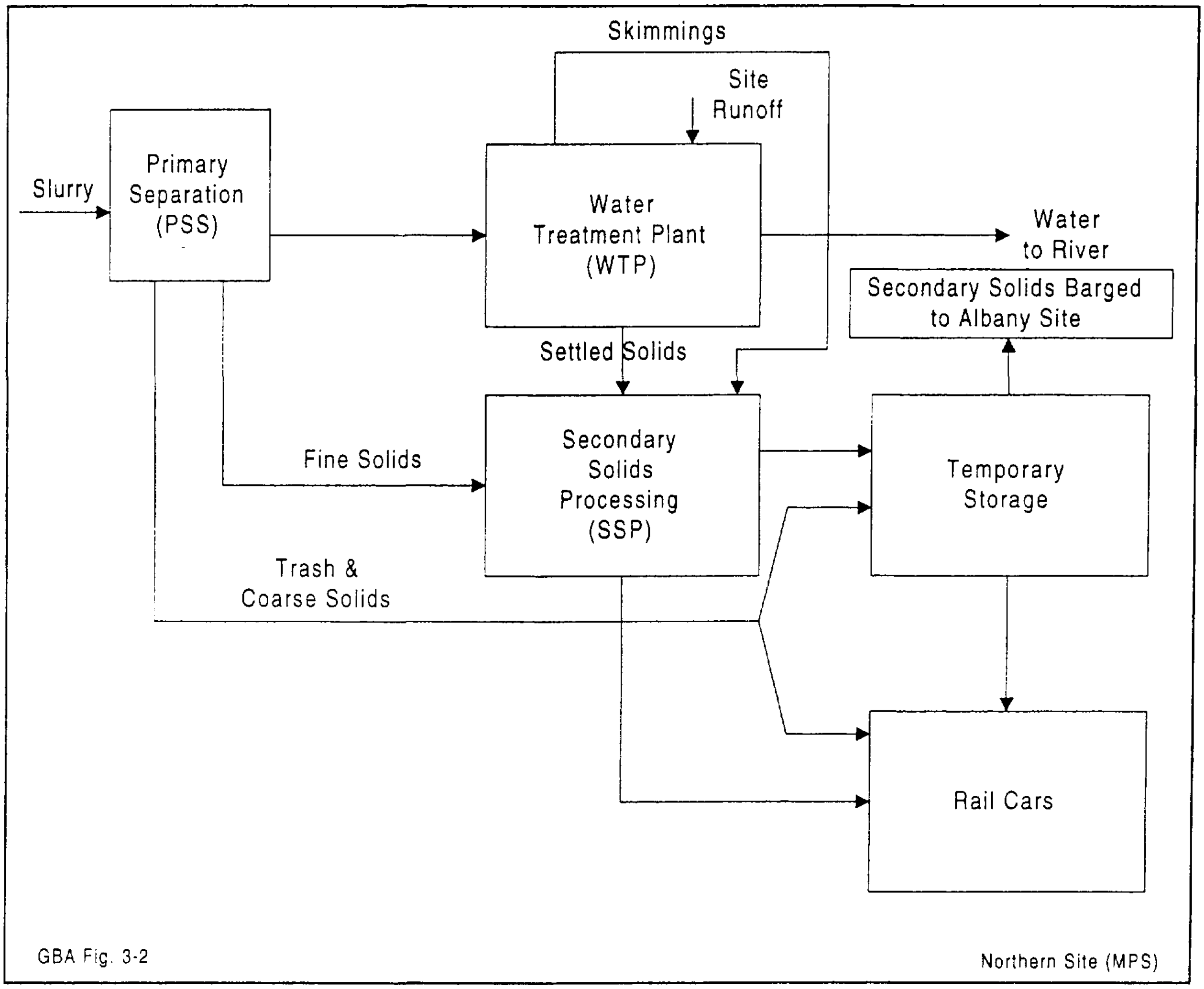

FIGURE 3-2, NORTHERN PROCESSING SITE (NPS) - SCHEMATIC DIAGRAM

The selected system utilizes a "separator" tower containing a set of trash racks and vibrating screens to remove debris down to about 20 mm. These saturated materials will travel down vibrating chutes to a conveyor for stockpiling. The remaining slurry will travel vertically through a series of hydrocyclones to remove coarse, medium and fine sands. These sands will be carried on vibrating chutes to a stockpile. Each stockpile will have an underdrain to collect drainage water for treatment.

After sand removal the remaining slurry is conducted to a set of circular tanks for flocculant addition and coagulation. Supernatant is delivered to the water treatment plant and settled solids can be further dewatered by filter press.

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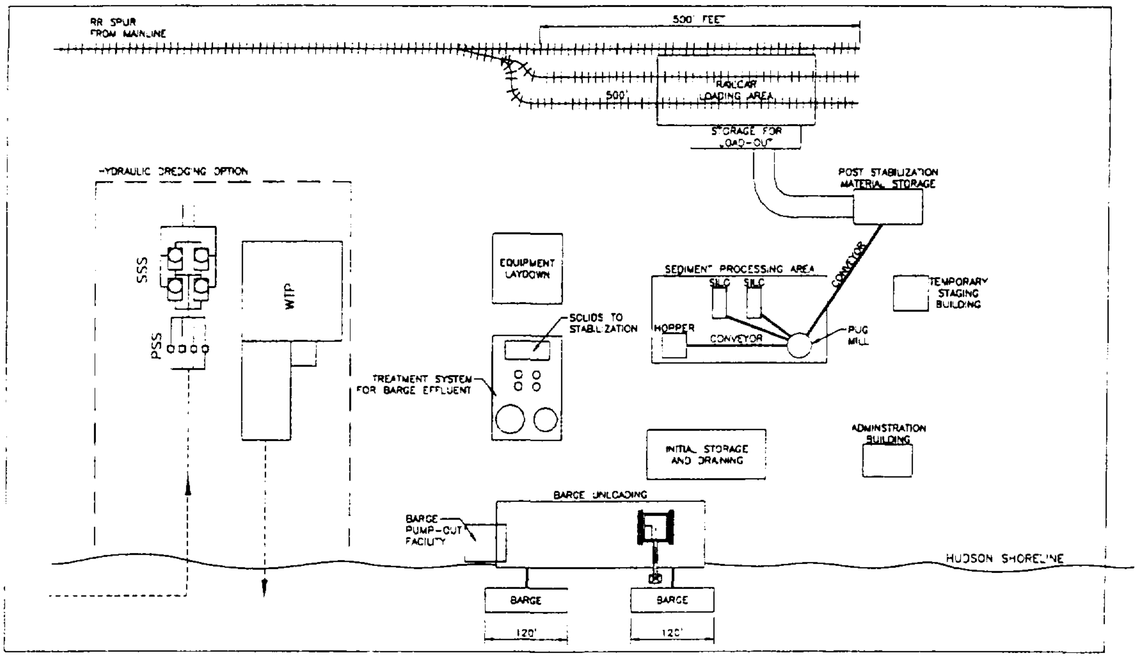

FIGURE 3-3, NORTHERN PROCESSING SITE (NPS) - CONCEPTUAL LAYOUT

A processing site is required to provide for dredged solids processing and railcar loading, treatment of slurry water and barge transport of stabilized solids to a second rail site for loading and haul to an industrial landfill(s). The principal solids and water processing elements at a transfer site are; (a) Primary Solids Separation (PSS) (screening and hydrocyclone separation), (b) Water Treatment Plant (WTP) (roughing and storage, coagulation, flocculation, sedimentation, dual media filtration and granular activated carbon filtration). (c) Secondary Solids Processing (SSP) through chemically enhanced mineralization, (d) Barge transport of stabilized solids to a second rail site (not evaluated in this report).

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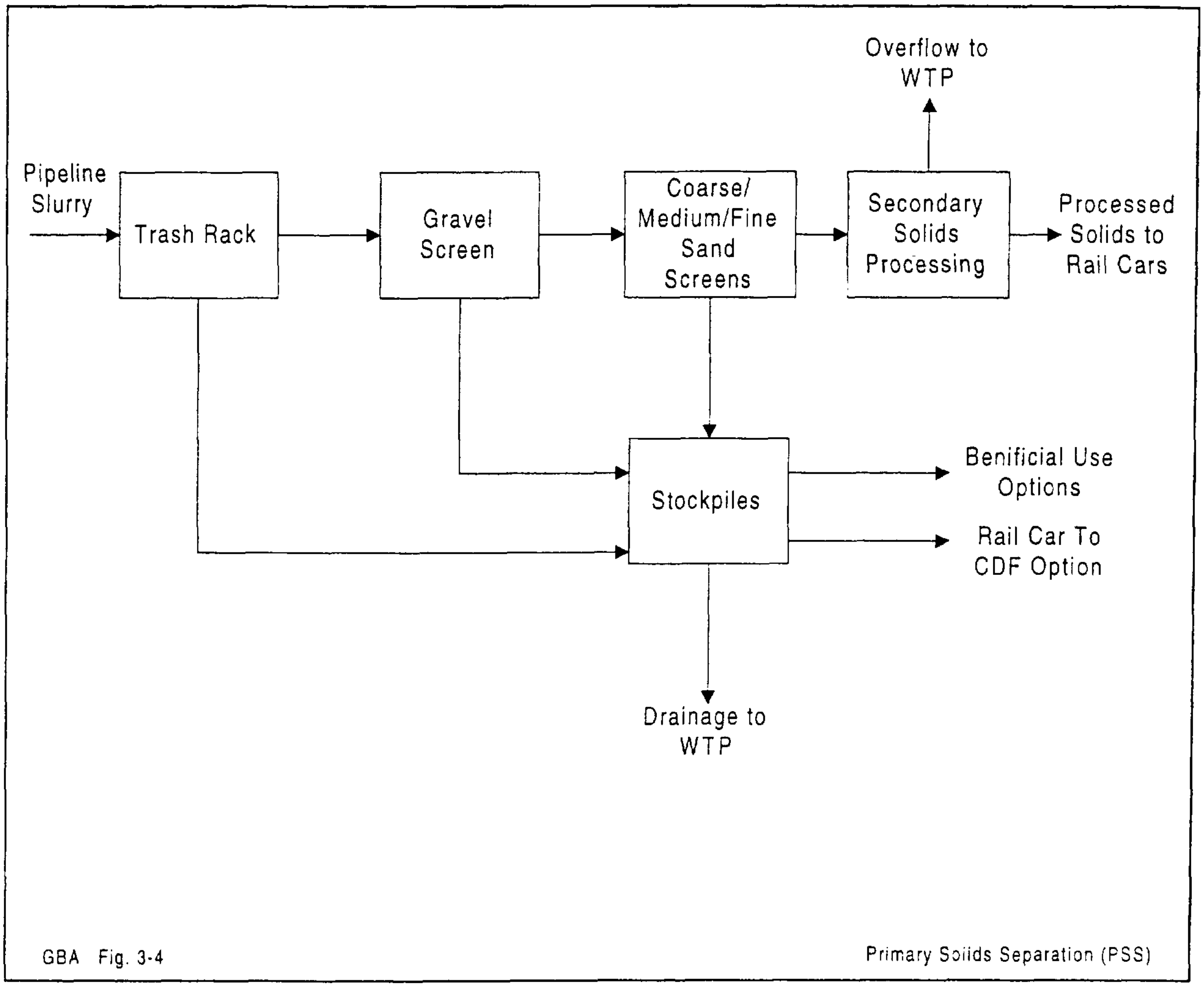

FIGURE 3-4, PRIMARY SOLIDS SEPARATION SCHEMATIC DIAGRAM

This system utilizes a "separator" tower containing a set of trash racks and vibrating screens to remove debris down to about 20 mm. These materials will travel down vibrating chutes to a conveyor for stockpiling. The remaining slurry will travel vertically through a series of hydrocyclones to remove coarse, medium and fine sands. These sands will be carried on vibrating chutes to a stockpile. Each stockpile will have an underdrain to collect drainage water for treatment.

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3.4.3 Water Treatment Plant (WTP)

Laboratory-scale process studies were performed earlier for Hudson River bed materials (MPI 1980b). The WTP at the Northern Processing Site will treat all return flows from the dredges as well as on-site precipitation. Its capacity must be balanced with the capacity of the dredges to deliver water and sediment to the site.

The report describes a return water treatment plant having a capacity of 13 mgd and consisting of coagulation, flocculation and sedimentation. The influent suspended solids are expected to be on the order of 2,000 mg/L. Influent PCB should vary from the low hundreds to the thousands of micrograms per liter (μg/L) based on the PCB content of the river bed material.

A design overflow rate of 350 gpd per sq ft was selected for the final sedimentation unit. Effluent suspended solids less than 4 mg/L and turbidity less than 10 NTU were expected with proper chemical doses. The average PCB concentration in the discharge was expected to be in the 10 to 20 μg/L range. The maximum discharge concentration was projected at 100 μg/L, while a minimum of 4 μg/L was anticipated. The projected sludge suspended solids concentration was three percent by weight; with an estimated daily sludge volume on the order of 0.9 mgd.

The report evaluated additional treatment consisting of filtration and granular activated carbon adsorption. Such treatment was not recommended since a small quantity of PCB would be removed through filtration-adsorption treatment at a unit cost of estimated at 100 times greater than the average cost of PCB removal by dredging.

A summary of WTP characteristics is presented in Table 3-2. A schematic diagram showing WTP elements is contained in Figure 3-5.

TABLE 3-2, WATER TREATMENT PLANT CHARACTERISTICS

	MPI 1980	Northern Site
Influent		
Flow, mgd	13	10 *(1)*
SS, mg/L	2,000	2,000?
Coagulation		
Rapid mix detention time, sec	2	2
Polymer in-line rapid mixer		
Chemicals		
Cationic polymer	52 mg/L "Nalco 7132 *(2)*	
Flocculation		
Detention time, min	15	15
Slow mixers	two vertical turbines, variable speed	
Sedimentation		
Overflow rate OF, gpd/sq ft	350	350
Sludge solids concentration, %	3.0%	3.0%
Sludge volume, mgd	0.87	0.87 *(1)*
Sludge removal	Two portable dredges	
Effluent		
SS, mg/L	10 - 20 mg/L	10 - 20 mg/L
Turbidity, NTU	<= 10	<= 10

Source: adapted from MPI 1980b

(1) Plant sized to alternative requirements

(2) Chemical feed to be reevaluated in detailed planning and design

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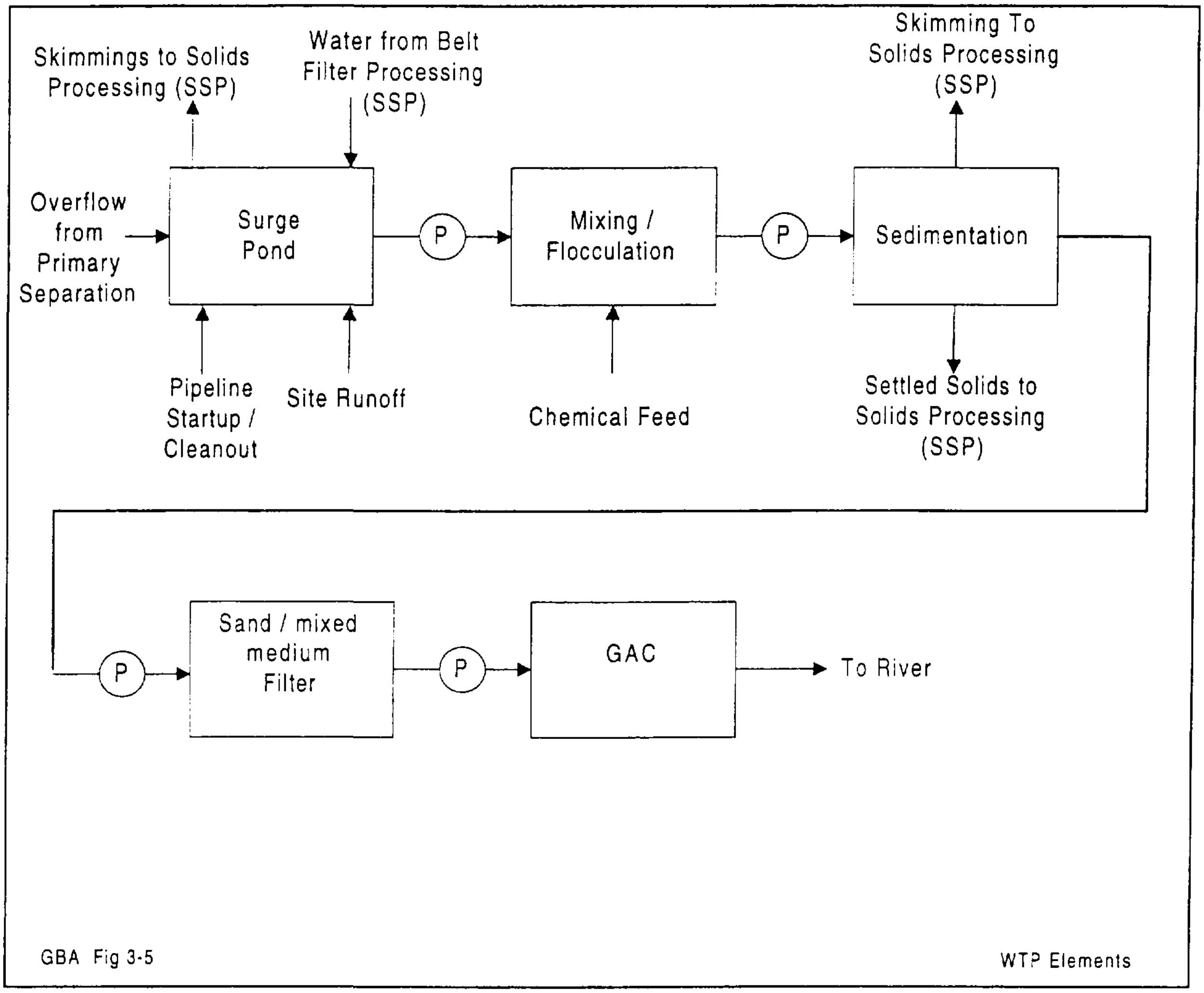

FIGURE 3-5, WATER TREATMENT PLANT (WTP) SCHEMATIC DIAGRAM

The Water Treatment Plant at the Northern Processing Site will treat all return flows from the dredges as well as on-site precipitation and water flows from the various site processes. Its capacity must be balanced with the capacity of the dredges to deliver water and sediment to the site.

3.4.4 Secondary Solids Processing (SSP)

After sand removal in the Primary Solids Separation tower the remaining slurry is conducted to a set of circular tanks for flocculant addition and coagulation. Supernatant is delivered to the water treatment plant and settled solids can be further dewatered and stabilized by filter press.

The final underflow from the separator tower will be delivered to a possibly proprietary process with a unit throughput of about 4 mgd. Four processing units will provide for backup capacity. Each SSP unit consists of a circular steel clarifier unit for polymer addition, flocculation and settling to remove particles down to the 7 to 14 Angstrom range. Settled solids are delivered to a dewatering grid and a belt filter press. Each process unit has a footprint of about 50 ft by 75 ft.

a. Beneficial Use

Beneficial use of the PCB-contaminated materials may prove to be an economical as well as an environmentally sound approach. A number of beneficial-use methods are now being developed, and in some cases, implemented. Section 412(c) of the Water Resources Development Act (WRDA) of 1990 authorized funds for the review, assessment and bench-scale demonstration of several treatment options for contaminated dredged material. Under this program the Port Authority of New York and New Jersey, US EPA and Corps of Engineers and other groups have sponsored and reported on methods for the stabilization or destruction of contaminants in dredged material with subsequent use in structural fills, concrete aggregate and other useful products. These processes include; Mechanical Stabilization to a Product and Contaminant Destruction to a Product. These approaches may warrant further examination as part of the detailed project planning and design.

3.4.5 Barge Transport (BSS)

Barge transport of processed solids will be required since the rail car loading capacity of the Northern processing site is inadequate. This issue has not been evaluated in this report. Barge Canal lock dimensions, which are a factor in barge transport, are 43.5 ft x 300 ft x 10 ft depth.

3.4.6 Railcar Loading (RSS)

Two rail access sites are available for the transport of processed materials. One site is located at the Northern end of the project area adjacent to the TI Pool. Northern Processing Site at the north end of the project area and one at the south end of the project area in the Albany vicinity approximately 40 miles from the Northern Site. The primary elements of rail car loading at the Northern Site are a) processed solids stockpile area, b) processed solids loading of rail cars, c) rail car storage capacity. Railcar loading requirements are affected by the length of the dredging season and the resulting solids throughput. Railcar loading has been analyzed by TAMS and is not evaluated in this report.

3.4.7 Solid Materials Handling (SMH)

The several unit processes discussed above will require the processing and transport of processed solids. The methods used may involve chemical feed units, solids dewatering equipment, end-loaders, hoppers, trucks, stockpiles and conveyor belts in various combinations. These units will be sized to meet the site throughput requirements.

4. DREDGING PRODUCTION

The time required to do the work is determined by the application of equipment production rates to the dredge areas and the cut volume of the areas to be dredged.

4.1 Types Of Production

The dredge areas were analyzed by both area (sq ft) and cut volume (cy) to evaluate dredge production, which is measured in three ways; a) Production Cut, b) Area Coverage Cut, and, c) Shoreline Cut. In each case the hydraulic dredge will make a "cleanup" swing to assure material removal.

4.1.1 Production Cut

A production cut has a bank or face of material in front of the dredge that is larger than can be moved by one swing pass in each set of the dredge.

4.1.2 Area Coverage Cut

In an area cut dredge production is controlled by the speed at which the dredge can move over the dredged area and is, therefore less than full production. These areas have a bank or face of material in front of a dredge that is less than can be moved by one pass in each set of the dredge. This shallow face of cut results in lower dredged solids and thus higher water content in the dredge slurry.

4.1.3 Shoreline Cut

An approximately 40 ft width from the bank in each dredge area is defined as a shoreline cut. These areas will be cleared of branches, stumps and logs prior to hydraulic dredging. The average dredge production rate for Area Coverage Cut is used for estimated production after shoreline area clearing.

4.2 Production Rates

Optimum production rates are estimated on the basis of the operating characteristics of existing equipment similar to that described in Section 3. The optimum production rate of the hydraulic dredge pumping directly to the Northern Processing Site via pipeline is determined by considering the excavating and pumping characteristics of the material, the pumping capability of the dredge and boosters, and the length and hydraulic characteristics of the pipeline. These estimates are summarized in Table 4-1.

The production rate adopted for alternative analysis is based on a reduced rate that considers the area coverage rate for the dredge and utilizes the maximum of five dredging seasons planned for the project. As may be noted in Table 4-1 the dredge production rate adopted for alternative analysis has been reduced by about 20% to 50% of the optimum rate. This reduced adopted rate provides a conservative estimate of dredging time required and allows additional time for adjustments in dredging operations as the project progresses.

TABLE 4-1, HYDRAULIC PIPELINE DREDGE OPTIMUM AND ADOPTED PRODUCTION RATES WITH HDPE PIPELINE

Estimate No.	1	2	3	4	5	6
Dredge Size, in.	12	12	12	12	12	12
Pipeline dia, in.	16	16	16	16	16	16
Pool	TI	TI	Lock 6	Lock 6	Lock 5	Lock 5
Material	Silt-soft clay	sand-silt	silt-soft clay	sand-silt	silt-soft clay	sand-silt
Pipeline length, ft (1)	12,400	12,400	32,500	32,500	41,100	41,100
Number boosters	2	2	4	4	5	5
System lift, ft	91	91	96	96	107	107
Percent solids	20%	15%	20%	15%	20%	15%
unit wt, pcf	110	120	110	120	110	120
Slurry Specific Gravity	1.15	1.14	1.15	1.14	1.15	1.14
Slurry Solids Content by Weight, %	21	20	21	20	21	20
Discharge velocity, fps	14.5	13.8	12.2	11.6	12.0	11.5
Optimum production, cy/hr	540	386	455	324	447	321
Adopted Production, cy/hr	**275**	**275**	**266**	**266**	**266**	**266**
Dredge Operating hrs	17	17	15	15	14	14
Slurry Flow, cfs	20.2	19.3	17.0	16.2	16.8	16.1
Slurry Flow, gpm	9,087	8,648	7,646	7,270	7,520	7,207
Slurry Flow, mgd per 24 hr	9.3	8.8	6.9	6.5	6.3	6.1
Pipeline Startup and cleanout						
Length	28,440	28,440	36,960	36,960	55,968	55,968
Startup Time @ Discharge vel., minutes	33	34	50	53	78	81
Cleanout Time @ 2 x startup time	65	69	101	106	155	162
Pipeline startup flows, million gals	0.3	0.3	0.4	0.4	0.6	0.6
Pipeline cleanout flows, million gals	0.6	0.6	0.8	0.8	1.2	1.2
Total non-production flow, million gals	0.9	0.9	1.2	1.2	1.8	1.8
Maximum operating hours	19	19	16	16	15	15
WTP Flow, 7-day avg, mgd	8.7	8.3	6.9	6.6	6.9	6.7

(1) Average pipeline length weighted by cut volume in pool
(2) Boosters required for weighted pipeline length. Fewer or more boosters may be required for a specific Dredge Zone

Dredging industry practice is to measure pipeline solids as percent of the cut or in-situ volume in the slurry. This developed from the normal practice of payment based on cubic yards removed from the cut. The GBA hydraulic dredge production estimates are based on empirical and theoretical data and on operational experience. As an example, the 20% solids by cut volume for Estimate No.

1 pumping silt and soft clay (TI Pool, one booster, Table 4-1) results in a slurry specific gravity of 1.15. Percent solids content by weight or by volume is about equal under these conditions.

A key factor in the production rates is the number of hours the equipment works per day. The average daily operating times are dependent upon the degree of exposure to unfavorable weather conditions as well as mechanical and operational delays. Delays due to weather are assumed to be minimal. The major delays will be in the clearing of the pump and cutter and the coordination of the booster pumps. The maximum daily operating times for the selected hydraulic dredge is estimated to be 19 hours per day. A reduction of one hour per day is made for each booster pump in use. The dredge is estimated to work 6 days per week or 26 days per month. Lost time due to moving between dredge areas must be evaluated although this is a minor factor in this alternative.

The appropriate balance among pump and pipeline capacities, the dredge swing, cutterhead speed (RPM), width of cut and dredge advance will be optimized as part of detailed design of the project.

4.3 Production Analysis

Dredge production characteristics for each alternative and for each Dredge Zone are presented in Appendix C. Results of the analyses are summarized in Table 4-2.

TABLE 4-2, SUMMARY OF HYDRAULIC DREDGING PRODUCTION ANALYSES

	Season 1	Season 2	Season 3	Season 4	Season 5	Totals
REM-3/10/Select						
Cut Volume, cy	677,000	801,000	661,000	---	---	2,139,000
Dredge Months	5.2	6.5	6.6	---	---	18.3
Booster Months	4.9	11.9	28.5	---	---	41.3
Average Monthly Production, cy	130,000	123,000	100,000			117,000
REM-0/0/3						
Cut Volume, cy	519,000	849,000	707,000	680,000	462,000	3,217,000
Dredge Months	4.1	6.7	6.0	6.7	5.0	28.5
Booster Months	3.4	9.4	14.7	26.4	26.0	80.0
Average Monthly Production, cy	127,000	127,000	118,000	102,000	92,000	113,000

Notes: 1. Hydraulic dredging is performed only in Sections 1 and 2. Mechanical dredging of Section 3 is to be evaluated by TAMS
2. Other combinations of work by season are possible with comparable overall results
3. Specific values given above will vary with final design characteristics.

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5. COST ESTIMATE ELEMENTS OUTLINE

Rational of the Cost Estimating Process

Assumptions

Site Construction and Decommissioning

Dredging and Materials Handling
- Monthly Costs
  - Operating Costs
  - Ownership Costs
- Special Costs
- Mobilization and Demobilization

Cost Elements [tabulation of equipment, sites and rates]

1. Northern Processing Site (NPS)
   - 1.1 Construction
     - Right of Way
     - Demolition
     - Power, telephone
     - Grading
     - Paving
     - Storm Drainage
     - Site Office
     - Security
     - Road Access
     - Rail Access
   - 1.2 Site Operations
   - 1.3 Site Decommissioning

2. Dredging System (DRG)
   - 2.1 12-in. Hydraulic Dredge
   - 2.2 16-in. Booster Barge
   - 2.3 Tender Tug
   - 2.4 Skimmer/Debris Collector
   - 2.5 Survey Boat
   - 2.6 25-Ton Derrick Barge
   - 2.7 Fuel Barge
   - 2.8 Deck Barge
   - 2.9 Boom System

3. Water Treatment Plant (WTP)
   - 3.1 Construction
   - 3.2 WTP Operations
   - 3.3 WTP Decommissioning

3. Primary Solids Separation (PSS)
   - 4.1 Construction
   - 4.2 PSS Operations
   - 4.3 PSS Decommissioning

4. Secondary Solids Processing (SSP)
   - 4.1 Construction
   - 4.2 SSP Operations
   - 4.3 SSP Decommissioning

5. Materials Handling (SMH)
   - 5.1 Construction
   - 5.2 SMH Operations
   - 5.3 SMH Decommissioning

7. Process Control System (PRO)
   - 7.1 DRG - position, velocity, density, dredge and booster performance
   - 7.2 PSS -
   - 7.3 WTP - water levels, flow, pumps, mixers, chemical feed
   - 7.4 SSP -
   - 7.5 RSH -
   - 7.6 SMH -
   - 7.7 LAB -

8. Environmental Monitoring

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6. REFERENCES

EPA 1999 - "Physical Separation (Soil washing) for Volume Reduction of Contaminated Soils and Sediments: Processes and Equipment," T. J. Olin, et al, EPA -905-R-99-006, Great Lakes National Program Office, Chicago, IL.

MPI 1980a - "Draft Environmental Impact statement, New York state Environmental Quality Review, PCB Hot Spot Dredging Program, Upper Hudson River, New York," prepared for the NY State, Department of Environmental Conservation, Malcolm Pirnie, Inc., September 1980.

MPI 1980b - "Design Report, PCB Hot Spot Dredging Program Containment Site," prepared for the NY State, Department of Environmental Conservation, Malcolm Pirnie, Inc., September 1980.

TAMS 1999 - "Hudson River Sediment Characterization," Memorandum dated October 25, 1999.

TAMS 2000 - "Removal Alternatives, Volume, Area, Depth Dredged," October 6, 2000

APPENDIX A, PRODUCTION ANALYSIS

Hudson River PCBs Reassessment FS

HYDRAULIC DREDGING CONCEPT DEVELOPMENT, Alternatives REM-3/10/Select & REM-0/0/3

HYDRAULIC DREDGING PRODUCTION ANALYSIS

Alternative REM-3/10/Select Areas

	River Section 1											River Section 2							
	Thompson Island Pool Dredging Zones (1)											Lock No. 6 Pool Dredging Zones			Lock No. 5 Pool Dredging Zones				Combined
	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9	T-10	T-11	L6-1	L6-2	L6-3	L5-1	L5-2	L5-3	L5-4	Totals
Pertinent Information:																			
1 Pool Elevation	119	119	119	119	119	119	119	119	119	119	119	114	114	114	103	103	103	103	
2 Non-navigable Section (2)																			
3 Processing Site	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	
Distances (River Miles):																			
4 Dredge Zone Centroid	194.0	193.5	193.0	192.5	192.0	191.5	191.0	190.5	190.0	189.5	188.9	188.1	187.1	186.8	185.8	184.8	183.9	183.6	
5 Processing Site	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	
Pumping Distance (Feet):																			
6 Total Pumping Distance	2,851	0	2,640	5,280	7,920	10,560	13,200	15,840	18,480	21,120	24,394	28,406	33,792	35,376	40,656	46,200	50,952	52,166	
7 Dredge Pumping Distance	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	
8 One Booster Pumping Distance	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	
9 Number of Boosters Required	1	0	1	1	1	1	2	2	2	2	3	3	4	4	4	5	5	6	
Areas (1000 Square Feet):																			
10 Areas of Dredging Zones	719	337	1,725	1,448	1,279	967	1,290	1,031	1,582	842	1,096	117	153	212	1,294	204	827	496	359 acres
Dredging Depths (Feet):																			
11 Typical Water Depth (3)																			
12 Required Depth of Removal (4)	2.9	3.2	3.2	3.2	3.4	4.0	3.3	3.4	3.5	4.4	3.4	3.0	3.0	3.0	4.8	4.0	3.1	5.1	
13 Minimum Depth Allowance (5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
14 Tolerance Allowance Depth (6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Dredging Volumes, cy																			
15 Required Volume	79,931	41,659	210,852	176,816	167,318	148,944	163,635	134,642	211,915	141,938	142,188	13,478	17,536	24,317	237,772	31,202	98,364	96,512	2,139,019
16 Minimum Depth Volume	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 Required + Min Depth Volumes	79,931	41,659	210,852	176,816	167,318	148,944	163,635	134,642	211,915	141,938	142,188	13,478	17,536	24,317	237,772	31,202	98,364	96,512	2,139,019
18 Tolerance Allowance Volume	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 Access Volume (7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Total Cut Volume	79,931	41,659	210,852	176,816	167,318	148,944	163,635	134,642	211,915	141,938	142,188	13,478	17,536	24,317	237,772	31,202	98,364	96,512	2,139,019
Total Cumulative Volumes 1000 cy																			
21 Season 1	80	122	332	509	677														677
22 Season 2						149	313	447	659	801									801
23 Season 3											142	156	173	198	435	466	565	661	661
24 Season 4																			
25 Season 5																			
Dredging Production cy/hr																			
26 Production Type (8)	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	
27 Coverage Rate, sq ft/hr	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	
28 Full Production Rate (9)	275	275	275	275	275	275	275	275	275	275	275	266	266	266	266	266	266	266	
29 Actual Production Rate	275	275	275	275	275	275	275	275	275	275	275	266	266	266	266	266	266	266	
Time Required, hr																			
30 Dredge Hours Required	291	151	767	643	608	542	595	490	771	516	517	51	66	92	896	118	370	364	
31 Dredge Operating Hours/Day (10)	18	19	18	18	18	18	17	17	17	17	16	16	15	15	15	14	14	13	
32 Move to next Dredge Zone												8	8	8	8	8	8	8	
Total Time (Days):																			
33 Total Dredge Days	16.1	8.0	42.6	35.7	33.8	30.1	35.0	28.8	45.3	30.4	32.3	3.5	4.7	6.4	60.0	8.7	26.8	28.3	477
34 Total Booster Days	16.1	0.0	42.6	35.7	33.8	30.1	70.0	57.6	90.7	60.7	96.9	10.5	18.9	25.8	240.2	43.6	134.0	169.8	1,177
Total Time (Months):																			
35 Total Dredge Months	0.6	0.3	1.6	1.4	1.3	1.2	1.3	1.1	1.7	1.2	1.2	0.1	0.2	0.2	2.3	0.3	1.0	1.1	18.3
36 Total Booster Months	0.6	0.0	1.6	1.4	1.3	1.2	2.7	2.2	3.5	2.3	3.7	0.4	0.7	1.0	9.2	1.7	5.2	6.5	45.3
37 Cummulative Dredge Months per Season	0.6	0.9	2.6	3.9	5.2	1.2	2.5	3.6	5.4	6.5	1.2	1.4	1.6	1.8	4.1	4.5	5.5	6.6	
38 Cummulative Booster Months per Season	0.6	0.6	2.3	3.6	4.9	1.2	3.8	6.1	9.6	11.9	3.7	4.1	4.9	5.9	15.1	16.8	21.9	28.5	

Notes: Values are Rounded

(1) Dredge zone characteristics in Sections 1 and 2 were estimated by GBA using dredge-zone polygons supplied by TAMS.
(2) Is access limited to a portion of the Dredge Zones because of shallow water.
(3) Typical water depth as determined by TAMS.
(4) Required dredging depth determined by TAMS.
(5) Removal of a minimum of 2 ft of material.
(6) Because of methods used to determine required dredging depth no additional allowance (0.5 ft) is provided.
(7) Examination of River bathymetry indicates no additional dredging is required for dredge access to the Dredge Zone.
(8) GBA estimate of production or coverage dredging.
(9) GBA estimate of overall average production rate for pumping sand and silt.
(10) GBA estimate of average productive work hours per day

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Hudson River PCBs Reassessment FS
HYDRAULIC DREDGING CONCEPT DEVELOPMENT, Alternatives REM-3/10/Select & REM-0/0/3

HYDRAULIC DREDGING PRODUCTION ANALYSIS
Alternative REM-0/0/3

	River Section 1													River Section 2											
	Thompson Island Pool Dredging Zones (1)													Lock No. 6 Pool Dredging Zones					Lock No. 5 Pool Dredging Zones						Combined
	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9	T-10	T-11	T-12	T-13	L6-1	L6-2	L6-3	L6-4	L6-5	L5-1	L5-2	L5-3	L5-4	L5-5	L5-6	Totals
Pertinent Information:																									
1 Pool Elevation	119	119	119	119	119	119	119	119	119	119	119	119	119	114	114	114	114	114	103	103	103	103	103	103	
2 Non-navigable Section (2)																									
3 Processing Site	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	North	
Distances (River Miles):																									
4 Dredge Zone Centroid	194.5	194.0	193.5	193.0	192.5	192.0	191.5	191.0	190.5	190.0	189.5	189.0	188.6	188.4	188.0	187.5	187.0	186.5	186.0	185.5	185.0	184.5	184.0	183.5	
5 Processing Site	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	193.5	
Pumping Distance (Feet):																									
6 Total Pumping Distance	5,280	2,640	0	2,640	5,280	7,920	10,560	13,200	15,840	18,480	21,120	23,760	25,872	26,928	29,040	31,680	34,320	36,960	39,600	42,240	44,880	47,520	50,160	52,800	
7 Dredge Pumping Distance	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	
8 One Booster Pumping Distance	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	
9 Number of Boosters Required	1	1	0	1	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	5	5	5	5	6	
Areas (1000 Square Feet):																									
10 Areas of Dredging Zones	1,501	1,776	1,232	1,787	1,462	1,906	1,591	1,574	1,206	2,196	1,401	2,139	797	479	1,092	1,986	1,601	301	1,155	1,773	1,095	1,645	1,830	927	791 acres
Dredging Depths (Feet):																									
11 Typical Water Depth (3)																									
12 Required Depth of Removal (4)	1.6	2.0	2.1	3.1	3.2	2.9	3.1	3.4	3.1	3.0	3.4	2.7	2.4	1.6	1.7	1.6	1.9	2.1	4.1	2.5	1.9	2.0	2.5	3.3	
13 Minimum Depth Allowance (5)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.5	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	
14 Tolerance Allowance Depth (6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Dredging Volumes, cy																									
15 Required Volume	84,369	124,302	90,915	196,959	162,897	191,172	175,101	186,926	132,936	232,735	166,003	206,282	67,886	26,245	64,279	108,569	106,847	22,010	167,892	158,057	72,261	113,734	160,120	108,483	3,126,980
16 Minimum Depth Volume	22,239	658	0	0	0	0	0	0	0	0	0	0	0	7,799	13,350	33,098	5,931	0	0	0	4,866	2,437	0	0	90,378
17 Required + Min Depth Volumes	106,608	124,960	90,915	196,959	162,897	191,172	175,101	186,926	132,936	232,735	166,003	206,282	67,886	34,044	77,629	141,667	112,778	22,010	167,892	158,057	77,127	116,171	160,120	108,483	3,217,358
18 Tolerance Allowance Volume	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 Access Volume (7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Total Cut Volume	106,608	124,960	90,915	196,959	162,897	191,172	175,101	186,926	132,936	232,735	166,003	206,282	67,886	34,044	77,629	141,667	112,778	22,010	167,892	158,057	77,127	116,171	160,120	108,483	3,217,358
Total Cumulative Volumes 1000 cy																									
21 Season 1	107	232	322	519																					519
22 Season 2					163	354	529	716	849																849
23 Season 3										233	399	605	673	707											707
24 Season 4															78	219	332	354	522	680					680
25 Season 5																					77	193	353	462	
Dredging Production cy/hr																									
26 Production Type (8)	Cover	Cover	Cover	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Cover	Cover	Cover	Cover	Prod	Prod	Prod	Cover	Cover	Prod	Prod	
27 Coverage Rate, sq ft/hr	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	
28 Full Production Rate (9)	275	275	275	275	275	275	275	275	275	275	275	275	275	266	266	266	266	266	266	266	266	266	266	266	
29 Actual Production Rate	259	259	272	275	275	275	275	275	275	275	275	275	275	259	259	259	259	266	266	266	259	259	266	266	
Time Required, hr																									
30 Dredge Hours Required	411	482	334	716	592	695	637	680	483	846	604	750	247	131	299	546	435	83	632	595	297	448	603	409	
31 Dredge Operating Hours/Day (10)	18	18	19	18	18	18	18	17	17	17	17	16	16	16	16	16	15	15	15	14	14	14	14	13	
32 Move to next Dredge Zone														8	8	8	8	8	8	8	8	8	8	8	
Total Time (Days):																									
33 Total Dredge Days	22.8	26.8	17.6	39.8	32.9	38.6	35.4	40.0	28.4	49.8	35.5	46.9	15.4	8.5	19.0	34.5	29.3	5.9	42.5	42.9	21.6	32.3	43.4	31.8	742
34 Total Booster Days	22.8	26.8	0.0	39.8	32.9	38.6	35.4	80.0	56.9	99.6	71.0	140.6	46.3	25.6	57.1	103.5	117.3	23.4	170.0	214.3	107.9	161.7	217.1	190.6	2,079
Total Time (Months):																									
35 Total Dredge Months	0.9	1.0	0.7	1.5	1.3	1.5	1.4	1.5	1.1	1.9	1.4	1.8	0.6	0.3	0.7	1.3	1.1	0.2	1.6	1.6	0.8	1.2	1.7	1.2	28.5
36 Total Booster Months	0.9	1.0	0.0	1.5	1.3	1.5	1.4	3.1	2.2	3.8	2.7	5.4	1.8	1.0	2.2	4.0	4.5	0.9	6.5	8.2	4.2	6.2	8.3	7.3	80.0
37 Cummulative Dredge Months per Season	0.9	1.9	2.6	4.1	1.3	2.8	4.1	5.6	6.7	1.9	3.3	5.1	5.7	6.0	0.7	2.1	3.2	3.4	5.0	6.7	0.8	2.1	3.7	5.0	
38 Cummulative Booster Months per Season	0.9	1.9	1.9	3.4	1.3	2.8	4.1	7.2	9.4	3.8	6.6	12.0	13.8	14.7	2.2	6.2	10.7	11.6	18.1	26.4	4.2	10.4	18.7	26.0	

Notes: Values are Rounded

(1) Dredge zone characteristics in Sections 1 and 2 were estimated by GBA using dredge-zone polygons supplied by TAMS.
(2) Is access limited to a portion of the Dredge Zones because of shallow water.
(3) Typical water deoth as determined by TAMS.
(4) Required dredging depth determined by TAMS.
(5) Removal of a minimum of 2 ft of material.
(6) Because of methods used to determine required dredging depth no additional allowance (0.5 ft) is provided.
(7) Examination of River bathymetry indicates no additional dredging is required for dredge access to the Dredge Zone.
(8) GBA estimate of production or coverage dredging.
(9) GBA estimate of overall average production rate for pumping sand and silt.
(10) GBA estimate of average productive work hours per day.

Notes: (1) Dredge zone characteristics in Thompson Island Pool were estimated by GBA using dredge-zone polygons supplied by TAMS
(2) Is access limited to a portion of the Dredge Zone because of shallow water
(3) Typical water depth as determined by TAMS
(4) Required dredging depth determined by TAMS for this alternative
(5) Removal of a minimum of 2 ft of material
(6) Because of the methods used to determine required dredging depth no additional allowance (0.5 ft) is provided for this alternative.
(7) Examination of river bathymetry indicates no additional dredging is required for dredge access to the Dredge Zone for this alternative.
(8) GBA estimate of production or coverage dredging.
(9) GBA estimate of overall average production rate for pumping sand and silt.
(10) GBA estimate of average productive work hours per day.

Dredge operates three shifts and averages 19 hours of production less one hour for each booster in use
Dredge operates six days per week
Dredging season is 6.5 months per year or 169 dredging days per season

Factors:

19-(1 hr/booster)	Operating Hours per Day
6	Work Days per Week
6.5	Dredging Months per Season
169	Dredging Days per Season

HUDSON RIVER PCBS REASSESSMENT FS

APPENDIX H

HYDRAULIC DREDGING REPORT AND DEBRIS SURVEY

H.2 Debris Survey

HUDSON RIVER DEBRIS

Introduction

This report summarizes results of a debris survey conducted by Superior Special Services and TAMS Consultants, Inc. during the first week of November 1999 in the Upper Hudson. The purpose of the survey was to identify the extent and nature of debris that may be encountered along the river bed should an active remedy such as removal or capping be selected by USEPA.

1.0 Instrumentation

To obtain data that would be needed to evaluate the presence of debris (trees, rocks, cars, metal debris, junk) in the river, and to obtain a visual understanding of river bottom conditions, a Coast Guard compliant survey boat was equipped with the instrumentation listed below. The survey boat and instrumentation are shown on Figures 1 and 2:

Dual Frequency Side-Scan Sonar
Multi-Beam Sonar Survey System
Sub-Bottom Profiling Sonar System
Remotely Operated Vehicle (ROV) with sonar, lights and video
Computer Monitors
Television, for ROV video viewing
Gyroscopes
Motion Reference Unit
All linked to three Differential Global Positioning Systems (DGPS)

2.0 Field Surveys

2.1 Pre-Survey Reconnaissance

On October 29, 1999 TAMS personnel conducted a pre-survey reconnaissance of the Upper Hudson River beginning with the Thompson Island Pool (TIP) and ending near the Federal Dam at Troy, New York. The purpose was to develop a general plan for the overall program and to identify potential problems that might be encountered. Among the matters that were resolved at this time were access to the non-navigable river section south of the TI Pool as well as access to the vicinity of several hot spots that also occur in off-channel areas. Finally, the reconnaissance also helped in determining the availability of boat launch and fueling facilities during the upcoming survey.

2.2 Debris Survey

The actual debris survey was conducted from November 1, 1999 through November 7, 1999 by Superior Special Services, Inc., with a TAMS representative directing the boat crew. The three-person Superior crew consisted of a boat captain and equipment operator, an instrumentation specialist, and an equipment tender and multibeam sonar specialist. Two of the crew members were also certified divers. The specific goal of the program was to assess five to seven different locations along the 40-mile section of the river and various data sets at potential remedial locations. Once in the river the capabilities of the instrumentation were tested and it was determined that the field team would attempt to obtain as much useful data as possible within the allotted time.

The survey began in the Thompson Island Pool (TIP) lasting for a period of two days at this location. The remainder of the time was spent primarily obtaining information from the historically identified Hot Spots downstream of TIP. While it was initially intended that five to seven locations would be assessed, with diver confirmation, the field team was able to access each of the historic Hot Spots identified on project maps (these have been designated by NYSDEC as HS 5 through HS 40) using the available instrumentation. Verification of images, from the sonar and sub-bottom profiler, was performed, as much as possible, by means of visual observations from the boat (in shallow areas) and through use of the ROV. The advantage of using the ROV was that it enabled continuous video taping of the area being evaluated. River velocities were also collected manually, at investigated locations by means of a current meter.

Side-scan sonar images were obtained in either 20-meter or 50-meter wide swaths. In most instances complete side-scan sonar coverage for a particular Hot Spot was not attempted since the goal of the survey was to assess these areas for the general presence of debris. Therefore, vessel passes over the Hot Spots were performed, at the direction of the TAMS representative, to obtain an over-view of bottom conditions covering as extensive an area as possible.

Sub-bottom profile data was usually collected on a single line transect over the Hot Spots in an attempt to confirm the presence of sediment deposits. Vegetated areas were typically avoided since signal interference occurs in these areas. Other interference occurred in areas where gas bubbles were trapped within the sediment. These areas were initially included in the sub-bottom sonar transects and discontinued when interferences were encountered. The sub-bottom profiling data is considered adequate to identify some debris at or near the surface of the sediments.

A multi-beam sonar composite image was collected at Hot Spot 14 within the TIP on the first day of the field survey. This trial was done to determine the time required to collect a data set and to establish the overall utility of the information being collected. An area one-half the size of Hot Spot 14 was scanned and selected results were plotted after data reduction was performed at the conclusion of the day's work. The multi-beam sonar was operated for approximately 45 minutes as the boat made multiple passes to collect an image covering 95 percent of the selected area. Based on this trial it was determined that the time and data storage requirements needed to collect this information were too great to continue this particular part of the program. However, the usefulness of multi-beam sonar imaging as an effective tool in determining pre- and post-dredge conditions were clearly demonstrated. After reducing the data at Hot Spot 14, it was easily converted into a bathymetric plot.

An estimate of the data collected for the week included 500 side-scan sonar images, one multi-beam sonar image of HS 14, 1+ JAZ drives of sub-bottom profile data, and almost 5-hours of ROV video tape. The approximate total of data collected was in excess of 2 gigabytes of information.

3.0 Results - Preliminary Evaluation of the Survey

This preliminary evaluation is based on initial observations made on the survey vessel while viewing the side-scan sonar, sub-bottom, and video images that were being both displayed and recorded. A further evaluation of selected images is presented in a following section.

3.1 Debris: Junk

Prior to initiating the survey it was not known if or to what extent man-made debris existed within the river. These items (e.g., cars, shopping carts, bales of wire, sunken boats and barges, boat motors, wooden docks, utility poles, farm equipment, concrete blocks, and other metallic or wooden debris) were thought to possibly exist in the river at areas of convenient access, such as at bridge crossings, near marinas, or from easily accessible roads or fields. It was assumed that these items would be have been either deliberately disposed or accidentally washed into the river during high flow events, while some items may have been blown into the river by the wind.

Man-made junk and debris was rarely seen in the river. Several side-scan sonar images contained car tires mounted on rims and some video footage showed a plastic bucket and a few bottles in shallow locations but rarely anything of significance. No cars, shopping carts, or similar metallic debris were detected.

At one location a swamped wooden boat was visually observed from the survey boat; it was also detected in a reflected side-scan image. Two or three sections of woven cable (each one a few hundred feet in length or more) were also identified lying along the river bottom. These are probably steel woven cable sections that may have been used to tow barges or act as protective barriers upstream of dams or dredge deposit mound areas.

3.2 Debris: Trees / Rocks / Boards and Slats

a. Trees

Logs and branches were discovered randomly throughout the 40-mile study area. Many of the logs and branches were located near islands. The operator at the Fort Miller Hydro plant stated that the facility usually removes two or three 40-foot trees per year from the bar-screen at the intake to the plant. This facility is within the un-charted section of the river between the Fort Miller Hydro plant and the Thompson Island dams.

b. Rocks

Rocks and rock outcrops are fairly well mapped throughout the Upper Hudson River. This field survey confirmed the location of many of the dredge/spoil deposit areas already mapped through earlier efforts associated with the Hudson River reassessment project. Side-scan sonar and the ROV video system also confirmed the presence of spoil areas north of the Route 4 Bridge near Northumberland and Schuylerville. Rock mounds and cobbles are typically found near the identified spoil areas. Thin sediment depositions may cover some rocky areas, but these reflective materials appear to be associated with underlying bedrock and do not appear to be loose rocks and cobbles.

c. Boards and Slats

Man-made wood debris consisting mainly of wooden slats was also observed. These slats were located in abundance just north of the Route 4 Bridge crossing, approximately 1¼ mile upstream of Lock 5. Video documentation is available regarding this find. Based on the initial discovery it is assumed that hundreds or more of these slats may be found at this location. Sediments appear to partially cover many of the slats as observed via the ROV system.

Other wood debris was discovered that appeared to be sections of docks or other waterfront structures. Larger pieces of lumber were not located in any significant amounts. The primary location where larger planks were found was in proximity to private boat docks. On occasion, planks and other scrap wood were found near areas where trees or branches had also accumulated; these usually are shallow and slow moving sections of the river.

4.0 Other Observations

While it was not the objective of this program to assess physical conditions within the river, other than the presence of debris, the following general observations were made.

4.1 Scour

At a few of the previously identified Hot Spot locations little or no sediment was observed. Using the ROV system, lack of sediment was observed initially at Hot Spot 26. Also, at Hot Spot 39 only minimal amounts of sediment appeared to be present. HS 38 consisted primarily of spoil mounds with some deposits of sediment in the spaces between the mounds. Side-scan sonar data indicates that most of the sediments originally documented in the northern half of Hot Spot 6 now appear to be coarse sediment and rock. Transport of this material during high flow conditions may be occurring at this and other locations along the Upper Hudson River.

4.2 Deposition

Just upstream of the Fort Miller Hydro facility thick deposits of sediments were observed by means of the sub-bottom profiler. Within the past year this location has almost completely silted along half of the Hydro facility's bar-screen zone. Using the ROV to conduct a visual inspection of the area in front of the bar screens revealed about a 13 foot high pile of wood debris (logs/branches/boards/ leaves and other green vegetation) had accumulated along parts of the bar screen structure, above the sediments mudline.

Sediment appears to have deposited down-stream of the southern tip of Rogers Island in the TIP, and the navigational channel east of Rogers Island appears to be getting shallower. Deposition appears to have also occurred in the TIP across the river from the southern half of Hot Spot 10 (along the right bank). Sediment deposits near the southern tip of Billings Island appear to be increasing in thickness.

4.3 Fish

Only four fish were seen during the five hours of video filming. Typically the ROV does not cause fish flight. Fishermen at the Schuylerville Marina also confirmed that fishing was poor this past year.

5.0 Data Evaluation

5.1 Method

A sample side-scan sonar bitmap image is provided as Image 1. These images were collected in sequential order on the date noted in the file name. Therefore, side-scan sonar image 06NOV044.MST was collected on November 6, 1999 and is the forty-fourth image for that day. The colors selected for the color image are helpful in interpreting the composition of the reflected image. Basically, the brighter (yellow) the image, the greater the return signal response. Therefore, harder materials show up lighter in color whereas soft sediments show up darker (approaching black) in color on the images. The primary sonar frequency used for consistent image comparison was 600 kHz. Several 150 kHz frequency images were collected for purposes of comparison.

Image 1 is an image that shows the reflected river bottom when viewed from the left looking toward the right. The three major yellow images are rock piles, which were confirmed through visual identification using the ROV system. The dark areas to the right of the three rock piles are in the "shadow" of the elevated piles. There also appears to be an elongated sediment mound, which is oriented approximately between the rock piles. The black area to the right of this mound is also a result of shadowing. The black area along the left edge is the segment directly beneath the side-scan sonar devise, which it is unable to "see". Dark areas can also represent depressions similar to shadows within a crater's edge on the moon, or may be shadowed areas behind rocks, tree logs or other elevated debris.

Similar interpretations were performed on most of the side-scan sonar images. Those images not used typically represented images which were a duplicate image of other collected data or were images which contained significant image "stretching". Stretching of the image occurs when the track of the boat is not sufficiently straight thereby elongating the image. Major directional changes made by the boat rendered some of the stretched images unusable since the data would not be accurately interpreted.

5.2 Side-Scan Sonar Data Interpretations

5.2.1 Junk

Based on observations made at the time of the survey and, as well, on a later interpretation of the collected data files, it does not appear that debris is a problem. Side-scan sonar and ROV images, which were collected primarily from areas within 200 feet of the shore, identified a few tires on rims, a bucket, some bottles and one swamped boat (easily visible along the shoreline). None of these items are of particular concern to impacting an active remedy such as capping or removal of contaminated sediments.

5.2.2 Trees

The vast majority of wood debris encountered consisted of tree branches, tree trunks or whole trees that may have been washed into the river during storms or high water conditions. Many cut logs were also discovered, some fireplace length and others that appear to be cut at one end with the branches removed. Employees at the Fort Miller Hydro facility reported that entire trees are removed at their bar-screens three or four times a year. They also remove other wood debris such as branches and boards on a regular basis. Within the river, however, wood debris is typically found at well defined locations, such as at river bends, in shallow or slow moving sections of the river, or perched atop dams. These areas are identified on the debris survey map.

Wood debris may present an obstacle to implementing a remedy. Therefore, identification and removal of large wood debris should be performed prior to initiating a remedial activity at any particular location. It is expected that smaller pieces of wood debris will not impact removal; operations by either mechanical or hydraulic dredging systems (see image 3).

5.2.3 Rocks

Significant quantities of rock debris were identified within specific areas during the debris survey. Previous mapping indicated the presence of rock mounds at dredge piles sites (identified as "spoil area" on the navigational charts). The presence of theses rock piles was confirmed during this survey, particularly by means of the ROV system. The observed rock mounds consisted of cobble-sized stone to objects two to three feet along one side and 12 to 18 inches thick. The side-scan sonar system also confirmed the presence of rock piles, or mounds, which appear to be associated with historic Champlain Canal dredging activities (see image 2).

In other locations, significant areas of exposed bedrock are present. One drawback of the side-scan sonar technology is that it is possible for the bottom of the river to obscure the true conditions. For example, coarse-grained sediments may have formed a crust overlaying softer sediments. These materials reflect back an image only of coarse hard materials. The underlying sediments are obscured. In most cases sub-bottom profiling instrumentation cannot penetrate these materials either. The alternative method to establish conditions at these locations is to physically probe the bottom; this was done at a number of locations.

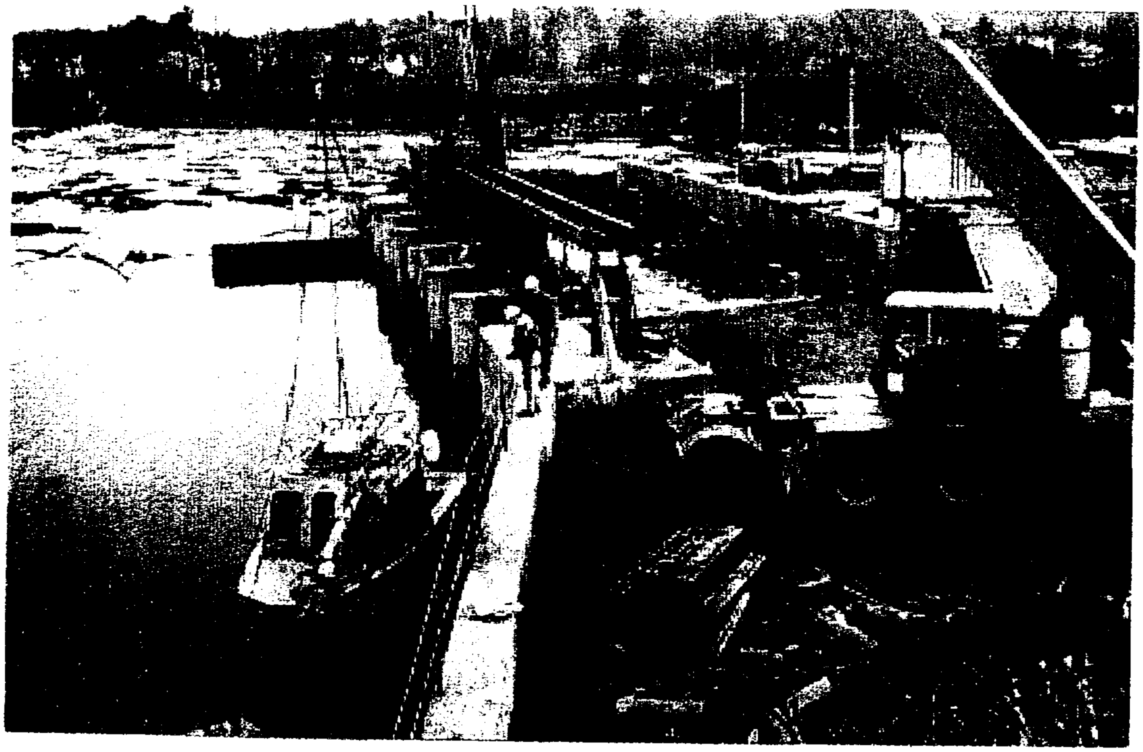
Scattered rocks and boulders that have been identified throughout the river can be removed prior to initiating remedial work in much the same manner that large pieces of wood debris would be removed. A more significant obstacle to remedial work is the presence of consolidated rock at the bottom of the river. The presence of rocky formation was detected both during this survey and earlier investigations that are recorded on FS Plate 2. It will be necessary to confirm the extent of such rocky formations prior to initiating a remedy. Then it is expected that most such areas will have to be avoided since removal work in these locations will either be inhibited or precluded.

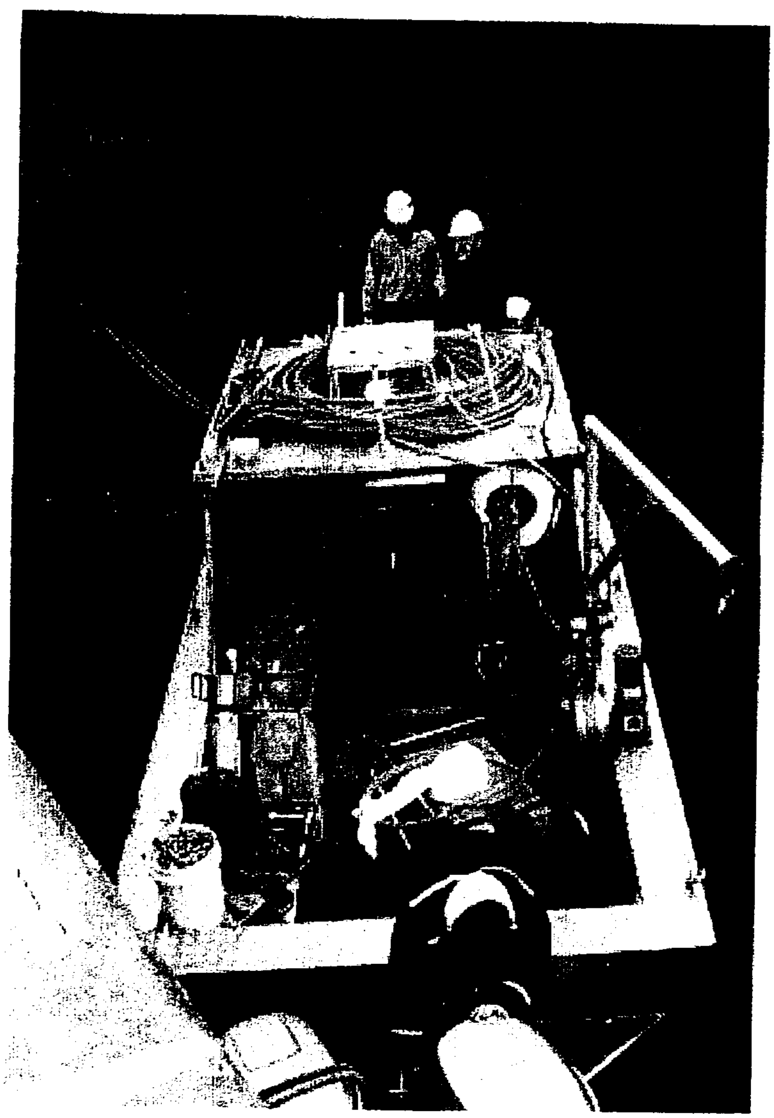
5.2.4 Boards and Slats

Man-made wood debris can be handled in the same manner as natural wood materials such as tree trunks and branches. This material will not impede planned remedial work.

6.0 Conclusions

The debris survey conducted during the first week of November 1999 demonstrated that instrumentation is available to detect most near surface material that would interfere with the implementation of an active remedy for the Upper Hudson. Another finding of the survey program is that manmade and plant debris is not likely to be a significant problem during remedial. The largest of these materials, along with cobble piles observed at several locations, can be removed prior to the initiation of work in any particular area. The presence of consolidated rock along the river bottom will preclude removal operations in some areas. The full extent of such rocky formations will also need to be established as part of the design phase of an active remedy.





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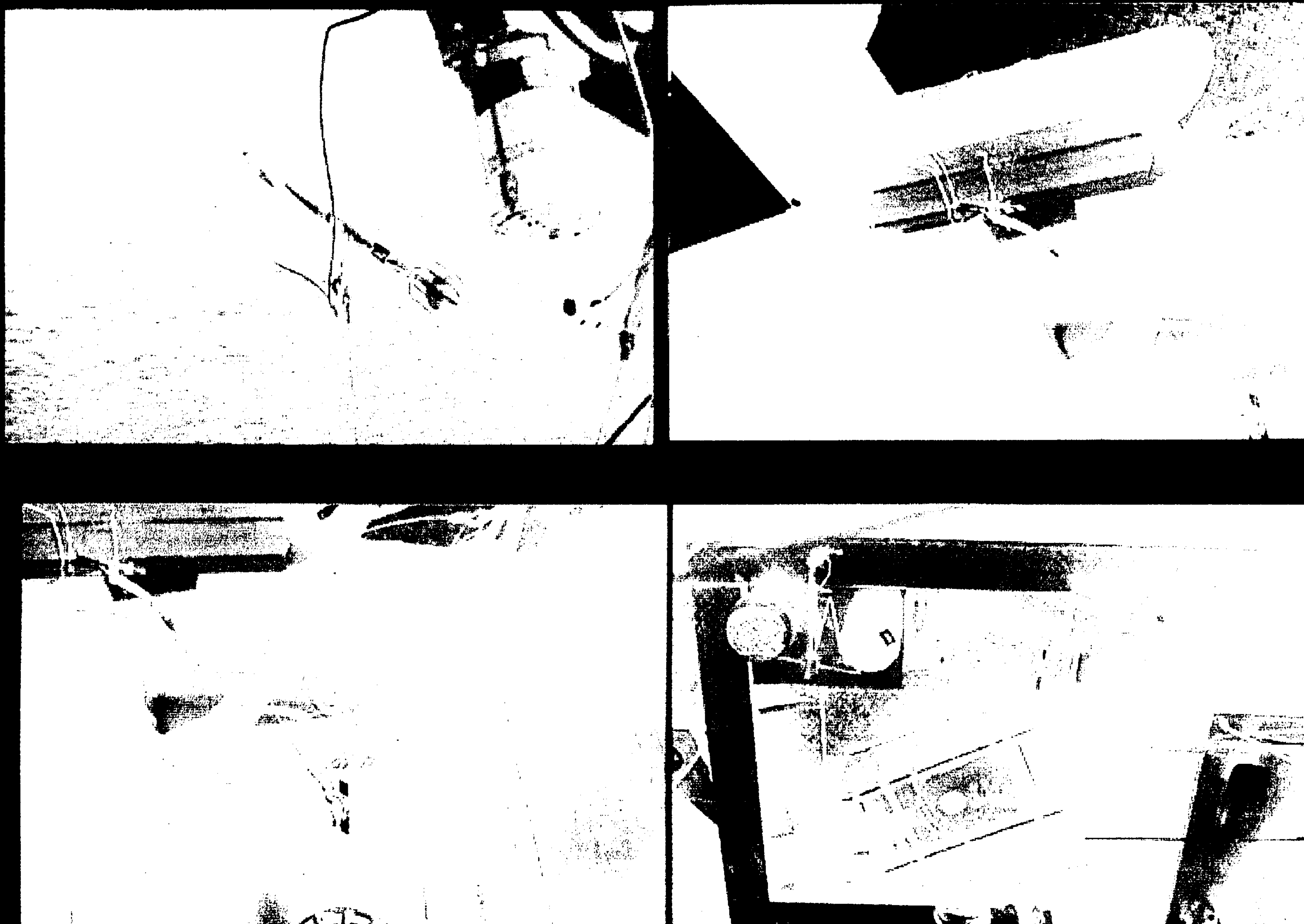

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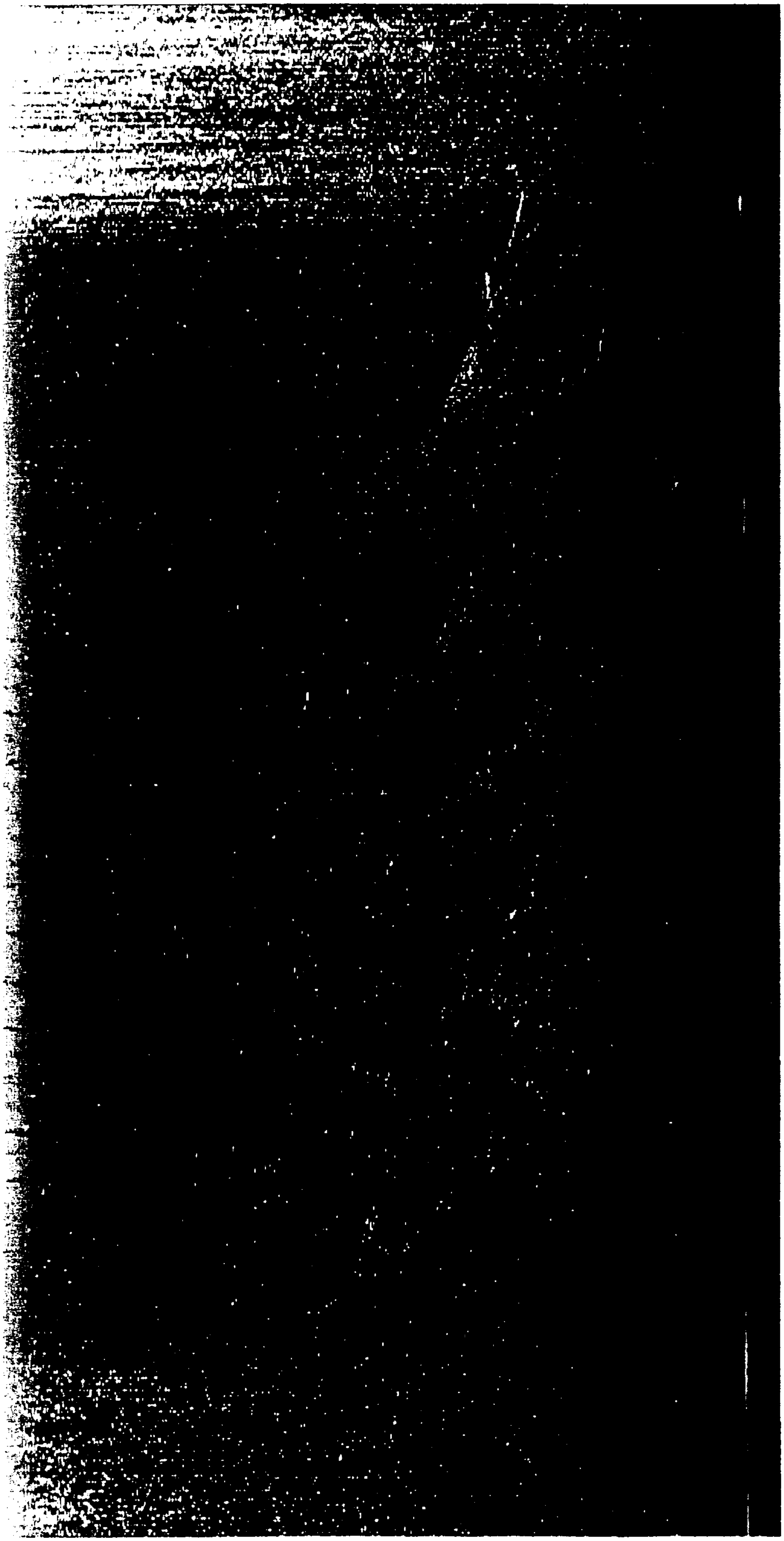

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