APPENDIX A

DATA USABILITY REPORT FOR PCB CONGENERS

LOW RESOLUTION SEDIMENT CORING STUDY

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A.1 INTRODUCTION

The usability of data relates directly to the data quality objectives of the environmental investigation (Maney and Wait, 1991; USEPA, 1993, 1994). The Hudson River PCB congener chemistry program required sophisticated, high resolution gas chromatography analyses with stringent quality control criteria. In addition, various inorganic and physical parameters were analyzed to define the chemical context within which the PCB congeners exist. This approach was necessary to delineate the concentration of PCB congeners within the context of geochemical and biological processes occurring in the river. This report focuses on the usability of the PCB data generated by the Low Resolution Sediment Coring Study, one of several studies including the High Resolution Sediment Coring Study and the Ecological Study, that when taken together constitute the overall program. The data usability assessment was done in a manner consistent with that used during the assessment of the PCB data generated during the High Resolution Sediment Coring Study.

TAMS/Gradient selected a total of 90 PCB congeners as target congeners based on their significance in environmental samples and the availability of calibration standards at the start of the overall program *(i.e.*, the high resolution sediment coring study). As the program evolved, Aquatec obtained qualitative and quantitative information for additional PCB congeners (non-target congeners) from each sediment sample analysis using relative retention time information detailed in the literature, and more recently verified with actual standards. For the low resolution sediment coring study, data for 126 different PCB congeners were utilized; these congeners are listed on Table A-1. Included in this group of 126 congeners are 12 for which Aquatec calibrated on a daily basis, listed as “No-Cal” on Table A-1. Also included in the 126 congeners is one pair, BZ #101 and BZ #90, which coeluted and could not be quantitated separately. Therefore, the database of 126 congeners consists of 125 data points per sample.

Certain target congeners are of particular importance in evaluating geochemical and biological processes within the Hudson River sediments. These are the 12 “principal” target congeners, which consist of BZ #1, 4, 8, 10, 18, 19, 28, 52, 101, 118, 138, and 180. The focus of this report will be on the usability of the analytical data for these 12 principal congeners.

This report serves as an overall evaluation of the PCB congener analyses performed for the

Hudson River low resolution sediment coring study. The evaluation is based on the assessment of data quality relative to the objectives of the study. This report will first provide a synopsis and assessment of the field sampling, analytical chemistry and data validation programs, and then evaluate data usability for the 126 congeners for which data was used in the low resolution sediment report, with particular emphasis on the 12 principal target congeners. A data usability report assessing the non-PCB chemical and physical analyses for the low resolution sediment samples is provided separately (Appendix B).

It should be noted that the data generated during the course of the low resolution sediment coring program included more than the 126 congeners discussed in this usability report. The usability of the data for additional congeners is provided in the usability reports associated with the part of the overall program in which the data from these additional congeners is used. However, for consistency with the high resolution sediment coring program, only the 126 congeners that are in common between the low and high resolution coring programs are utilized.

A.2 FIELD SAMPLING PROGRAM

TAMS/Gradient designed the low resolution sediment coring study to examine the long-term inventory of PCB in the sediment of the Thompson Island pool; to refine the PCB mass estimates for six hot spots below the Thompson Island pool; and to explore several areas in which little was known with regard to PCB distribution. TAMS/Gradient described the low resolution sediment collection program, sampling procedures, analytical protocols, and quality control/quality assurance requirements in Volume 4 of the “Phase 2B Sampling and Analysis Plan/Quality Assurance Project Plan - Hudson River PCB Reassessment RI/FS” (TAMS/Gradient, June 1994; referred to in this report as the Phase 2B SAP/QAPP). TAMS/Gradient collected cores using a vibrating coring device (vibra-coring). Three to five cores were collected at each station. Once the cores were returned to shore, the sampling team extruded and aliquoted sediments from the cores in a manner described in the Phase 2B SAP/QAPP, and illustrated in Figure A-1. For most samples, this procedure involved reserving the lowest portion of the core (approximately a 3-inch thick slice from the bottom) for radionuclide (^{137}Cs) analysis, then dividing the remainder of the core into three slices of equal thickness, with a 1-inch thick portion of the top slice of the core also being designated for radionuclide (^{137}Cs and ^{7}Be) analysis. The sampling team aliquoted each slice into appropriate containers and submitted the samples to a contract laboratory for analysis.

Scientists from TAMS and their subcontractors performed sampling for the low resolution sediment coring study from July 13, 1994 through August 12, 1994. The sampling team collected a total of 371 sediment samples (excluding duplicates and co-located samples) from 170 sampling cores in the Thompson Island pool and at various locations downstream from the Thompson Island pool. Aquatec allocated these samples into 20 sample delivery groups (SDGs). The TAMS/Gradient Program Quality Assurance Officer (QAO) conducted a field sampling audit on July 21, 1994 to assess compliance of the sampling procedures with the Phase 2B SAP/QAPP. The audit findings indicate that the sampling program was being conducted in a technically acceptable manner consistent with the Phase 2B SAP/QAPP (Wait, 1994).

A.3 ANALYTICAL CHEMISTRY PROGRAM

A.3.1 Laboratory Selection and Oversight

TAMS/Gradient retained a number of analytical laboratories to perform the analyses required for this program. To verify that the selected laboratories had the capacity, capabilities, and expertise to perform sample analyses in strict accordance with the specified methodologies, each qualifying laboratory underwent an extensive audit by TAMS/Gradient's senior chemists. TAMS/Gradient retained Aquatec Laboratories, a division of Inchcape Testing Service located in Colchester, Vermont to perform the low resolution sediment sample PCB congener, total organic carbon (TOC), and total kjeldahl nitrogen (TKN) analyses for the Hudson River RI/FS program. Aquatec was the sole analytical laboratory which conducted the PCB congener analyses for the entire program, including the high resolution sediment study and the ecological study, thus maximizing the comparability of the PCB data across these programs.

TAMS/Gradient conducted routine laboratory audits during the low resolution sediment coring study to verify compliance of Aquatec with the Phase 2B SAP/QAPP requirements.

Unique requirements of the PCB congener method necessitated refinements of previously published methods. In conjunction with these changes, Aquatec conducted Method Detection Limit (MDL) studies and Extraction Efficiency (EE) studies for the sediments to evaluate the adequacy of the methods. To conduct these studies, TAMS/Gradient collected seven replicate Hudson River sediment samples. For the MDL studies, TAMS/Gradient collected the samples upstream from the zone of major PCB contamination. TAMS/Gradient collected samples used for the EE study from within the zone of major PCB contamination. A synopsis of the MDL/EE studies is provided in a TAMS/Gradient memorandum dated July 12, 1993 (Cook, 1993). The TAMS/Gradient Program Quality Assurance Officer oversaw and approved the method refinements throughout the process.

A.3.2 Analytical Protocols for PCB Congeners

The method used by TAMS/Gradient for the determination of PCB congeners in Phase 2B is a program-specific method, essentially the same as that used in the high resolution sediment coring program except as noted herein, and was based on NYSDEC's Analytical Services Protocol Method 91-11 (NYSDEC, 1989) for PCB congeners. Appendix A4 of the Phase 2A SAP/QAPP describes procedures for the calibration, analysis, and quantitation of PCB congeners by fused silica capillary column gas chromatography with electron capture detection (GC/ECD). The method is applicable to samples containing PCBs as single congeners or as complex mixtures, such as commercial Aroclors. Aquatec extracted sediment samples with hexane, and performed applicable cleanup procedures prior to analysis by GC/ECD, as detailed in Appendix A3 of the Phase 2A SAP/QAPP. Aquatec analyzed hexane extracts for PCB congeners on a dual capillary-column GC/ECD, as detailed in Appendix A4 of the Phase 2A SAP/QAPP and identified PCB congeners using comparative retention times on two independent capillary columns of different polarity.

Aquatec used calibration standards for each target congener to define retention times. In addition, Aquatec routinely analyzed Aroclor standards and mixtures of Aroclor standards to verify identification and quantitation of the primary calibration standards. Because of the non-linear nature of the ECD over any significant calibration range (for this project 1 to 100 ppb in extract), Aquatec generated the calibration curves used for quantitation from a quadratic weighted least squares regression model where the correlation coefficient is greater than 0.99 (McCarty, 1995; USEPA, 1986 - Method 8000B, proposed 1995 update; promulgated in Update III, December 1996).

For each PCB congener which elutes as a single congener on each GC column, Aquatec reported the result as the lower of the two values. Although this quantitation scheme is in compliance with USEPA CLP guidelines for dual-column analyses (USEPA, 1991), it may introduce a slightly low bias when calculating homologue and total PCB sums. TAMS/Gradient compared data in the database relative to absolute results on both columns and found the bias was usually negligible, and on a worst-case basis, may be as low as 2% to 10% low. For situations where coelution occurred on one column, Aquatec quantitated the result from the column not displaying coelution. When only coelution results were available, Aquatec performed a calculation to decipher concentrations using response factors derived by Mullen (1984). Five of the 12 principal congeners (BZ #1, 18, 28, 52, and 180) were eluted as a single congener peak on both GC columns. Six principal congeners (BZ #4, 8, 10, 19, 118, and 138) were eluted as a single congener peak on one column and coeluted on the other column. One congener, BZ #101, was coeluted on both columns and always reported with BZ #90.

Approximately 10% of all samples analyzed by GC/ECD also underwent additional analysis using a GC-ion trap detector (ITD) as an additional means of confirming PCB congener identifications, as detailed in Appendix A5 of the Phase 2A SAP/QAPP. When possible, Aquatec selected samples with the highest concentrations of PCB congeners for confirmation analysis by GC/ITD. Usually, Aquatec performed two GC/ITD analyses per SDG, even if congener concentrations were minimal throughout the SDG.

At the start of the Phase 2B sampling and analysis program, TAMS/Gradient and Aquatec selected 90 target PCB congeners. These target congeners are listed in Table A-1 (identified by "yes" in the "Target Congener" column) and identified by BZ number (Ballschmiter and Zell, 1980). TAMS/Gradient and Aquatec based the selection of these 90 PCB congeners on their significance in environmental samples and the commercial availability of calibration standards. TAMS/Gradient referred to PCB congeners for which calibration standards were available as "target congeners". To verify that congener response for these calibration standards was reproducible over time, TAMS/Gradient examined calibration data from November 1992 and October 1993. TAMS/Gradient found temporal consistency to be acceptable on both GC columns (the RTX-5 and the SB-Octyl 50 columns) (Bonvell, 1994a).

The high resolution column chromatography techniques employed by Aquatec produced an acceptable PCB resolution for numerous congeners not contained in the target congener calibration standards. Thus, TAMS/Gradient decided during method refinement to report approximately 50 additional PCB congeners. The laboratory identified these additional PCB congeners based upon the relative retention times reported in the published literature (Mullen, 1984; Schulz, 1989; Fischer and Ballschmiter, 1988, 1989). Aquatec calibrated these additional "non-target" congeners using the calibration curve for target congener BZ #52. Aquatec chose BZ #52 because it eluted as a single congener peak in the middle region of the chromatogram for both GC columns and is a major component of Aroclor 1242, the Aroclor anticipated in Hudson River samples. Using additional congener calibration standards which became commercially available by August 1993, Aquatec performed analyses to verify and refine the historical relative retention times, and to determine individual congener calibration parameters. These analyses confirmed a majority (36) of the historical non-target congener relative retention times. For all analyses performed prior to August 1993, the results for 14 non-target congeners were not confirmed by this analysis; thus TAMS/Gradient considered them unusable and deleted them from the database, leaving a database of 126 congeners. A review of high resolution sediment data indicated that the 36 confirmed non-target congeners represent a significant percentage, up to 25 percent, of the total PCB mass. Therefore, TAMS/Gradient decided to include the non-target congener results to calculate homologue and total PCB masses in the Hudson River. If TAMS/Gradient did not include these non-target congener results, the resulting calculations for homologue and total PCBs would have been significantly biased low. Since the non-target congener results were to be included in the calculations of homologue and total PCB mass, TAMS/Gradient applied an individual correction factor to each congener's results based on the analysis of the additional congener standards. The application of these correction factors served to minimize the uncertainty associated with quantitation of non-target congeners. A series of TAMS/Gradient memoranda describe the method for deriving these calibration correction factors (Bonvell, 1993a, b, c). A listing of the derived calibration correction factors is provided in a TAMS/Gradient memorandum (Bonvell, 1994b).

To establish a method of quantitating total Aroclor concentrations from PCB congener data, Aquatec performed duplicate analyses of seven Aroclor standards (Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260). TAMS/Gradient defined the quantitation of an Aroclor for this program as the sum of all congeners present in the standard Aroclor mixture at a concentration greater that 0.1% of the total Aroclor mass. The percentage of the total mass represented by such congeners was then compared to the actual (prepared) concentrations of each Aroclor standard. The results produced the following yields for the seven Aroclor standards: Aroclor 1016=93.3%, Aroclor 1221=86.8%, Aroclor 1232=91.0%, Aroclor 1242=90.6%, Aroclor 1248=89.2%, Aroclor 1254=95.8%, and Aroclor 1260=87.0%. Thus, in each case, the 90 target and 36 non-target congeners represented more than 87% of the original Aroclor mass. For those Aroclors most important to the Hudson River based on General Electric's reported usage (Brown *et al.*, 1984), these congeners represented more than 90% of the Aroclor mass (*i.e.*, Aroclors 1242, 1254, and 1016).

A.4 DATA VALIDATION

An essential aspect of understanding the uncertainties of the Phase 2B sediment data is understanding the significance of the qualifiers associated with the results. Each result may have an associated qualifier. Qualifiers denote certain limitations or conditions that apply to the associated result. Initially, the analytical laboratories applied qualifiers to the results, and then the data validators modified the qualifiers, as necessary, based on the established validation protocols. Data reporting and validation qualifiers direct the data users concerning the use of each analytical result. TAMS/Gradient used two sets of qualifiers in the database, one set for PCB congener data, and a second set for non-PCB chemical and physical data. Aquatec developed an extensive list of data reporting qualifiers to be applied to the PCB congener data. The list is based on standard USEPA qualifiers used for organic analyses, with additional qualifiers provided to note unique issues concerning PCB congener analysis, *e.g.*, the quantitation scheme. The data reporting qualifiers for PCB congener data, as applied by Aquatec, are defined in detail in Table A-2. Qualifiers for non-PCB data are discussed in a separate document (Appendix B).

During validation, the validators made modifications to the data qualifiers which are reflected in the database. CDM Federal Programs Corporation and their subcontractors, under a separate USEPA contract, performed data validation for the low resolution sediment coring study.

Validation procedures employed by CDM for GC/ECD analyses for the low resolution sediment coring study were the same as for the high resolution coring study except as noted below. These procedures are detailed in Appendix A6 of the Phase 2A SAP/QAPP, and validation guidelines for GC/ITD analyses are provided in Appendix A7 of the Phase 2A SAP/QAPP. TAMS/Gradient devised the validation procedures to reflect the data quality objectives of the program, as well as to conform with USEPA (1988, 1992a) standards as appropriate. USEPA Region II concurred with these method-specific validation protocols. In addition, TAMS/Gradient designed comprehensive data validation templates to facilitate consistency of approach and actions during validation. Prior to validation of the PCB data, Gradient conducted a training workshop to aid CDM in properly performing the validation. Gradient reviewed and commented on the initial CDM validation reports and provided real-time QA oversight.

The initial data validation efforts for the low resolution sediment samples were completed in August 21, 1995. The results were subsequently incorporated into the TAMS/Gradient database and were available for review in August 1996. The issues encountered during review of PCB data from the high resolution sediment coring study regarding the inappropriate application of blank data during validation were resolved prior to TAMS/Gradient's review of the low resolution sediment coring data.

As an overall assessment of data quality, the TAMS/Gradient Program QAO reviewed pertinent aspects of the sampling and analysis program (*e.g.*, historical data, implementation of sampling protocols, laboratory performance) relative to the data quality objectives. Decisions on data usability sometimes overrode data qualification codes, as justified in this report. All qualifier changes made by the TAMS/Gradient Program QAO, as reflected in this data usability report, are noted in the final database (code “Y” in the QA Comment field of database). For the low resolution sediment coring study, TAMS/Gradient Program QAO modified 349 qualifiers out of 46,375 PCB congener data records (125 data points [126 congeners] for 371 samples) as a result of data usability issues, representing less than 0.8% of the data. Specifically, TAMS/Gradient Program QAO restored the rejected data to usable status for three reasons. First, octachloronaphthalene (OCN) was deemed to be an unacceptable surrogate standard (see Section A.5.2), and therefore, TAMS/Gradient Program QAO restored any sample results rejected solely due to poor OCN recoveries. Second, CDM rejected certain positive BZ #18 detects due to poor dual column precision. The TAMS/Gradient Program QAO changed the rejection qualifier (R) to estimated and presumptively present (JN). The TAMS/Gradient Program QAO based this decision on the routine presence of BZ #18 in historical sediment samples containing PCBs, the consistent PCB congener pattern distribution present throughout the Hudson River sediments, and the confirmation of the presence and concentration of BZ #18 by the GC/ITD analysis on the samples analyzed. Both the preponderance of BZ #18 retention time data and BZ #18 identification verification by GC/ITD for most ITD-confirmed samples warrants inclusion of this principal congener in the database. Third, certain rejections due to retention time shifts were restored because validators noted that shifts were documented in associated QC samples, and thus, adjusted retention time windows could be used for accurate congener identification.

A.5 DATA USABILITY

A.5.1 Approach

Most previous studies of PCB chemistry in Hudson River sediments have focused on the concentration of specific Aroclors, total PCBs and/or the distribution of PCB homologues. The current assessment of PCB fate and distribution in the Hudson River required TAMS/Gradient scientists to implement sophisticated equilibrium chemistry and transport modeling studies requiring concentration ratios of certain PCB congeners. As noted previously (Section A.1), 12 target congeners are of particular importance. The usability of these 12 “principal” congeners is the focus of this low resolution sediment coring study data assessment.

Principal congeners will be employed in the following studies by the data users:

- Molar dechlorination product ratio (MDPR) - The molar sum of BZ #1, 4, 8, 10, and 19 are compared to the molar sum of all 126 congeners analyzed. This ratio is then compared to a similar index for Aroclor 1242 to assess, calculate, and evaluate the extent of dechlorination.

- Transport modeling - BZ #4, 28, 52, 101, and 138 are considered independently as compounds to model PCB transport.

- Aroclor 1016 and 1242 - BZ #18 is used to estimate the potential contribution of Aroclor 1016 and 1242 to Hudson River sediments.

- Aroclor 1254 - BZ #118 is used to estimate the potential contribution of Aroclor 1254 to Hudson River sediments.

- Aroclor 1260 - BZ #180 is used to estimate the potential contribution of Aroclor 1260 to Hudson River sediments.

Thus, 12 principal congeners (BZ #1, 4, 8, 10, 18, 19, 28, 52, 101, 118, 138, and 180) are the focus of this usability report. However, the remaining target and non-target congeners have important implications to the low resolution sediment coring study as well. TAMS/Gradient used these congeners to calculate the concentrations of total PCBs, PCB homologues, and Aroclor mixtures, as well as for congener pattern analysis.

A.5.2 Usability - General Issues

The data quality objectives for the Hudson River low resolution sediment coring study required the development of a sensitive program-specific gas chromatography method. Available standard agency methods were not adequate to achieve the congener-specific identifications and detection limits needed for the project. TAMS/Gradient based the method utilized on a modified NYSDEC ASP Method 91-11 (1989) protocol encompassing information published in the literature, as well as in-house research conducted by Aquatec. This research included Method Detection Limit (MDL) studies and Extraction Efficiency (EE) studies conducted in accordance with USEPA (1984, 1986) guidance. During the course of these studies, and the inception of the first study of the overall program (high resolution sediment coring); TAMS/Gradient and Aquatec noted various nuances to the methods that required refinement. As such, TAMS/Gradient and Aquatec made modifications to some of the original protocols. This section will discuss some of the more significant changes and ramifications of those changes.

- **Additional Calibrated Congeners**

Aquatec increased the number of PCB congeners contained in the calibration standards from the original 90 target congeners selected by TAMS/Gradient to include an additional 18 congeners, 12 of which are included in the 126 congeners utilized for the low resolution coring study. The 12 of these additional congeners which are utilized in the low resolution coring study are as follows: BZ#17, 20, 33, 42, 45, 74, 110, 135, 143, 156, 174, and 178. Aquatec selected these additional congeners for daily calibration due to their presence in Aroclor mixtures and potential significance for the ecological study. This change occurred before the analysis of the low resolution and ecological studies, but after analysis of the high resolution core, water column and transect studies. These 12 congeners are reported in all data sets. Use of the data for six additional calibrated non-target congeners (BZ#59, 72, 165, 168, 176, and 179) should be limited since they are not consistently quantitated for all data sets. Comparison of the concentrations of these congeners between the low resolution sediment coring study and the previous studies is not appropriate as the two methods of quantitation are not comparable; therefore, these six congeners are not included in the discussions of data in the low resolution report. None of these six additional congeners were selected as principal congeners, and therefore, the data analyses efforts should not be affected.

- **Identification of Non-Target Congeners**

At the beginning of the overall program, Aquatec identified non-target congeners based on historical relative retention times reported in the literature. In August 1993, Aquatec analyzed calibration standards for each of the non-target congeners. Using these additional calibration standards, Aquatec performed analyses to confirm historical relative retention times. Though these analyses verified a majority of the historical non-target congener relative retention times, some of the historical relative retention times used to identify non-target congeners did not match the relative retention times determined by the analyses of the non-target congener standards. At that time, TAMS/Gradient deleted 14 non-target congeners from the database for all analyses performed prior to August 1993 due to these unconfirmed identifications. The 14 non-target congeners deleted were: BZ #35, 39, 46, 100, 104, 130, 131, 132, 134, 162, 165, 173, 176, and 179. Aquatec identified and confirmed these 14 congeners based on the current laboratory-derived relative retention times for samples analyzed during and after August 1993, which includes all the low resolution sediment analyses. Therefore, the results for these 14 non-target congeners will remain in the database for all samples analyzed during and after August 1993; however, the data are not utilized in the low resolution coring study report and are not included in this data usability discussion. Use of these non-target congener data has been limited since they are not consistently available for all data sets. If a situation arises where information for the deleted non-target congeners is critical to a data user, an in-depth review of the chromatograms and re-calculation of the concentrations could potentially produce usable results for some of these congeners.

- **Quantitation of Non-Target Congeners**

The laboratory originally quantitated non-target congeners using the calibration curve determined for BZ#52. Since the non-target congener results were to be included in the calculations of homologue and total PCB mass, TAMS/Gradient desired a more accurate method of quantifying the non-target congeners. Aquatec analyzed calibration standards for the non-target congeners in September 1993, and again in April 1994, for the determination of congener-specific response factors. Based on this information, TAMS/Gradient calculated correction factors for each non-target congener and applied these to the laboratory data within the database (Bonvell, 1994b).

- **GC Column Change**

Initially, Aquatec used a HP-5 (or RTX-5) column and a SB-octyl-50 GC column for PCB congener analyses. In November 1993, Aquatec obtained new SB-octyl-50 columns for pending analyses of Phase 2 biological samples. Each of the new SB-octyl-50 columns showed signs of column degradation resulting in severe peak retention time shifts. Due to the concern that an acceptable SB-octyl-50 column would not be obtainable, TAMS/Gradient solicited approval from USEPA Region II for a replacement column, Apiezon_L. TAMS/Gradient was concerned about data comparability for the overall program, but had no alternative. USEPA Region II concurred with the replacement of the SB-octyl-50 column with the Apiezon_L column in December 1993. The Apiezon_L column was selected for the following reasons:

- The Apiezon_L column phase is similar to the SB-octyl-50 column phase.

- The Apiezon_L column provides PCB congener separations similar to the SB-octyl-50 column.

- The PCB congener retention times on the Apiezon_L column are more stable than on the SB-octyl-50 column.

- The NYSDEC analytical laboratory performing Hudson River PCB congener analyses was using the Apiezon_L column successfully for fish samples.

In February 1994, Aquatec performed a comparison study for the two column sets, HP-5/SB-octyl-50 and HP-5/Apiezon_L (Cook, 1994). Aquatec analyzed four Phase 2 pilot fish samples on both the HP-5/SB-octyl-50 column combination and also the RTX-5/Apiezon_L column combination. The PCB congener results compared well qualitatively and quantitatively with a few exceptions. The results for BZ #15 and 37 were consistently 2 to 10 times higher on the SB-octyl-50 column pair. Data users are cautioned that the results for BZ #15 and 37 reported through March 1994 and the same congeners reported after March 1994 are not comparable due to differences in the method of quantitation. For example, comparisons of sediment data between the high resolution sediment coring study and the low resolution sediment coring study are not appropriate for BZ #15 and 37. All of the low resolution sediment samples were collected and analyzed after March 1994.

- **Lower Column Concentration Bias**

The USEPA CLP protocol specifies that for dual column GC analyses, the lower of the two values from each column will be reported (USEPA, 1991). TAMS/Gradient incorporated this same quantitation scheme into this program. This quantitative method may introduce a slight low bias when calculating homologue and total PCB sums. TAMS/Gradient determined that this bias was usually negligible, and on a worst-case basis, may be as much as 2 to 10% low. Therefore, the data user should consider these totals as usable, but estimated values, due to the uncertainties of the individual results which are summed to form these values.

- **Surrogate Spike Compound**

At the inception of the high resolution sediment coring study, TAMS/Gradient and Aquatec employed two surrogates, tetrachloro-m-xylene (TCMX) and octachloronaphthalene (OCN). Aquatec noted, soon after the program began, that OCN recoveries were a problem. For many of the sediment samples, OCN recoveries were less than 10% and sometimes 0% although the TCMX and matrix spike/matrix spike duplicate results for these same samples were usually acceptable. Re-extraction and re-analysis of the same samples produced similar results. The purpose of surrogate spike analyses is to evaluate the performance of the extraction procedure. TAMS/Gradient and Aquatec determined that OCN was an inappropriate surrogate for this program. Research by Aquatec suggested that OCN was breaking down to heptachloronaphthalene and hexachloronaphthalene. This information was known before the analysis of the low resolution sediment coring samples and therefore BZ #192 was used as a surrogate compound as well. During the validation process, CDM did not, in general, reject data that had OCN recoveries below 10%, but when they did, the TAMS/Gradient Program QAO considered these results to be usable and changed the "R" qualifier (rejected data) to a "J" qualifier (estimated value) for any result which had been rejected solely due to poor OCN recoveries.

- **Confirmation by GC/ITD**

Aquatec analyzed approximately 10% of all samples analyzed by GC/ECD by GC/ITD to provide an additional mechanism to verify congener identification and, as a secondary objective, quantitation of congeners. The ITD is not as sensitive as the ECD (approximately an order of magnitude less sensitive); therefore, when possible, samples with the highest concentration of PCBs were selected for GC/ITD confirmation. Although this may result in a program bias for only confirming high concentration samples, the overall effect does not impair data usability.

One unanticipated effect of selecting high concentration samples is that they were often diluted for the GC/ECD analysis to a greater extent than the GC/ITD analysis. Consequently, the sample-specific quantitation limit for the GC/ECD was often greater than that of the GC/ITD analysis. In some cases, congeners were detected by the GC/ITD at concentrations less than the GC/ECD quantitation limit and thus were not detected by the GC/ECD analysis. CDM qualified such congeners with “M” during data validation, even though, the results from the two analyses were consistent. TAMS/Gradient converted 46 of the “M” qualifiers which met this criterion to “UJ”.

In addition, there is the potential for some quantitative bias associated with the GC/ITD results relative to the GE/ECD results. Aquatec quantified each congener detected in the GC/ITD analysis using an average response factor for each level of chlorination (*i.e*., homologue group) rather than using response factors determined specifically for each individual congener. As such, potential bias, which will vary for each congener within a chlorination homologue group, is present with the GC/ITD results.

A.5.3 Usability - Accuracy, Precision, Representativeness, and Sensitivity

TAMS/Gradient established a quality assurance system for this program to monitor and evaluate the accuracy, precision, representativeness, and sensitivity of the results relative to the data quality objectives. These are all important elements in evaluating data usability (*e.g.,* USEPA, 1992b, 1993). Accuracy is a measure of how a result compares to a true value. Precision indicates the reproducibility of generating a value. Representativeness is the degree to which a measurement(s) is indicative of the characteristics of a larger population. Sensitivity is the limit of detection of the analytical method.

This section will evaluate each of these parameters for the low resolution sediment coring study. TAMS/Gradient assessed accuracy using holding times, instrument performance and calibrations for both the GC/ECD and GC/ITD, internal standard performance for the GC/ITD, surrogate criteria for both the GC/ECD and GC/ITD, spike recoveries, matrix spike/matrix spike duplicate recovery results, and compared identification results. TAMS/Gradient assessed precision by comparing matrix spike and matrix spike duplicate results. TAMS/Gradient evaluated representativeness by comparing field duplicate results, and assessed sensitivity using blank results and the sample-specific quantitation limits achieved.

Comparability and completeness are two other important data quality attributes. Comparability expresses the confidence with which data are considered to be equivalent to other data sets (USEPA, 1992b). Comparable data allowed for the ability to combine the analytical results obtained from this study with previous Hudson River studies. An in-depth discussion of data comparability was provided in Chapter 3 of the report on the high resolution sediment coring program. In addition, Gauthier (1994) has provided Aroclor translation procedures for Hudson River capillary column GC data relative to previous packed column GC studies. Completeness is a measure of the amount of usable data resulting from a data collection activity (USEPA, 1992b). For this program, a 95% completeness goal was established. A discussion of completeness for the low resolution sediment coring study is provided in the conclusions section of this report.

A.5.3.1 Accuracy

- **Holding Times**

Exceedance of holding times may indicate a possible loss of PCB congeners due to volatilization, chemical reactions, and/or biological alterations. Due to the persistent nature of PCBs, only severe exceedance should be considered deleterious to quantitative accuracy. For the sediment samples, TAMS/Gradient established an extraction holding time of 7 days from sampling, followed by an analysis holding time of 40 days from extraction.

Aquatec missed the extraction holding times for four sediment samples and four sediment sample re-extractions by 2 to 22 days and 72 to 90 days, respectively. Aquatec missed the analytical holding times for 10 primary sample analyses and 6 dilution analyses by 16 to 62 days. CDM appropriately qualified as associated results for these samples as estimated. Aquatec has routinely demonstrated the stability of all PCB congener standards in solvent is at least six months. The TAMS/Gradient Program QAO considered all data qualified as estimated due to analytical holding time violations to be usable as estimated values.

- **GC/ECD Instrument Performance**

Adequate chromatographic resolution and retention time stability throughout an analytical sequence are essential attributes for qualitative identification of congeners on a GC. TAMS/Gradient defined criteria for congener resolution and retention time windows in the Phase 2A SAP/QAPP and these were applied to the low resolution sediment coring program. The data validation reports appropriately noted exceedances according to these criteria and qualified the data affected data as estimated. There were few qualifications based on resolution or retention time windows exceedances. Aquatec initially established retention time windows for both columns at ± 0.3% relative to the average initial calibration retention times for all target congeners and surrogates. For data validation purposes, EPA Region II agreed to allow expanded retention time windows of ±0.5%

- **GC/ECD Calibration**

Instrument calibration requirements were established to verify the production of acceptable quantitative data. Initial calibrations (IC) using 5-level standard concentration curves demonstrate an instrument is capable of acceptable performance prior to sample analysis. The IC criteria is 20% relative standard concentration error (%RSCE) for monochlorobiphenyl and 15% RSCE for all remaining PCB congeners, as well as a correlation coefficient $\geq$ 0.995. Continuing calibration standards document maintenance of satisfactory performance over time. The data validation reports appropriately noted any deviation from these criteria. Deviations from the criteria were not significant. TAMS/Gradient noted no significant continuing calibration problems.

- **Surrogate Spike Recoveries**

Aquatec spiked surrogate compounds into all sediment samples prior to extraction to monitor recoveries. Recoveries may be indicative of either laboratory performance or sample matrix effects. For the low resolution sediment coring study, Aquatec used TCMX, OCN, and BZ #192 as surrogates. As previously discussed, OCN did not perform properly as a representative surrogate, therefore, only TCMX and BZ #192 recoveries provided useful information. The TAMS/Gradient Program QAO considered data which had been rejected solely because of poor OCN recoveries to be usable as estimated values. Data was restored to usable status for six sediment samples including 39B0008, 39D0814, 39F1222, 10C0009, 10D0009, and 11A1019.

- **Matrix Spike/Matrix Spike Duplicate Recoveries**

Within each SDG, two aliquots of a representative sediment sample were spiked with a suite of 20 congeners (BZ #8, 18, 28, 44, 52, 66, 77, 101, 105, 118, 126, 128, 138, 153, 170, 180, 187, 195, 206, and 209). The purpose of the spikes were, in part, to evaluate the accuracy of the analytical method relative to laboratory performance and specific sample matrix. The advisory limits for spiked congener recoveries are 60-150%. TAMS/Gradient noted no significant spike recovery problems for the low resolution sediment cores. Matrix spike/matrix spike duplicate analyses were analyzed for 22 low resolution sediment core samples. This represents a frequency of 5.9%, which exceeds the 5% requirement stipulated in Phase 2B SAP/QAPP.

- **Compound Identification**

TAMS/Gradient established qualitative criteria to minimize erroneous identification of congeners. An erroneous identification can be either a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present). The calculated concentrations for congeners detected in both columns should not differ by more than 25% between columns (%D $\leq$ 25%). This criterion applies to only those congeners which can be resolved as individual congeners on both columns. If the %D for the results between the two columns is > 25% but $\leq$50%, the results were estimated. If the %D was > 50% but $\leq$ 90%, the results were estimated and presumptively present (GN). If the %D between columns was > 90%, the results were unusable (R).

TAMS/Gradient noted problems with congener identifications as a result of dual column imprecision for numerous SDGs. The majority of the estimated and rejected data for the low resolution sediment coring study were a result of dual GC column imprecision. CDM qualified the following congeners as rejected at frequencies greater than 10% as a result of dual column imprecision: BZ #2 (14%), BZ #3 (23%), BZ #12 (19%), BZ #137 (14%), and BZ #194 (10%). With the level of background organic material present in Hudson sediments, resultant interferences, particularly for congeners with low concentrations, likely caused these differences between the dual GC column results.

As previously mentioned, the QAO restored BZ #18 data had been rejected because of dual column imprecision. This change was made for 67 samples. The QAO based this decision on the routine presence of BZ #18 in Hudson River sediments, the consistent PCB congener pattern distribution present throughout the sediments, and the confirmation of the presence and concentration of BZ #18 by the GC/ITD analysis of the samples so analyzed. This treatment of the data is consistent with the approach taken in the high resolution sediment coring study.

- **GC/ITD Instrument Performance**

Verifying proper GC/ITD performance required evaluating GC column resolution, ion trap detector sensitivity, and ion trap calibration. The GC resolution criteria required baseline separation of BZ #87 from BZ #154 and BZ #77. The ion trap sensitivity requires the signal/noise ratio to be m/z 499 for BZ #209 and m/z 241 for chrysene-d_{12} to be greater than 5. For ion trap calibration, the abundance of m/z 500 relative to m/z 498 for BZ #209 must be $\geq$ 70% but $\leq$95%. CDM appropriately qualified GC/ITD exceedances of these parameters during validation. The criteria were met and the GC/ITD results were useful in confirming GC/ECD results. In general, TAMS/Gradient noted no significant ITD performance problems for samples analyzed during the low resolution sediment coring study.

- **GC/ITD Calibration**

The initial calibration criteria for acceptable quantitative data for GC/ITD analyses required percent relative standard deviations (% RSD) of the congener relative response factor (RRF) to be less than 20%. For continuing calibration, the RRF for each congener must be within 20% of the mean calibration factor from the 5-level calibration at the beginning and end of each calibration sequence. For the low resolution sediment coring study, TAMS/Gradient noted no significant GC/ITD calibration problems.

- **GC/ITD Internal Standard Performance**

To demonstrate the stability of the ITD, internal standard performance criteria were monitored. Internal standard area counts must not vary by more than 30% from the most recent calibration or by more than 50% from the initial calibration. In addition, the absolute retention time of the internal standard must be within 10 seconds of the retention time in the most recent calibration, and ion abundance criteria must be met for chrysene-d_{12} and phenanthrene-d_{10}. For the low resolution sediment coring study, TAMS/Gradient noted no significant internal standard problems.

- **Confirmation by GC/ITD**

CDM qualified all positive GC/ITD results that had signal/noise ratios of less than 3 as not detected due to uncertainty in the identification. TAMS/Gradient considered these results to be usable as undetected data at the reported quantitation limits.

Aquatec analyzed approximately 10% of all samples analyzed by GC/ECD by GC/ITD to provide an additional mechanism to verify congener identification and, as a secondary objective, quantitation of congeners. Since the ITD method was not designed to be a primary quantitative tool, some variations in quantitative results were expected. TAMS/Gradient considered quantitative differences between the GC/ITD and GC/ECD results less than a factor of five to be acceptable, while differences greater than five times were considered unacceptable. CDM qualified GC/ECD results that were detected at concentrations above the GC/ITD quantitation limit but that were not confirmed by GC/ITD with a “Q”. TAMS/Gradient converted all “Q” qualifiers to “JN” due to the potential of reporting false positive results. CDM qualified 47 sediment results with “Q” qualifiers (of which one was a principal congener); TAMS/Gradient considered these results to indicate the presumptive presence of the affected congener. CDM qualified GC/ECD results that were not detected or were less than one-fifth the GC/ITD results with an “M”. TAMS/Gradient converted these “M” qualifiers to “R” as the nondetect GC/ECD may be a false negative or the GC/ECD result may be significantly biased low. Of the 458 sediment results which CDM qualified with “M” (of which 21 were principal congeners); TAMS/Gradient considered 412 of these results to be unusable. As noted previously (Section A.5.2), the other 46

"M" qualified data points were changed to "UJ".

A.5.3.2 Precision

- **Matrix Spike/Matrix Spike Duplicate Comparison**

The analysis of matrix spike (MS) and matrix spike duplicate (MSD) samples can also provide valuable information regarding method precision relative to laboratory performance and specific sample matrix. The advisory limit for relative percent difference (RPD) of spiked congeners in a MS/MSD pair is 40%, and for nonspiked congeners, the precision criterion is 40% Relative Standard Deviation (RSD).

Overall, the MS/MSD performance for the low resolution sediment coring study was good.

A.5.3.3 Representativeness

- **Field Duplicate Results**

Analysis of field duplicate samples provides an indication of the overall precision of the sampling and analysis program. These analyses measure both field and laboratory precision; therefore, the results will likely have more variability than laboratory duplicates and MS/MSD samples, which only measure laboratory precision. Data validators used a 50% RPD criterion for evaluating field duplicate precision. Any congener precision greater than 50% RPD was qualified as estimated ("J").

A total of 21 field duplicate samples were analyzed for the low resolution sediment coring study. This represents a frequency of 5.7%, which exceeds the 5% requirement stipulated in the Phase 2B SAP/QAPP. Overall, field duplicate precision was acceptable; especially in the context of river sediments, which are typically heterogeneous. Table A-3 summarizes the duplicate precision results for the 12 principal congeners for each field co-located sample. Typically a few congeners for each pair of co-located sediments exceeded the precision criterion. CDM appropriately qualified the results for these results as estimated. TAMS/Gradient considered these data to be usable as estimated values.

A.5.3.4 Sensitivity

- **Blanks**

An important data quality objective associated with the low resolution sediment coring study was to obtain detection limits as low as the analytical method could produce. Due to the low detection limits achieved, low concentration blank contamination was detected during the preparation and analysis of the sediments. As a result, numerous congeners in all samples in all SDGs required qualification due to blank contamination. TAMS/Gradient reviewed the distribution of blank contaminants and found most contamination associated with the monochlorobiphenyls, particularly with BZ #2. Blank levels for BZ #2 usually ranged from 20 to 80 ppb in extract. Since BZ #2 is not a dechlorination product, a major Aroclor component, or a principal congener, TAMS/Gradient did not consider this to be a serious data quality problem. CDM qualified principal congeners in several samples due to blank contamination including: BZ #1 (15 results); BZ #4 (10 results); BZ #8 (8 results); BZ #10 (30 results); BZ #18 (14 results); BZ #19 (9 results); BZ #28 (11 results); BZ #52 (9 results); BZ #101 with BZ #90 (3 results); BZ #118 (16 results); BZ #138 (3 results); and BZ #180 (9 results). TAMS/Gradient considered these results to be usable as non-detects.

CDM qualified results during data validations with a “B”, which indicated that the result was within 5 times of the blank action level (*i.e.*, the highest concentration in a blank associated with that sample result). TAMS/Gradient converted all “B” qualified results in the database to nondetect results due to uncertainty in this detection. Table A-4 summarizes the congener detects changed to non-detects for the sediment samples. TAMS/Gradient considered these results to be usable as non-detects at the reported quantitation limit.

- **Quantitation Limits**

Evaluating dechlorination processes and modeling transport pathways of PCB congeners in sediments necessitated obtaining low detection limits. TAMS/Gradient and Aquatec devised analytical methods to enhance lower detection limits. This, in part, required employing sample/extract cleanup methods to remove matrix interferences, and maximizing sample size when possible. For the low resolution coring study, TAMS/Gradient defined optimum detection limits as 1 μg/kg for monochlorobiphenyls, 0.5 μg/kg for dichlorobiphenyls through hexachlorobiphenyls, and 0.5-1 μg/kg for heptachlorobiphenyls through decachlorobiphenyl. Results of the MDL study necessitated raising the detection limit for BZ #2 (a monochlorobiphenyl) significantly above these requirements (approximately a factor of 3).

In general, achieving appropriate detection limits for the sediment samples was not a problem. Whenever TAMS/Gradient noted elevated detection limits, the affected samples contained high organic content; specifically, the presence of PCBs. The relative ratio of congeners detected within each high-concentration sample remained reasonably consistent, therefore the elevated detection limit for non-detected congeners did not affect data usability.

A.5.4 Usability - Principal Congeners

The 12 principal target congeners employed in the high resolution sediment coring study are key to delineating PCB geochemistry in the Hudson River. The following synopsis will provide data users with the strengths and weaknesses of the principal target congener data within the context of this study:

BZ #1. The reported results for BZ #1 met the data quality objectives of the program. Results for BZ #1 in 10 sediment samples were rejected (out of 371 samples) based on quality control exceedances. Analytically, BZ #1 eluted as a single peak on both GC columns. Detection limits for BZ #1, a monochlorobiphenyl, were generally 1 to 6 ppb, which were acceptable.

BZ #4. All reported results for BZ #4 met the data quality objectives of the program and are usable for project decisions. Analytically, BZ #4 eluted as a single peak on one GC column, and coeluted with BZ #10, another principal congener, on the other GC column. Data for both BZ #4 and BZ #10 were considered usable. With regard to detection limits, a goal of 0.5 ppb was established. In general, this goal was met, however, there were many samples with associated blank levels of 10 to 20 ppb of BZ #4 in the extract, which required raising the detection limit. This did not affect data usability.

BZ #8. All reported results for BZ #8 met the data quality objective of the program and are usable for project decisions. Analytically, BZ #8 eluted as a single peak on one GC column and coeluted with BZ #5 on the other GC column, which was acceptable for the purposes of this program. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #8 further indicated that the method was successful.

BZ #10. The usability assessment for BZ #10 is similar to that for BZ #4. BZ #10 eluted as a single peak on one GC column and coeluted with BZ #4 on the other GC column. All results that were reported for both BZ #4 and BZ #10 were considered usable. In general, the detection limit goal of 0.5 ppb was met.

BZ #18. Numerous results for BZ #18 were initially rejected by the data validator due to poor dual column precision. The TAMS/Gradient Program QAO changed the rejection qualifier to a presumptively present qualifier based on the presence of BZ #18 in historical sediment samples containing PCBs, the consistent PCB congener pattern distribution present throughout the Hudson River sediment, and GC/ITD confirmational analysis on about 10% of the data. Detailed review of the affected BZ#18 data suggested an interferant causing the high %D values. Analytically, BZ #18 eluted as a single peak on both GC columns. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #18 further indicated that the method was successful. As such, all reported results for BZ #18 met the data quality objectives of the program.

BZ #19. All reported results for BZ #19 met the data quality objectives of the program. Analytically, BZ #19 eluted as a single peak on one GC column and coeluted on the other. The detection limit goal of 0.5 ppb was met for nearly all samples.

BZ #28. The reported results for BZ #28 met the data quality objectives of the program. The BZ #28 result for one sediment samples was rejected due to dual GC column imprecision. Analytically, BZ #28 eluted as a single congener peak on both GC columns. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #28 further indicates the method was successful.

BZ #52. All reported results for BZ #52 met the data quality objectives of the program and are usable for project decisions. Analytically, BZ #52 eluted as a single congener peak on both GC columns. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike recovery for BZ #52 further indicated that the method was successful.

BZ #101. Data users should be aware that BZ #101 always coeluted with BZ #90 (on both GC columns), and therefore was always reported with BZ #90. For all reported results, all other QA/QC requirements were met, and therefore, these results are usable for project decisions. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #101 further indicated that the method was successful.

BZ #118. The reported results for BZ #118 met the data quality objectives of the program in most samples. BZ #118 results in 9 sediment samples were rejected due to dual column imprecision. Analytically, BZ #118 eluted as a single peak on one GC columns and coeluted with BZ #122 on the other GC column. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #118 further indicated that the method was successful.

BZ #138. The reported results for BZ #138 met the data quality objectives of the program for most samples. BZ #138 results in 11 sediment samples were rejected due to dual column imprecision. Analytically, BZ #138 eluted as a single peak on one GC column and coeluted on the other GC column. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #138 further indicated that the method was successful.

BZ #180. The reported (valid) results for BZ #180 met the data quality objectives of the program. BZ #180 results in 32 sediment samples were rejected due to dual column imprecision.The 32 rejections (8.6%) exceeds the 5% unusable data DQO (data is less than 95% complete), so the completeness objective was not met for BZ#180. Analytically, BZ #180 eluted as a single peak on both GC columns. The detection limit goal of 0.5 ppb was met for nearly all samples. Matrix spike results for BZ #180 further indicated that the method was successful.

Typically, rejection of parameters occurred randomly. In no single sample were all principal target parameters rejected. Rejection of one or more parameters does not signify rejection of the entire sample or the entire core. Total PCB and total tri and higher chlorinated congeners was calculated for each sample despite rejected parameters, because the contribution of mass for a single congener to the total PCB mass in a sample is small (approximately 1-2%) for the majority of samples.

A.6 CONCLUSIONS

The analytical chemistry program implemented by TAMS/Gradient for the Hudson River low resolution sediment coring study was extremely sophisticated, requiring the use of state-of-the-art GC methodology. Data for 126 congeners were utilized from a total of 371 sediment samples analyzed (excluding 21 field duplicate samples). (The low resolution database also contains data for an additional 20 non-target congeners which were not used in the low resolution sediment coring study report.) Considering the complexity of the program, TAMS/Gradient considers the outcome of the analytical chemistry program to have been successful.

A summary of the number of qualifiers applied to each PCB congener is tabulated in Table A-5. For the low resolution sediment coring study, 46,375 congener measurements were recorded, of which 1,228 values were rejected. Congeners most often rejected include BZ #2 (14%), BZ #3 (23%), BZ #12 (19%), BZ #137 (14%) and BZ #194 (10%). The reason for most of these rejections was the imprecision between the GC columns. A 97.4% overall completeness rate was achieved for the low resolution sediment coring analytical program, which successfully exceeded the 95% completeness objective. The only principal congener which did not meet the completeness objective was BZ #180 (91% completeness), however, this did not impair the overall integrity of the program.

A majority (54%) of all congener results (both detects and nondetects) were qualified as estimated or as estimated and presumptively present. Again, the main reason for most of the qualifications was detection at concentrations below the calibrated quantitation limit and/or exceedance in the dual GC column precision criteria. Numerous congeners for nearly all SDGs had calculated concentrations on each GC column which differed by more than 25%, but less than 50%, which warranted qualification as estimated values. With the level of background organic material present in Hudson sediments, resultant interferences, particularly for congeners with low concentrations, likely caused these differences between the GC columns. Other problems contributing to data qualification included missed holding times, and some GC/ECD calibration criteria exceedances. Data users should consider all detect and non-detected results which were estimated to be usable relative to the data quality objectives of the program.

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Table A-1
List of 126 Phase 2 Target and Non-Target PCB Congeners Used in Low Resolution Sediment Coring Study Report

Congener Number	Homologue Group	Congener Name	Target Congener [a]
BZ #1	Mono	2-Chlorobiphenyl	Yes
BZ #2	Mono	3-Chlorobiphenyl	Yes
BZ #3	Mono	4-Chlorobiphenyl	Yes
BZ #4	Di	2,2'-Dichlorobiphenyl	Yes
BZ #5	Di	2,3-Dichlorobiphenyl	Yes
BZ #6	Di	2,3'-Dichlorobiphenyl	Yes
BZ #7	Di	2,4-Dichlorobiphenyl	Yes
BZ #8	Di	2,4'-Dichlorobiphenyl	Yes
BZ #9	Di	2,5-Dichlorobiphenyl	Yes
BZ #10	Di	2,6-Dichlorobiphenyl	Yes
BZ #12	Di	3,4-Dichlorobiphenyl	Yes
BZ #15	Di	4,4'-Dichlorobiphenyl	Yes
BZ #16	Tri	2,2',3-Trichlorobiphenyl	Yes
BZ #17	Tri	2,2',4-Trichlorobiphenyl	No - Cal
BZ #18	Tri	2,2',5-Trichlorobiphenyl	Yes
BZ #19	Tri	2,2',6-Trichlorobiphenyl	Yes
BZ #20	Tri	2,3,3'-Trichlorobiphenyl	No - Cal
BZ #22	Tri	2,3,4'-Trichlorobiphenyl	Yes
BZ #23	Tri	2,3,5-Trichlorobiphenyl	No
BZ #24	Tri	2,3,6-Trichlorobiphenyl	No
BZ #25	Tri	2,3',4-Trichlorobiphenyl	Yes
BZ #26	Tri	2,3',5-Trichlorobiphenyl	Yes
BZ #27	Tri	2,3',6-Trichlorobiphenyl	Yes
BZ #28	Tri	2,4,4'-Trichlorobiphenyl	Yes
BZ #29	Tri	2,4,5-Trichlorobiphenyl	Yes
BZ #31	Tri	2,4',5-Trichlorobiphenyl	Yes
BZ #32	Tri	2,4',6-Trichlorobiphenyl	No
BZ #33	Tri	2',3,4-Trichlorobiphenyl	No - Cal
BZ #34	Tri	2',3,5-Trichlorobiphenyl	No
BZ #37	Tri	3,4,4'-Trichlorobiphenyl	Yes
BZ #40	Tetra	2,2',3,3'-Tetrachlorobiphenyl	Yes
BZ #41	Tetra	2,2',3,4-Tetrachlorobiphenyl	Yes
BZ #42	Tetra	2,2',3,4'-Tetrachlorobiphenyl	No - Cal
BZ #44	Tetra	2,2',3,5'-Tetrachlorobiphenyl	Yes
BZ #45	Tetra	2,2',3,6-Tetrachlorobiphenyl	No - Cal
BZ #47	Tetra	2,2',4,4'-Tetrachlorobiphenyl	Yes
BZ #48	Tetra	2,2',4,5-Tetrachlorobiphenyl	No
BZ #49	Tetra	2,2',4,5'-Tetrachlorobiphenyl	Yes
BZ #51	Tetra	2,2',4,6'-Tetrachlorobiphenyl	No

TABLE A-1 (continued)

BZ #52	Tetra	2,2',5,5'-Tetrachlorobiphenyl	Yes
BZ #53	Tetra	2,2',5,6'-Tetrachlorobiphenyl	Yes
BZ #56	Tetra	2,3,3',4'-Tetrachlorobiphenyl	Yes
BZ #58	Tetra	2,3,3',5'-Tetrachlorobiphenyl	No
BZ #60	Tetra	2,3,4,4'-Tetrachlorobiphenyl	No
BZ #63	Tetra	2,3,4',5-Tetrachlorobiphenyl	No
BZ #64	Tetra	2,3,4',6-Tetrachlorobiphenyl	No
BZ #66	Tetra	2,3',4,4'-Tetrachlorobiphenyl	Yes
BZ #67	Tetra	2,3',4,5-Tetrachlorobiphenyl	No
BZ #69	Tetra	2,3',4,6-Tetrachlorobiphenyl	No
BZ #70	Tetra	2,3',4',5-Tetrachlorobiphenyl	Yes
BZ #74	Tetra	2,4,4',5-Tetrachlorobiphenyl	No - Cal
BZ #75	Tetra	2,4,4',6-Tetrachlorobiphenyl	Yes
BZ #77	Tetra	3,3',4,4'-Tetrachlorobiphenyl	Yes
BZ #82	Penta	2,2',3,3',4-Pentachlorobiphenyl	Yes
BZ #83	Penta	2,2',3,3',5-Pentachlorobiphenyl	Yes
BZ #84	Penta	2,2',3,3',6-Pentachlorobiphenyl	Yes
BZ #85	Penta	2,2',3,4,4'-Pentachlorobiphenyl	Yes
BZ #87	Penta	2,2',3,4,5'-Pentachlorobiphenyl	Yes
BZ #90 (w/BZ#101)	Penta	2,2',3,4',5-Pentachlorobiphenyl	No
BZ #91	Penta	2,2',3,4',6-Pentachlorobiphenyl	Yes
BZ #92	Penta	2,2',3,5,5'-Pentachlorobiphenyl	Yes
BZ #95	Penta	2,2',3,5',6-Pentachlorobiphenyl	Yes
BZ #96	Penta	2,2',3,6,6'-Pentachlorobiphenyl	No
BZ #97	Penta	2,2',3',4,5-Pentachlorobiphenyl	Yes
BZ #99	Penta	2,2',4,4',5-Pentachlorobiphenyl	Yes
BZ #101(w/BZ#90)	Penta	2,2',4,5,5'-Pentachlorobiphenyl	Yes
BZ #105	Penta	2,3,3',4,4'-Pentachlorobiphenyl	Yes
BZ #107	Penta	2,3,3',4,5'-Pentachlorobiphenyl	Yes
BZ #110	Penta	2,3,3',4',6-Pentachlorobiphenyl	No - Cal
BZ #114	Penta	2,3,4,4',5-Pentachlorobiphenyl	No
BZ #115	Penta	2,3,4,4',6-Pentachlorobiphenyl	Yes
BZ #118	Penta	2,3',4,4',5-Pentachlorobiphenyl	Yes
BZ #119	Penta	2,3',4,4',6-Pentachlorobiphenyl	Yes
BZ #122	Penta	2',3,3',4,5-Pentachlorobiphenyl	Yes
BZ #123	Penta	2',3,4,4',5-Pentachlorobiphenyl	Yes
BZ #126	Penta	3,3',4,4',5-Pentachlorobiphenyl	Yes
BZ #128	Hexa	2,2',3,3',4,4'-Hexachlorobiphenyl	Yes
BZ #129	Hexa	2,2',3,3',4,5-Hexachlorobiphenyl	Yes
BZ #135	Hexa	2,2',3,3',5,6'-Hexachlorobiphenyl	No - Cal
BZ #136	Hexa	2,2',3,3',6,6'-Hexachlorobiphenyl	Yes
BZ #137	Hexa	2,2',3,4,4',5-Hexachlorobiphenyl	Yes
BZ #138	Hexa	2,2',3,4,4',5'-Hexachlorobiphenyl	Yes
BZ #140	Hexa	2,2',3,4,4',6'-Hexachlorobiphenyl	No
BZ #141	Hexa	2,2',3,4,5,5'-Hexachlorobiphenyl	Yes
BZ #143	Hexa	2,2',3,4,5,6-Hexachlorobiphenyl	No - Cal
BZ #144	Hexa	2,2',3,4,5',6-Hexachlorobiphenyl	No
BZ #146	Hexa	2,2',3,4',5,5'-Hexachlorobiphenyl	No
BZ #149	Hexa	2,2',3,4',5',6-Hexachlorobiphenyl	Yes
BZ #151	Hexa	2,2',3,5,5',6-Hexachlorobiphenyl	Yes

TABLE A-1 (continued)

BZ #153	Hexa	2,2',4,4',5,5'-Hexachlorobiphenyl	Yes
BZ #156	Hexa	2,3,3',4,4',5-Hexachlorobiphenyl	No - Cal
BZ #157	Hexa	2,3,3',4,4',5'-Hexachlorobiphenyl	Yes
BZ #158	Hexa	2,3,3',4,4',6-Hexachlorobiphenyl	Yes
	Hexa	2,3',4,4',5,5'-Hexachlorobiphenyl	Yes
BZ #167	Hexa	3,3',4,4',5,5'-Hexachlorobiphenyl	No
BZ #169	Hepta	2,2',3,3',4,4',5-Heptachlorobiphenyl	Yes
BZ #170	Hepta	2,2',3,3',4,4',6-Heptachlorobiphenyl	Yes
BZ #171			
BZ #172	Hepta	2,2',3,3',4,5,5'-Heptachlorobiphenyl	No
BZ #174	Hepta	2,2',3,3',4,5,6'-Heptachlorobiphenyl	No - Cal
BZ #175	Hepta	2,2',3,3',4,5',6-Heptachlorobiphenyl	No
BZ #177	Hepta	2,2',3,3',4',5,6-Heptachlorobiphenyl	Yes
BZ #178	Hepta	2,2',3,3',5,5',6-Heptachlorobiphenyl	No - Cal
BZ #180	Hepta	2,2',3,4,4',5,5'-Heptachlorobiphenyl	Yes
BZ #183	Hepta	2,2',3,4,4',5',6-Heptachlorobiphenyl	Yes
BZ #184	Hepta	2,2',3,4,4',6,6'-Heptachlorobiphenyl	No
BZ #185	Hepta	2,2',3,4,5,5',6-Heptachlorobiphenyl	Yes
BZ #187	Hepta	2,2',3,4',5,5',6-Heptachlorobiphenyl	Yes
BZ #189	Hepta	2,3,3',4,4',5,5'-Heptachlorobiphenyl	Yes
BZ #190	Hepta	2,3,3',4,4',5,6-Heptachlorobiphenyl	Yes
BZ #191	Hepta	2,3,3',4,4',5',6-Heptachlorobiphenyl	Yes
BZ #193	Hepta	2,3,3',4',5,5',6-Heptachlorobiphenyl	Yes
BZ #194	Octa	2,2',3,3',4,4',5,5'-Octachlorobiphenyl	Yes
BZ #195	Octa	2,2',3,3',4,4',5,6-Octachlorobiphenyl	Yes
BZ #196	Octa	2,2',3,3',4,4',5',6-Octachlorobiphenyl	Yes
BZ #197	Octa	2,2',3,3',4,4',6,6'-Octachlorobiphenyl	No
BZ #198	Octa	2,2',3,3',4,5,5',6-Octachlorobiphenyl	Yes
BZ #199	Octa	2,2',3,3',4,5,6,6'-Octachlorobiphenyl	Yes
BZ #200	Octa	2,2',3,3',4,5',6,6'-Octachlorobiphenyl	Yes
BZ #201	Octa	2,2',3,3',4',5,5',6-Octachlorobiphenyl	Yes
BZ #202	Octa	2,2',3,3',5,5',6,6'-Octachlorobiphenyl	Yes
BZ #203	Octa	2,2',3,4,4',5,5',6-Octachlorobiphenyl	No
BZ #205	Octa	2,3,3',4,4',5,5',6-Octachlorobiphenyl	Yes
BZ #206	Nona	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	Yes
BZ #207	Nona	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl	Yes
BZ #208	Nona	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl	Yes
BZ #209	Deca	2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	Yes

TABLE A-1 (continued)

Homologue Group	Congener Ratio[b]
Mono	3:3
Di	9:12
Tri	18:24
Tetra	23:42
Penta	23:46
Hexa	19:42
Hepta	16:24
Octa	11:12
Nona	3:3
Deca	1:1
Sum	126:209

Notes: [a]*Yes: Target; No: Non-target; No - Cal: Calibrated non-target.*

[b]*Ratio of number of congeners used to total number of congeners in homologue group.*

Table A-2
Data Qualification Codes

Source of Qualifier	Definition of Qualifier Code	Data Validation/ Assessment Qualifier Code	Database Qualifier Code
Laboratory	Compound not detected above reporting limit of 0.1 ppb in extract for all PCB congeners (0.5 ppb in extract for the monochlorinated biphenyls). The reported value is the quantitation limit (QL).	U	U
Laboratory	Compound detected above reporting limit, but below calibration range. This qualifier is applied to any positive result that is less than the lowest calibration standard. The reported result is an estimated value, due to uncertainty in the reported value near the quantitation limit.	J	J
Laboratory	Compound concentration exceeds the calibration range. This qualifier is applied to any positive result that exceeds the calibration range. The laboratory may report some congeners with concentrations up to twice the concentration in the highest calibration standard, in order to report some very low concentrations and low quantitation limits. The reported result is an estimated value, due to uncertainty in the quantitation above the calibrated range of the instrument.	E	J
Laboratory	Specific column result used for quantitation due to confirmation column coelution. This qualifier designates congeners whose results are always quantitated from a specific column due to coelution with congeners or surrogates on the other column. The reported result should be considered an estimated value, due to inability to confirm the concentration of the result because of coelution on the other column. The S qualifier precludes the P qualifier since a %Difference (%D) between columns is excepted to be greater than 25% due to coelution on one column.	S	J
Laboratory	Tentative identification, specific column result used with no confirmation information. This qualifier designates congeners which could not be confirmed due to an interferant (or surrogate) peak, however, there is good reason to believe its presence. The reported value should be considered an estimated value, due to inability to confirm reported concentrations.	T	JN
Laboratory	Estimated concentration due to coelution on both columns. This qualifier designates congeners which coelute with congeners or surrogates on both analytical columns. In order to report a concentration for the congener of interest, the concentrations of the coeluting congeners are subtracted from it. Therefore, the reported result is an estimated value.	X	J
Laboratory	Confirmation column result exceeds reported result by more than 25%.	P	J

Table A-2 (Continued)
Data Qualification Codes

	This qualifier is applied to a congener result if the concentration on the quantitation and confirmation columns exceed the percent difference (%D) criteria of 25. The reported result is an estimated value, due to poor precision of results between columns.		
Laboratory	Specific column or estimated result exceeds confirmation result by more than 25% despite expected confirmation coelution. This qualifier is applied to a congener result if the result from the quantitation column exceeds the confirmation result by more than 25 %D, even though the confirmation column result was expected to be greater due to coelution on the confirmation column. Therefore, the reported result should be considered an estimated value, bias high.	H	J
Data Validation	Estimated data due to exceeded quality control criteria. This qualifier is applied to data if problems with data quality are noted and estimation of the data is deemed necessary. Justification for qualification are given in the data validation report.	G	J
Data Validation	Reject data due to exceeded quality control criteria. This qualifier is applied to data if serious problems with data quality are noted and rejection of the data is deemed necessary. Justification for rejection of data are given in the data validation report. Rejected data are not usable and do not meet the data quality objectives of the program. No numerical value is reported.	R	R
Data Validation	The compound was also detected in associated blank(s). This qualifier is applied to GC/ECD results that are within five times the concentration detected in the associated blanks. The reported result may be considered not detected; a false positive is suspected due to blank contamination.	B	U
Data Validation	GC/ECD result at concentration within GC/ITD calibration range, but not confirmed by GC/ITD analysis. This qualifier is applied to GC/ECD results that are not confirmed by GC/ITD analysis, even though the results are at sufficient concentration to be detected by GC/ITD. The reported result is suspect as it may be a false positive.	Q	JN
Data Validation	Positive GC/ITD result was not detected by GC/ECD analysis or greater than five times GC/ECD result. This qualifier is applied to GC/ECD results if the concentration of the GC/ITD results are greater than five times the GC/ECD results. Also the non-detected GC/ECD result is qualified if a congener is detected by GC/ITD and not detected by GC/ECD. The reported result is suspect as it may be a false negative or a misidentification.	M	R
Data Validation	Presumptive evidence for the presence of a material. This qualifier is applied to GC/ECD results that exceeded the compound identification criteria. The reported result is suspect as it may be a false positive.	N	N
Data Management	Results generated by decoupling BZ #4 and 10 using regression analysis.	L	J

Table A-2 (Continued)
Data Qualification Codes

Data Management	Results updated by Aquatec due to revisions in GC column performance.	K	--
Data Management	Results requalified by QAO due to decisions made during data usability assessment.	Y	J

Table A-3
Low Resolution Sediment PCB Field Co-located Samples
Hudson River RI/FS PCB Reassessment

TAMS ID	BZ	Parameter	Units	Sample Result and Qualifier		Duplicate Result and Qualifier		RPD (%)
LH-28C-0015	1	BZ#1	ug/Kg DW	42400		37000		14
LH-28C-0015	4	BZ#4	ug/Kg DW	50800	J	42300	J	18
LH-28C-0015	8	BZ#8	ug/Kg DW	8630	J	6920	J	22
LH-28C-0015	10	BZ#10	ug/Kg DW	7520	J	6270	J	18
LH-28C-0015	18	BZ#18	ug/Kg DW	3010	J	2550		17
LH-28C-0015	19	BZ#19	ug/Kg DW	9120	J	7290	J	22
LH-28C-0015	28	BZ#28	ug/Kg DW	1440		1080		29
LH-28C-0015	52	BZ#52	ug/Kg DW	3350		2630		24
LH-28C-0015	101	BZ#101 with BZ#[90]	ug/Kg DW	428	J	367	J	15
LH-28C-0015	118	BZ#118	ug/Kg DW	158	JN	148	J	7
LH-28C-0015	138	BZ#138	ug/Kg DW	35.9	JN	204	J	-140
LH-28C-0015	180	BZ#180	ug/Kg DW	352	U	56.7	J	145
LH-28C-1530	1	BZ#1	ug/Kg DW	120000		85500		34
LH-28C-1530	4	BZ#4	ug/Kg DW	170000	J	123000	J	32
LH-28C-1530	8	BZ#8	ug/Kg DW	85100	J	69400	J	20
LH-28C-1530	10	BZ#10	ug/Kg DW	16900	J	11100	J	41
LH-28C-1530	18	BZ#18	ug/Kg DW	16300		12800		24
LH-28C-1530	19	BZ#19	ug/Kg DW	28400	J	19600	J	37
LH-28C-1530	28	BZ#28	ug/Kg DW	8810		8990		-2
LH-28C-1530	52	BZ#52	ug/Kg DW	14000		11100		23
LH-28C-1530	101	BZ#101 with BZ#[90]	ug/Kg DW	1040	J	721	J	36
LH-28C-1530	118	BZ#118	ug/Kg DW	1280	U	728	U	NC
LH-28C-1530	138	BZ#138	ug/Kg DW	829	J	671	J	21
LH-28C-1530	180	BZ#180	ug/Kg DW	270	J	189	J	35
LH-28C-3046	1	BZ#1	ug/Kg DW	9890	J	8540		15
LH-28C-3046	4	BZ#4	ug/Kg DW	31800	J	27000	J	16
LH-28C-3046	8	BZ#8	ug/Kg DW	41400	J	36300	J	13
LH-28C-3046	10	BZ#10	ug/Kg DW	585	J	482	J	19
LH-28C-3046	18	BZ#18	ug/Kg DW	18900	J	19100		-1
LH-28C-3046	19	BZ#19	ug/Kg DW	5600	J	4760	J	16
LH-28C-3046	28	BZ#28	ug/Kg DW	10300	J	10500		-2
LH-28C-3046	52	BZ#52	ug/Kg DW	13500	J	14200		-5
LH-28C-3046	101	BZ#101 with BZ#[90]	ug/Kg DW	259	J	182	J	35
LH-28C-3046	118	BZ#118	ug/Kg DW	149	J	114	J	27
LH-28C-3046	138	BZ#138	ug/Kg DW	730	J	723	J	1
LH-28C-3046	180	BZ#180	ug/Kg DW	90.7	J	88	J	3
LH-39M-0008	1	BZ#1	ug/Kg DW	5680	J	4490		23
LH-39M-0008	4	BZ#4	ug/Kg DW	7530	J	7210	J	4
LH-39M-0008	8	BZ#8	ug/Kg DW	4250	J	3900	J	9
LH-39M-0008	10	BZ#10	ug/Kg DW	794	J	776	J	2
LH-39M-0008	18	BZ#18	ug/Kg DW	1120	J	1030	J	8
LH-39M-0008	19	BZ#19	ug/Kg DW	1430	J	1300	J	10
LH-39M-0008	28	BZ#28	ug/Kg DW	646		596		8
LH-39M-0008	52	BZ#52	ug/Kg DW	1070		1030		4
LH-39M-0008	101	BZ#101 with BZ#[90]	ug/Kg DW	87.8	UJ	109	J	-22
LH-39M-0008	118	BZ#118	ug/Kg DW	54.9	J	71.2	J	-26
LH-39M-0008	138	BZ#138	ug/Kg DW	26.6	JN	41.7	J	-44
LH-39M-0008	180	BZ#180	ug/Kg DW	119	U	25	J	131

Table A-4
PCB Detects Changed to Non-detects
Low Resolution Sediment Samples
Hudson River RI/FS PCB Reassessment

Congener Name	Number of results considered nondetect*	Total number of results	Percentage of results considered nondetect
BZ#1	54	371	15
BZ#2	12	371	3
BZ#3	122	371	33
BZ#4	37	371	10
BZ#6	214	371	58
BZ#7	33	371	9
BZ#8	30	371	8
BZ#9	27	371	7
BZ#10	111	371	30
BZ#12	26	371	7
BZ#15	46	371	12
BZ#16	114	371	31
BZ#17	57	371	15
BZ#18	53	371	14
BZ#19	32	371	9
BZ#20	203	371	55
BZ#22	27	371	7
BZ#23NT	32	371	9
BZ#25	48	371	13
BZ#26	67	371	18
BZ#27	34	371	9
BZ#28	39	371	11
BZ#31	22	371	6
BZ#32NT	11	371	3
BZ#33	75	371	20
BZ#37	46	371	12
BZ#40	21	371	6
BZ#41	36	371	10
BZ#42	87	371	23
BZ#44	71	371	19
BZ#45	15	371	4
BZ#47	37	371	10
BZ#49	172	371	46
BZ#52	34	371	9
BZ#53	59	371	16
BZ#56	35	371	9
BZ#66	57	371	15
BZ#70	39	371	11
BZ#74	24	371	6
BZ#75	199	371	54
BZ#77	105	371	28
BZ#82	1	371	0
BZ#83	10	371	3
BZ#84	15	371	4
BZ#85	119	371	32
BZ#87	87	371	23
BZ#91	8	371	2
BZ#92	13	371	4
BZ#95	38	371	10
BZ#97	62	371	17
BZ#99	11	371	3

Table A-4
PCB Detects Changed to Non-detects
Low Resolution Sediment Samples
Hudson River RI/FS PCB Reassessment

Congener Name	Number of results considered nondetect*	Total number of results	Percentage of results considered nondetect
BZ#101 with BZ#[90]	12	371	3
BZ#105	123	371	33
BZ#107	20	371	5
BZ#110	61	371	16
BZ#115	92	371	25
BZ#118	58	371	16
BZ#119	104	371	28
BZ#122	5	371	1
BZ#123	19	371	5
BZ#126	30	371	8
BZ#128	108	371	29
BZ#129	34	371	9
BZ#135	26	371	7
BZ#136	5	371	1
BZ#137	9	371	2
BZ#138	12	371	3
BZ#141	59	371	16
BZ#143	18	371	5
BZ#149	38	371	10
BZ#151	18	371	5
BZ#153	53	371	14
BZ#156	44	371	12
BZ#157	51	371	14
BZ#158	1	371	0
BZ#167	9	371	2
BZ#170	87	371	23
BZ#171	17	371	5
BZ#174	40	371	11
BZ#177	6	371	2
BZ#178	31	371	8
BZ#180	33	371	9
BZ#183	80	371	22
BZ#185	18	371	5
BZ#187	53	371	14
BZ#190	57	371	15
BZ#194	126	371	34
BZ#195	35	371	9
BZ#196	53	371	14
BZ#198	145	371	39
BZ#199	14	371	4
BZ#200	43	371	12
BZ#201	67	371	18
BZ#202	24	371	6
BZ#205	24	371	6
BZ#206	98	371	26
BZ#207	4	371	1
BZ#208	10	371	3
BZ#209	14	371	4

* = [Not specified by Gradient]

Table A-5
Low Resolution Coring Sample PCB Analysis Summary
Hudson River RI/FS PCB Reassessment

Congener Name[1]	Total Number of Results	Unqualified Nondetects	Estimated Nondetects	Unqualified Detects	Estimated Detects	Estimated and Presumed Present Detects	Rejected Results	% Rejected
BZ#1	371	32	24	205	87	13	10	3%
BZ#2	371	235	84	0	0	0	52	14%
BZ#3	371	90	193	0	0	1	87	23%
BZ#4	371	1	38	0	332	0	0	0%
BZ#5	371	280	81	0	0	0	10	3%
BZ#6	371	136	88	102	39	0	6	2%
BZ#7	371	114	62	1	185	0	9	2%
BZ#8	371	0	52	0	319	0	0	0%
BZ#9	371	13	28	0	330	0	0	0%
BZ#10	371	2	112	0	252	5	0	0%
BZ#12	371	204	69	4	9	15	70	19%
BZ#15	371	2	49	0	320	0	0	0%
BZ#16	371	89	140	0	118	0	24	6%
BZ#17	371	3	59	0	309	0	0	0%
BZ#18	371	24	46	159	83	59	0	0%
BZ#19	371	0	32	0	327	12	0	0%
BZ#20	371	40	217	0	107	0	7	2%
BZ#22	371	9	28	198	126	7	3	1%
BZ#23NT	371	94	0	0	277	0	0	0%
BZ#24NT	371	79	0	0	292	0	0	0%
BZ#25	371	10	40	206	110	3	2	1%
BZ#26	371	2	67	0	301	1	0	0%
BZ#27	371	0	34	0	337	0	0	0%
BZ#28	371	13	26	217	114	0	1	0%
BZ#29	371	292	68	0	0	0	11	3%
BZ#31	371	0	22	0	348	1	0	0%
BZ#32NT	371	12	0	0	8	351	0	0%
BZ#33	371	18	82	0	267	0	4	1%
BZ#34NT	371	71	0	0	238	62	0	0%
BZ#37	371	9	48	0	314	0	0	0%
BZ#40	371	117	53	0	170	0	31	8%
BZ#41	371	41	50	0	265	0	15	4%
BZ#42	371	17	90	0	263	0	1	0%
BZ#44	371	29	59	164	102	6	11	3%
BZ#45	371	11	14	189	149	6	2	1%
BZ#47	371	2	37	0	332	0	0	0%
BZ#48NT	371	160	0	0	211	0	0	0%
BZ#49	371	2	172	0	188	9	0	0%
BZ#51NT	371	12	0	0	106	253	0	0%
BZ#52	371	24	10	240	96	1	0	0%
BZ#53	371	9	63	0	298	0	1	0%
BZ#56	371	31	45	0	285	0	10	3%
BZ#58NT	371	365	0	0	3	3	0	0%
BZ#60NT	371	104	0	0	258	9	0	0%
BZ#63NT	371	62	0	0	180	129	0	0%
BZ#64NT	371	5	0	0	67	299	0	0%
BZ#66	371	8	58	0	303	0	2	1%
BZ#67NT	371	196	0	0	135	40	0	0%
BZ#69NT	371	360	0	0	11	0	0	0%
BZ#70	371	13	43	179	124	3	9	2%
BZ#74	371	21	27	157	151	6	9	2%

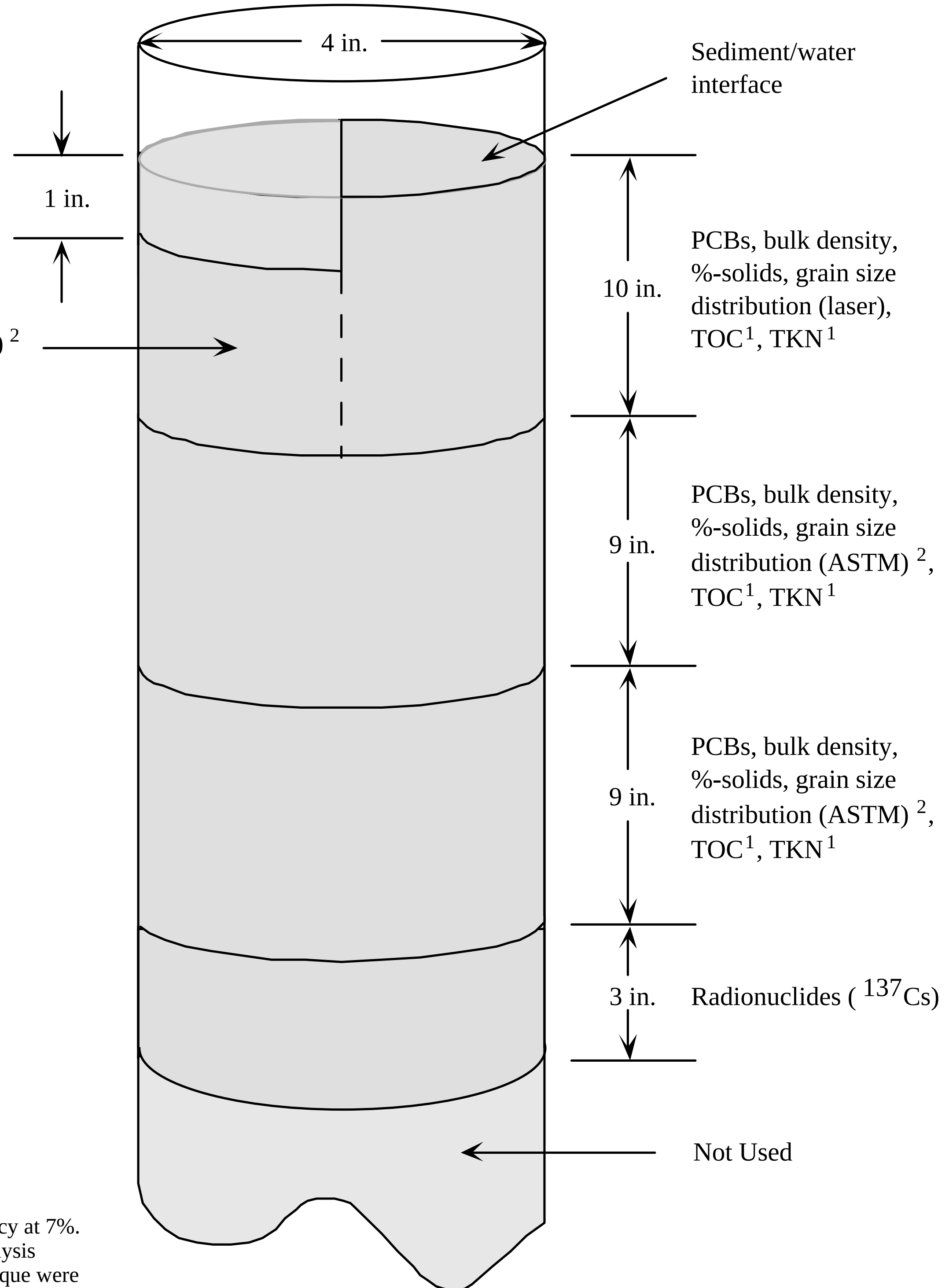
Table A-5
Low Resolution Coring Sample PCB Analysis Summary
Hudson River RI/FS PCB Reassessment

Congener Name[1]	Total Number of Results	Unqualified Nondetects	Estimated Nondetects	Unqualified Detects	Estimated Detects	Estimated and Presumed Present Detects	Rejected Results	% Rejected
BZ#75	371	38	206	0	126	0	1	0%
BZ#77	371	29	112	0	220	6	4	1%
BZ#82	371	116	26	28	159	23	19	5%
BZ#83	371	96	34	17	182	17	25	7%
BZ#84	371	16	23	45	277	7	3	1%
BZ#85	371	56	132	0	178	0	5	1%
BZ#87	371	56	97	0	207	0	11	3%
BZ#91	371	16	12	40	299	2	2	1%
BZ#92	371	16	17	144	184	5	5	1%
BZ#95	371	14	40	0	317	0	0	0%
BZ#96NT	371	208	0	0	157	6	0	0%
BZ#97	371	100	69	63	108	4	27	7%
BZ#99	371	31	17	122	144	36	21	6%
BZ#101 wit	371	12	14	0	345	0	0	0%
BZ#105	371	49	136	0	176	0	10	3%
BZ#107	371	137	45	0	169	0	20	5%
BZ#110	371	4	63	0	304	0	0	0%
BZ#114NT	371	252	0	0	110	9	0	0%
BZ#115	371	174	131	0	52	0	14	4%
BZ#118	371	30	66	0	263	3	9	2%
BZ#119	371	155	153	0	37	4	22	6%
BZ#122	371	284	75	0	1	0	11	3%
BZ#123	371	227	72	0	56	0	16	4%
BZ#126	371	245	81	0	31	0	14	4%
BZ#128	371	100	124	10	115	6	16	4%
BZ#129	371	214	85	0	63	0	9	2%
BZ#135	371	57	42	0	263	0	9	2%
BZ#136	371	90	48	2	214	1	16	4%
BZ#137	371	213	49	0	37	20	52	14%
BZ#138	371	28	18	1	259	54	11	3%
BZ#140NT	371	362	0	0	9	0	0	0%
BZ#141	371	154	92	0	116	0	9	2%
BZ#143	371	267	77	0	6	0	21	6%
BZ#144NT	371	326	0	0	42	3	0	0%
BZ#146NT	371	120	0	0	184	67	0	0%
BZ#149	371	40	49	0	273	0	9	2%
BZ#151	371	43	33	0	289	0	6	2%
BZ#153	371	33	64	0	268	0	6	2%
BZ#156	371	147	75	0	129	10	10	3%
BZ#157	371	240	110	0	8	0	13	4%
BZ#158	371	174	40	0	146	0	11	3%
BZ#167	371	231	59	0	65	3	13	4%
BZ#169NT	371	369	0	0	2	0	0	0%
BZ#170	371	93	102	0	170	0	6	2%
BZ#171	371	247	72	0	43	0	9	2%
BZ#172NT	371	316	0	0	0	55	0	0%
BZ#174	371	159	74	0	125	0	13	4%
BZ#175NT	371	367	0	0	3	1	0	0%
BZ#177	371	126	35	3	183	7	17	5%
BZ#178	371	108	59	0	194	0	10	3%
BZ#180	371	78	46	44	144	27	32	9%

Table A-5
Low Resolution Coring Sample PCB Analysis Summary
Hudson River RI/FS PCB Reassessment

Congener Name[1]	Total Number of Results	Unqualified Nondetects	Estimated Nondetects	Unqualified Detects	Estimated Detects	Estimated and Presumed Present Detects	Rejected Results	% Rejected
BZ#183	371	168	125	0	66	0	12	3%
BZ#184NT	371	210	0	0	146	15	0	0%
BZ#185	371	250	80	0	31	0	10	3%
BZ#187	371	56	68	45	171	13	18	5%
BZ#189	371	289	67	0	1	0	14	4%
BZ#190	371	173	94	0	95	0	9	2%
BZ#191	371	292	64	0	2	2	11	3%
BZ#193	371	291	69	0	0	0	11	3%
BZ#194	371	139	162	2	24	8	36	10%
BZ#195	371	228	86	0	35	2	20	5%
BZ#196	371	174	93	0	94	0	10	3%
BZ#197NT	371	371	0	0	0	0	0	0%
BZ#198	371	170	190	0	1	0	10	3%
BZ#199	371	276	72	0	12	0	11	3%
BZ#200	371	248	97	0	16	0	10	3%
BZ#201	371	147	98	0	116	0	10	3%
BZ#202	371	246	76	0	36	0	13	4%
BZ#203NT	371	208	0	0	146	17	0	0%
BZ#205	371	260	93	0	0	0	18	5%
BZ#206	371	152	129	9	39	15	27	7%
BZ#207	371	279	71	0	2	6	13	4%
BZ#208	371	238	63	2	42	2	24	6%
BZ#209	371	260	71	2	16	5	17	5%
TOTALS	46,375	15,651	7,352	2,600	17,789	1,755	1,228	2.6%

Notes:
1. NT in the congener name stands for non-target indicating a congener added to the program in addition to the original target 90 congeners. See text for discussion.



Notes:
1. TOC/TKN sample frequency at 7%.
2. Grain size distribution analysis based on the ASTM technique were performed at least once per core for approximately 68% of the cores collected.
3. The segment thicknesses shown are median values for four segment cores.

Legend:
TOC - Total Organic Carbon Analysis
TKN - Total Kjeldahl Nitrogen Analysis

Source: TAMS/Gradient Database, Release 3.5 TAMS

Figure A-1
Low Resolution Sediment Core Preparation

APPENDIX B

DATA USABILITY REPORT FOR NON-PCB CHEMICAL

AND

PHYSICAL DATA LOW RESOLUTION SEDIMENT CORING STUDY

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B.1 INTRODUCTION

The usability of data is highly dependent on the data quality objectives (DQOs) defined for an environmental investigation. Throughout its duration, the Hudson River PCB congener chemistry program has required stringent quality control criteria to maintain data usability for all of the analytical parameters performed in support of the project. For the Phase 2B low resolution sediment coring study, various non-PCB chemical and physical parameters were analyzed to aid in defining the context within which the PCB congeners exist. These parameters helped to delineate the concentration of the PCB congeners within the context of geochemical and biological processes occurring in the Hudson River.

This report serves as an overall evaluation of the data usability for the Hudson River Phase 2B Low Resolution Sediment Coring Study non-PCB analyses based upon criteria set forth by TAMS/Gradient. The low resolution field sampling program, analytical protocols, and quality control/quality assurance requirements are described in Appendix A. The data usability reports assessing the PCB congeners for the low resolution sediment coring study are also provided in Appendix A.

B.2 DATA USABILITY APPROACH

Data validation of the non-PCB parameters was performed by CDM based upon the specific method criteria listed in the Appendices of the "Phase 2B Sampling and Analysis Plan/Quality Assurance Project Plan, Volume 4: Low Resolution Sediment Coring, Hudson River PCB Reassessment RI/FS" (TAMS/Gradient, 1992a, referred to hereafter in this report as the Phase 2B SAP/QAPP), and the USEPA Region II validation guidelines (USEPA, 1992a), where applicable. The non-PCB chemical and physical data for the low resolution sampling program included grain-size (particle size) distribution, total organic carbon (TOC), total kjeldahl nitrogen (TKN), and radionuclide (^{137}Cs and ^{7}Be) analyses.

TAMS/Gradient determined the usability of the data based upon an evaluation of the data validation reports in conjunction with historical or expected results and the program data quality objectives (DQOs) as defined in the Phase 2B SAP/QAPP for the low resolution sediment coring study. Additionally, TAMS/Gradient based the usability evaluation upon the intended use(s) of the data, consistency with other data sets (both internal, *i.e.*, from the Hudson River PCB Reassessment RI/FS and external, *i.e.*, historical data or data gathered from the literature), and professional judgment.

Criteria used, in part, to evaluate usability include accuracy, precision, representativeness, sensitivity, and completeness. Accuracy is a measure of how a result compares to a true value. Precision indicates the reproducibility of generating a value. Representativeness is the degree to which a measurement(s) is indicative of the characteristics of a larger population. Sensitivity is represented by the limit of detection of the analytical method. Completeness is a measure of the amount of usable data resulting from a data collection activity (USEPA, 1992b). For this program, a 95% completeness goal was established. These criteria are discussed in detail in Appendix A as well as the Phase 2B SAP/QAPP.

Accuracy was evaluated for TOC, TKN, and radionuclide analyses through the assessment of quality control samples, including initial and continuing calibration verification (ICV and CCV, respectively), laboratory control samples (LCS), and/or matrix spikes. Precision was evaluated for grain-size analyses, TOC and TKN through the assessment of laboratory duplicate analyses. Sensitivity was evaluated for all parameters based upon the assessment of blanks and/or detection levels. Representativeness was evaluated for grain-size, TOC and TKN analyses through the assessment of field duplicate results.

During the usability assessment, the final qualifications of the data presented in the Hudson River low resolution sampling project database were determined. In most cases, TAMS/Gradient maintained the qualifications added during validation and interpreted these qualifications in terms of usability of the results relative to project objectives. In cases where the qualification of the data was changed from the validation actions, details of the technical justification for these changes, and the resultant usability of the data, are presented in this appendix for all non-PCB results.

An essential aspect of understanding the uncertainties of the Phase 2B chemical and physical data is understanding the qualifiers associated with the results. Initially, the analytical laboratories applied qualifiers to the results. The data validators then modified these qualifiers, as necessary, using established validation protocols from the USEPA Region II standard operating procedure (SOP) for data validation (USEPA, 1992a), where applicable, the specific DQOs and quality control (QC) criteria established for the non-PCB analyses in the SAP/QAPP, and professional judgment. The data were validated using protocols established by TAMS/Gradient and all data validation was performed by CDM. The validation qualifiers were further modified during the usability assessment to direct the data users concerning the use of each result, if required. Specifically, the data were evaluated in accordance to the Special Analytical Services (SAS) request and the Phase 2B SAP/QAPP, adherence to technical specifications of the analytical method, and achievement of precision and accuracy objectives. The definition of the final qualification flags that appear in the database for non-PCB results are based upon USEPA data validation guidance (USEPA, 1992a) and are listed below:

Qualifiers for Non-PCB Data

U	The chemical or parameter was analyzed for, but was not detected above the level of the associated value. The associated value is the sample quantitation limit. The associated value is usable as a nondetect at the reported detection level.
J	The associated value is an estimated quantity due to QA/QC exceedance(s). The estimated value may be inaccurate or imprecise. The associated value is an estimated result.
UJ	The chemical or parameter was analyzed for, but was not detected above the level of the associated value. The associated value is an estimated sample quantitation limit and may be inaccurate or imprecise. The value is usable as a nondetect value with an estimated detection limit.
R	The value (result) was rejected due to significant errors or QA/QC exceedance(s). The result is not usable for project objectives.

A complete list of result qualifiers for both the PCB and non-PCB data can be found in the "Qualify Table" of the project database. Table B-1 presents a summary of data usability statistics for laser grain-size, TKN, and TOC analyses. Tables B-2 and B-3 present summary statistics for the sieve grain-size and radionuclide analyses, respectively.

B.3 GRAIN-SIZE DISTRIBUTION DATA

Grain-size distribution was determined for all low resolution sediment core sections to classify the type of sediment collected. Grain-size results are used for interpreting sediment PCB chronologies and degradation, particularly where important geochemical features correspond to changes in sediment texture. Due to the limited sample sizes for the low resolution top sediments and the need to classify the entire grain-size distribution on the same basis, a laser particle technique was used to measure grain-size in the top core slices. These cores were also analyzed by a sieve and hydrometer method (hereafter, sieve/hydrometer), in addition to the field (visual) classification. Grain-size distribution for the top sediment core slices was determined mathematically by combining the laser method and sieve/hydrometer method results. Additionally, the remaining low resolution sediment core slices, with the exception of the bottom slices, were measured using standard sieve/hydrometer methodologies for grain-size distribution. Low resolution sediment core slices were collected and analyzed for grain-size distribution by Midwest Laboratories, Inc. (150 samples, including seven field duplicates) using a sieve and hydrometer method (ASTM Methods D-421 and D-422) and by GeoSea Consulting, Ltd. (179 samples, including nine field duplicates) using a combined sieving method (ASTM D421-85 equivalent, to remove the particles greater than 1 mm) and laser methodology (for the particle size distribution under 2 mm). Data were validated by CDM and were subsequently evaluated for usability by the TAMS/Gradient team. QC samples (field duplicates) were collected and analyzed for grain-size distribution at a frequency of greater than or equal to 5%. The interpretation of the QC results and the accuracy and representativeness of the grain-size data are evaluated in this section.

B.3.1 Sieve/Hydrometer Grain-Size Distribution Data

B.3.1.1 Accuracy

At the commencement of the low resolution core study, sample bins were incorrectly labeled by Midwest Laboratories. In order to have reporting bins which were consistent with previous sampling rounds and so that the laser grain-size analyses results would be comparable, the bins were re-labeled under the direction of TAMS. Data quality was unaffected by the re-labeling of the bins.

Accuracy was compromised for the sieve/hydrometer results due to inappropriate method procedures. The method requires that after hydrometer analysis, the sample soil suspension must be transferred to a No. 200 (75 μm) sieve. The material remaining on the sieve is then dried and sifted through the remaining sieves. Instead of transferring the suspension to the appropriate sieve, the laboratory dried the sample prior to hydrometer analysis, destroying the true sand/silt split. This changed the natural distribution of the soil sample for all intervals below 75 μm. As a result of this method deviation, the grain-size data from the less than 75 μm fraction is not accurate. Therefore, all of the low resolution sample sieve/hydrometer data from the less than 75 μm fraction were considered estimated (qualified J) due to lack of differentiation between the sand and silt fractions.

The results are usable as estimated values for which uncertainty exists.

During validation, all sieve/hydrometer grain-size results were qualified as estimated ("J") because a number of samples were not analyzed within the 35 day Verified Time of Sample Receipt (VTSR) limit. In addition, the validator chose to qualify ("J") all results because the 2.8 mm fraction was not analyzed by the laboratory. Since the 35 VTSR holding time criterion was established solely for project management reasons, exceedance of this holding time criterion did not affect overall data quality or compromise comparability of the data to previous sampling events. In addition, the lack of the 2.8 mm fraction analysis is not critical because this fraction was bracketed by other analytical intervals. During data usability assessment, the TAMS/Gradient team reversed the validator's decision to qualify as estimated (*i.e.*, the "J" qualifier was removed) the sieve/hydrometer grain-size results because overall data quality and accuracy were not effected by either of these issues.

B.3.1.2 Precision

Eight laboratory duplicate pairs were analyzed for sieve/hydrometer grain-size, exceeding the 5% minimum frequency stipulated in the Phase 2B SAP/QAPP. Overall precision of the sieve/hydrometer data was acceptable based upon results for the eight laboratory duplicates. Duplicate precison was assessed by a percent similarity criterion developed specifically for evaluating grain-size data (Shilabeer *et al.*, 1992), with a percent similarity precision objective of 80% or greater established in the Phase 2B SAP/QAPP. All laboratory duplicate analyses achieved a percent similarity of $\geq$ 80%.

B.3.1.3 Sensitivity

There were no issues affecting sensitivity of the grain-size analyses.

B.3.1.4 Representativeness

Seven field duplicates pairs were analyzed in association with the 143 sieve/hydrometer grain-size samples,a frequency of 4.9%, slightly less than the 5% frequency stipulated in the Phase 2B SAP/QAPP. Overall precision of the sieve/hydrometer data was acceptable based upon results for the seven field duplicate pairs, as all duplicate analyses achieved a percent similarity of $\geq$ 80%.

Based upon the method deviation performed by the laboratory (described in section B.3.1.1), data users are cautioned that the grain-size distribution for the less than 75 µm fraction does not represent the true sand and silt split.

B.3.1.5 Summary of Data Usability

All Midwest Laboratories, Inc. sieve/hydrometer data are usable for general geochemical classifications and ratios of fractions. A total of 13% of the results were qualified as estimated (J) due to uncertainty in the <75 µm fraction. The completeness for these data was 100%. The summary statistics for these analyses are presented in Table B-2.

B.3.2 Laser Grain-Size Distribution Data

B.3.2.1 Accuracy

During data validation, laser/sieve results for 64 of the 179 samples were qualified as estimated ("J") because the samples were not analyzed within the 35 VTSR holding time criterion. The validator also estimated these data because the laboratory did not analyze particle size intervals 2.25 mm, 3.75 mm, and 7.75 mm. As with the sieve/hydrometer analyses, the 35 VTSR criterion was established solely for project management reasons. Thus, holding time exceedances do not affect the quality of the grain-size distribution results. In addition, the lack of the three particle size intervals does not impact the overall quality of the data or the comparability of the laser/sieve data to previous sampling events because these intervals were bracketed by the other sieve sizes analyzed. The TAMS/Gradient team reversed the qualification of the data during the data usability assessment. Therefore, there were no issues affecting the accuracy of the laser/sieve results.

B.3.2.2 Precision

Ten laboratory duplicate pairs were analyzed in association with the laser/sieve grain-size samples. This exceeded the 5% frequency required by the Phase 2B SAP/QAPP. Overall precision of the sieve/hydrometer data was acceptable based upon results for the ten laboratory duplicates (all duplicate analyses achieved a percent similarity of $\geq$ 80%).

B.3.2.3 Sensitivity

There were no issues affecting sensitivity of the laser/hydrometer grain-size analyses.

B.3.2.4 Representativeness

Overall precision of the laser/sieve data was acceptable based upon results for nine field duplicate pairs (all duplicate analyses achieved a percent similarity of $\geq$ 80%). Field duplicates were analyzed at the required frequency of 5%.

B.3.2.5 Summary of Usability

All of the low resolution sample laser/sieve data are considered acceptable without qualification. The GeoSea Consulting LTD (Canada) laser/sieve data are usable without qualification for general geotechnical classifications and rations of fractions. Completeness of 100% was achieved for these analyses. Summary statistics for these analyses are presented in Table B-1.

B.3.3 Overall Grain-Size Usability

In addition to the field classification, low resolution sediments were classified by two laboratory techniques discussed above:

- combined sieve and laser particle analysis (Laser); and
- combined sieve and hydrometer analysis (ASTM).

Results from these techniques are summarized in Tables B-1 and B-2. Both Laser and ASTM techniques were applied to a large subset of the samples collected. Visual field inspections were performed for every sediment sample.

Evident in all three data sets is the predominance of samples classified as silt (fines in the case of the ASTM results). The predominance of this fraction reflects the orientation of the sampling program, *i.e.*, to obtain cores from areas of substantive PCB contamination, generally areas of fine-grained sediments. In general, the three methods yield similar results for most samples. The results of these methods are compared by principal fraction in Figures B-1 to B-3.

In Figure B-1 the results of the visual and Laser classifications are compared for the shallow sediments only, (*i.e.*, just the top slice of each of 169 cores). The uppermost diagram shows the coincidence between principle fraction by visual inspection versus that obtained by the Laser technique. The two lower diagrams represent the distribution of matched samples as classified by each method. In most instances, the two methods agree on the principal fraction for samples classified as silt and fine sand, effectively verifying the subjective visual classification. When the two methods disagree, it is usually by only one class (*i.e.*, fine sand by visual inspection is assigned silt by the Laser technique). In most of these instances, the actual fractions are very close (*e.g.*, 35% silt and 32% fine sand). The coarser materials, *i.e.*, medium or coarse sand and gravel, were not as constant as silt and fine sand for the two methods. In particular, the medium sand as classified by visual inspection could be found in every class by the Laser method. This is indicative of the poor sorting of the coarse sediments, which made visual classification more difficult.

In Figure B-2, the visual inspection results are compared with the ASTM method for samples (n = 143) from a range of depths and locations, as opposed to the shallow sediment samples presented in Figure B-1. Again, the two methods generally agree for silt and fine sand; however, the coarser fractions are more problematic. As discussed above, this is attributed to the poorly sorted nature of the sample materials.

Figure B-3 compares the results for the Laser and ASTM methods directly for the 69 shallow sediment samples run by both methods. The top diagram shows the agreement of the principal fractions between the two methods. Although the methods agree for most fines, the Laser method characterizes more samples as silt than does the ASTM method. This trend is apparent for all sediment classes, with the Laser method tending to characterize more samples into smaller fractions than the ASTM method. The lower half of Figure B-3 is a histogram of the percent similarity calculated for each Laser-ASTM measurement pair. Percent similarity is calculated by summing the smallest value in each of the sediment classes for a pair of measurements as shown below:

Sediment and Class Fraction

	Silt	Fine Sand	Medium Sand	Coarse Sand	Gravel	
Laser Analysis of Sample 1	45	28	12	15	0	= 100%
ASTM Analysis of Sample 1	35	32	18	12	3	= 100%
Similarity (%)	35	28	12	12	0	= 87% Similarity

The range of percent similarity for this data set is 34% to 98% with a mean value of 76%. This is quite similar to the work of Shillabeer, *et al.*, 1992, where a set of 406 sediment sample pairs was analyzed by both Laser and sieve techniques. A mean similarity of 79% and a range of 55% to 97% similarity was obtained, with the Laser technique consistently predicting larger fractions of the finer sediments. This matches the results obtained for the low resolution coring program quite well. The authors attributed the difference to the way the techniques measure particles. Essentially the Laser technique reports the particle-size distribution by volume while the ASTM (sieve) method is sensitive to particle diameter and shape.

Thus, the two methods report different distributions for the same sample. Since the primary goal of these analyses was to classify sediments in a qualitative sense for potential PCB contamination, this difference is unlikely to be important. In particular, the Laser results can be applied directly to the existing Phase 2 database, to expand and confirm the correlations seen between the side-scan sonar and the confirmatory samples (TAMS *et al.*, 1997). This application is presented later in the low resolution sediemtn coring report.

In summary, for the low-resolution sediment core samples, all grain-size data are usable for both qualitative and quantitative analyses. The laser analysis of the fine-grained material is a more accurate representation of the particle size distribution of the fraction below 75 µm. Uncertainty exists for the sieve/hydrometer results for particle size intervals less than 75 μm due to method deviations.

B.4 TOTAL KJELDAHL NITROGEN (TKN) DATA

Total Kjeldahl Nitrogen (TKN) is defined as the sum of free-ammonia and organic nitrogen compounds. The project objective for this measurement, along with the total organic carbon (TOC) measurement, was to determine the importance of the carbon-to-nitrogen ratio in the sediment. According to the Phase 2B SAP/QAPP, low resolution sediment coring samples were to be collected and analyzed for total carbon/total nitrogen (TC/TN). Approximately 10% of the TC/TN samples were to be analyzed for TOC/TKN to verify that negligible amounts of inorganic carbon and inorganic nitrogen were present in the samples and to verify the assumption that the TOC/TKN analyses from previous sampling events are comparable to the current TC/TN data. However, due to a problem with procuring an analytical laboratory, the TC/TN analyses were excluded from the low resolution sampling program.

A total of 28 sediment samples, of which one was a field duplicate, were collected for TKN analysis during the low resolution sediment coring program. All TKN analyses were performed by Aquatec under the requirements of the USEPA Special Analytical Services (SAS) program. The samples were prepared and analyzed for TKN using USEPA Method 351.2 from *Methods for the Chemical Analysis of Water and Wastes* (USEPA, Revised 1983). Data are reported on a dry-weight basis in units of mg/kg.

B.4.1 Accuracy

Accuracy, as measured by holding times, calibration QC (initial and continuing calibration checks and blanks), matrix QC (matrix spike samples), and laboratory control samples (LCSs) met acceptance criteria as set forth in the SAS request with the following exception. Two matrix spikes exceeded the upper limit for percent recovery (125%) as stipulated in the Phase 2B SAP/QAPP. Therefore, the TKN results for the four samples associated with these matrix spikes were qualified as estimated (“J”) based upon the high recoveries of the associated spike analyses. The results are usable as estimated values that may be biased high.

B.4.2 Precision

Six laboratory duplicate pair analyses were performed. All duplicate TKN measurements met the laboratory split (duplicate) precision criterion of relative percent difference (RPD) $\leq$ 20%, as stipulated in the Phase 2A SAP/QAPP.

B.4.3 Sensitivity

Blanks were analyzed as required by the method. All blank concentrations were below the method detection limit (MDL). Therefore, all sensitivity criteria were met for TKN analyses.

B.4.4 Representativeness

One field duplicate pair was associated with the 28 sediment samples. During validation, CDM determined that the representativeness of the TKN results was compromised for 3 of the 28 samples due to poor field duplicate precision. The TKN results associated with the field duplicate were estimated (qualified "J"). According to the data validation guidelines, for results > 5xMDL (results were 4420 mg/kg and 4090 mg/kg) , the relative percent difference (RPD) should be used to evaluate precision. CDM had evaluated precision using the absolute difference between results. Since the RPD for the analysis was 7.4%, precision criteria were met and no actions were required. Therefore, TAMS/Gradient reversed the decision to qualify these data and the "J" qualifier was removed from the affected samples.

The frequency criterion of 5% for field duplicate analyses was not met for TKN. (The actual frequency of one duplicate pair in 27 environmental samples was 3.7%.) No actions were taken because precision evaluation was made possible through the review of laboratory duplicate analyses.

B.4.5 Summary of Usability

The overall data quality was acceptable and all TKN results are usable for project objectives. A total of 15% of the TKN results were qualified as estimated ("J") due to high matrix spike recoveries. The overall completeness for TKN was 100%, meeting the project DQO for completeness. Summary statistics for TKN are presented in Table B-1.

B.5 TOTAL ORGANIC CARBON (TOC) DATA

A total of 28 sediment samples (including one field duplicate) were collected for TOC analyses during the low resolution sediment coring program. The TOC analyses were performed by Aquatec. All samples were prepared and analyzed for TOC analysis using the 1986 version of the Lloyd Kahn TOC in Sediment Method, rather than the 1988 version. Since the 1986 version of the method was used, the TOC data were validated based on duplicate relative percent differences rather than on criteria related to the initial laboratory establishment of precision as well as quadruplicate precision as defined in the February 18, 1994 memorandum from TAMS. The overall quality of the data was not compromised by the using the 1986 method criteria.

B.5.1 Accuracy

Accuracy, as measured by holding times, calibration QC (initial and continuing calibration checks and blanks), method blanks, LCSs, and matrix QC (matrix spike samples) met acceptance criteria as set forth in the SAS request with the following exceptions. Approximately 25% of the TOC results were qualified as estimated ("J") due to potential sample degradation as a result of exceeding the recommended analysis holding time. The affected TOC results are usable as estimated values that may be biased low. In addition, a continuing calibration verification (CCV) exceeded the upper limit o f the recovery criteria range (80 to120%). Therefore, approximately 14% of the TOC results were qualified as estimated ("J"). The affected TOC results are usable as estimated values that may be biased high.

B.5.2 Precision

Laboratory duplicate analyses were not performed for TOC analyses. Precision evaluation was still made possible because all samples were analyzed in duplicate as required by the 1986 version of the Lloyd Kahn method. Quality control criteria for these duplicate analyses were set forth in a memorandum from TAMS Consultants dated February 18, 1994.

The precision of the TOC results was compromised for approximately 18% of the results due to poor replicate precision (RPDs were > 25% but $\leq$ 100%). The affected TOC results were usable as estimated values, but a bias could not be determined. One TOC result was rejected (R) because uncertainty in quantitation existed based upon extremely poor replicate precision (RPD > 100%). The result is unusable for project objectives.

B.5.3 Sensitivity

Sensitivity issues affecting the TOC analyses, in terms of blank evaluation and detection limits, were not noted during the usability assessment. All blank results were < 0.01% TOC.

B.5.4 Representativeness

One field duplicate sample was associated with the TOC analyses. The precision criterion of RPD < 100% was met for this analysis; the RPD for the duplicate pair analyzed was 25.5%. Frequency criteria for field duplicate analyses were not met, but, since all samples were analyzed in duplicate, precision evaluation was still possible.

B.5.5 Summary of Data Usability

Approximately 48% of the TOC results were qualified as estimated ("J") due to QC exceedances including holding time exceedances, high CCV recovery, and laboratory duplicate imprecision. The results are usable as estimated values. All TOC results are usable with the exception of one result, which was considered unusable (rejected) due to severely poor replicate precision. Therefore, overall completeness for low resolution sediment core TOC analyses is 96.3% meeting the project DQO for completeness. Summary statistics for TOC are presented in Table B-1.

B.6 RADIONUCLIDE ANALYSES

Radionuclide analysis was performed on all low resolution sediment core sections to establish sediment core chronology. Dried and homogenized sediment aliquots were analyzed for several principal radionuclides by B&W Nuclear Environmental Services, Inc., in Parks Township, PA and Lynchburg, VA. For the Phase 2B investigation, only beryllium-7 (^{7}Be) and cesium-137 (^{137}Cs) were validated and assessed for data usability. The top sediment core slices were only analyzed for ^{7}Be. All sediment core slices were analyzed for ^{137}Cs.

Several issues may have affected the overall usability of the radionuclide data: small sample size; exceeded holding times for ^{7}Be; sample density and geometry differences; the presence of wood chips in the samples; and blank and background corrections.

The first core samples submitted for radionuclide analysis were of limited sample size, which affected the statistical counting error for the ^{7}Be results. The limited size and low ^{7}Be activity in the core samples resulted in statistical errors greater than the acceptable 10% maximum error specified in the QAPP. To reduce this error, the time of sample analysis was increased to up to 60 hours. (The QAPP stated that the samples were to be counted for 8 hours or until the statistical error was less than or equal to 10%.) As a result of the increased counting time, the holding times for the ^{7}Be samples were potentially compromised. Therefore, to produce usable data, TAMS/Gradient established an approach to the analysis of ^{7}Be (August 30, 1994). The samples could be counted for ^{7}Be for 8 to 24 hours as long as the statistical error was less than 40%. Otherwise, the samples were counted for 36 to a maximum of 48 hours to achieve a statistical error of less than 50%.

The calibration curves established for the radionuclide analysis were produced using Allegheny River sediment. Since B&W generated the calibration curve based on weights of the sediment in the cans rather than on the percent full, there was some concern that the Allegheny River sediment density was not comparable to the Hudson River sediment's density. In order to produce accurate results the geometries of the calibration standards and samples need to be comparable. B&W analyzed a Hudson River LCS to determine if the calibrations generated were acceptable. The study showed that there was no significant difference between the Allegheny River and Hudson River Sediments in the 59.5 Kev to the 898 Kev range (B&W, 1994). The study also indicated that there was no difference in matrix density.

The presence of wood chips in the samples could dilute the radionuclide activity by affecting the geometry of the sample; therefore, wood chips were removed from most of the samples prior to counting. Some of the initial samples received by B&W were prepared and analyzed with the wood chips retained in the sample. This issue is further addressed in the accuracy section, B.6.1, below.

The radionuclide method requires that activities (results) be corrected for background, blanks, the radionuclide branching ratio, the efficiency geometry of the detector, and for radionuclide specific decay.

TAMS/Gradient established validation criteria for radionuclides to verify that sample results were accurate.

For the low resolution coring program, a total of 178 sediment samples (including 9 duplicates) were analyzed for radionuclides, generating 980 records (including field and laboratory duplicates). A total of 169 (178 less the 9 duplicates) validated samples (a total of 338 records for both ^{7}Be and ^{137}Cs) were reported in the project database.

B.6.1 Accuracy

The validator qualified as estimated ("J") sample results in a number of SDGs due to the lack of an associated Laboratory Control Sample (LCS) analyses for both ^{7}Be and ^{137}Cs. TAMS/Gradient concluded that this was not a technically appropriate reason to qualify the associated results because the lack of the associated QC sample did not impact the overall quality of the data. Therefore, the decision to qualify results due to lack of LCS analyses was reversed during the usability assessment.

The accuracy of some low resolution core samples was compromised due to the presence of wood chips in the samples. Approximately 20% of the low resolution core samples contained wood chips in a range of 10% to 90% by volume. The presence of wood chips could dilute the radionuclide activity by affecting the geometry of the sample; therefore, the wood chips were removed prior to counting. Some of the initial samples received by B&W were prepared and analyzed with the wood chips retained in the sample. The radionuclide activity results for the sample containing wood chips may be biased low compared to those samples in which the majority of the wood chips were removed prior to counting. No qualifications were made to the data during this usability assessment due to the qualitative nature of the results. Data from samples containing wood chips are clearly indicated as such in the project database.

There were no other issues affecting accuracy noted during the data usability assessment.

B.6.2 Precision

Precision, in terms of laboratory duplicate analyses, was met for all ^{7}Be and ^{137}Cs radionuclide analyses with the exception of four ^{7}Be laboratory duplicare analyses. This affected approximately 9% of the ^{7}Be samples, which were already estimated (J) due to statistical error exceedances. During validation some ^{137}Cs results were estimated because laboratory duplicate frequency was not met. During the usability assessment the TAMS/Gradient team reversed this decision. Therefore, no qualifications were made due to the lack of an associated laboratory duplicate.

B.6.3 Sensitivity

For radionuclide analyses, measured background counts were subtracted from sample counts prior to calculation of concentrations. In some cases, this resulted in negative concentration values, which should be considered zero for purposes of data interpretation. Low-level activities, for which the counting statistics show a high relative error (counting error of greater than 50% of the reported result), are also considered not significantly different from background. These evaluations were applied to the data during validation; therefore, some low-level positive values were considered to be not detected, *i.e.*, no activity, following data validation. Following background correction, of the 169 total records for each radionuclide, 70% and 16% of the ^{7}Be and ^{137}Cs radionuclide results, respectively, had activities significantly greater than background. These results were considered estimated (qualified J) due to statistical counting errors between 10% and 50%. Approximately 12% and 18% of the radionuclide results for ^{7}Be and ^{137}Cs, respectively, did not have low-level activities that were significantly above background due to statistical counting errors greater than 50%. Thus, these results were considered to be estimated and comparable to background activity (qualified UJ). The statistical counting errors, representing one standard deviation, have been maintained in the database to give the data user additional information regarding the uncertainty of the reported radionuclide activities.

In addition to the radionuclide results that were reported with activities and statistical errors, approximately 18% of the ^{7}Be and 52% of the ^{137}Cs results were qualified by the laboratory with a "LLD", meaning lower level of detection. During the assessment, the TAMS/Gradient team determined that these radionuclide results did not have reportable activities above background and thus were considered to be detection limits (qualified U).

B.6.4 Representativeness

Field duplicate pairs were collected for radionuclide analyses. However, representativeness for these data is a qualitative indicator for radionuclide analyses, rather than a quantitative indicator. Therefore, the field duplicate data were reviewed for consistency, *i.e.*, to verify that radionuclides which were not detected in samples were also not detected in the field duplicate sample. All of the nine ^{7}Be and the eight ^{137}Cs field duplicate pairs exhibited consistent results, with the exception of LH-39M-0001. In that sample, ^{7}Be was detected (412 pCi/Kg) but was not detected in the field duplicate sample (less than the LLD [458 pCi/Kg]), and qualified "U"). No actions were required, since the the results are comparable.

B.6.5 Summary of Data Usability Assessment

Based upon QA oversight during analysis and review of radionuclide calibrations, data packages, and data validation reports, all ^{7}Be and ^{137}Cs results were considered usable by TAMS/Gradient. Approximately 82% of the ^{7}Be and 17% of the ^{137}Cs results were qualified (estimated J) due to statistical counting errors and imprecision. The results are usable as estimated values and detection limits. No ^{7}Be or ^{137}Cs radionuclide results were rejected (qualified R) during data validation or this data usability assessment. Therefore, completeness of 100% was achieved for these analyses, meeting the project DQO for completeness. Summary statistics for these analyses are presented in Table B-3.

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Table B-1
Low Resolution Sediment Non-PCB Sample Analysis Summary
Hudson River RI/FS PCB Reassessment

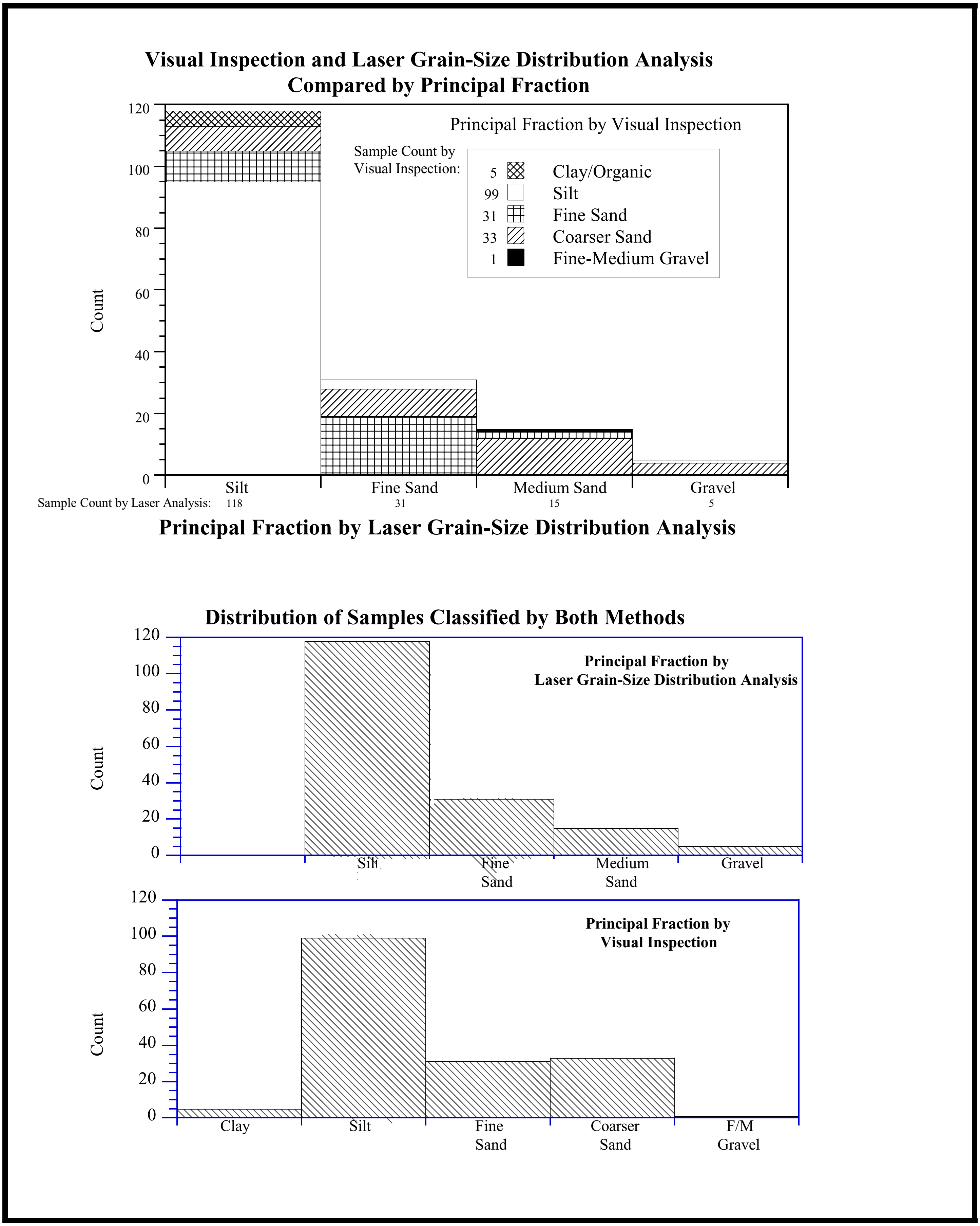
Parameter	Total Number of Results	Unqualified Nondetects	Estimated Nondetects	Unqualified Detects	Estimated Detects	Rejected Results	% Rejected
Clay% (Laser)	170	0	0	170	0	0	0%
Coarse Sand% (Laser)	170	0	0	170	0	0	0%
Fine Sand% (Laser)	170	0	0	170	0	0	0%
Geometric Mean Diame	170	0	0	170	0	0	0%
Gravel% (Laser)	170	0	0	170	0	0	0%
Median Diameter	170	0	0	170	0	0	0%
Medium Sand% (Laser)	170	0	0	170	0	0	0%
Silt% (Laser)	170	0	0	170	0	0	0%
Skewness (Laser)	170	0	0	170	0	0	0%
Sorting (Laser)	170	0	0	170	0	0	0%
TKN	27	0	0	23	4	0	0%
TOC	27	0	0	13	13	1	4%
Totals	1754	0	0	1736	17	1	0%

Table B-2
Low Resolution Sediment Sieve Grain Size Sample Analysis Summary
Hudson River RI/FS PCB Reassessment

Parameter	Total Number of Results	Unqualified Nondetects	Estimated Nondetects	Unqualified Detects	Estimated Detects	Rejected Results	% Rejected
<0.075 mm	143	0	0	0	143	0	0%
>0.075 mm	143	0	0	143	0	0	0%
>0.150 mm	143	0	0	143	0	0	0%
>0.425 mm	143	0	0	143	0	0	0%
>1.0 mm	143	0	0	143	0	0	0%
>1.4 mm	143	0	0	143	0	0	0%
>2.0 mm	143	0	0	143	0	0	0%
>4.0 mm	143	0	0	143	0	0	0%
>4.75 mm	143	0	0	143	0	0	0%
Coarse Sand % (Sieve)	143	0	0	143	0	0	0%
Fine Sand % (Sieve)	143	0	0	143	0	0	0%
Fines % (Sieve)	143	0	0	0	143	0	0%
Gravel % (Sieve)	143	0	0	143	0	0	0%
Largest >4.75 mm	143	0	0	143	0	0	0%
Medium Sand % (Sieve	143	0	0	143	0	0	0%
Totals	2145	0	0	1859	286	0	0%

Table B-3
Low Resolution Sediment Radionuclide Sample Analysis Summary
Hudson River RI/FS PCB Reassessment

Parameter	Total Number of Results	Unqualified Nondetect	Estimated Nondetects	Unqualified Detects	Estimated Detects	Rejected Results	% Rejected
Be-7	169	30	20	0	119	0	0%
Cs-137	169	88	31	23	27	0	0%
Totals	338	118	51	23	146	0	0%



Source: TAMS/Gradient Database, Release 3.5

TAMS

Figure B-1
Classification of Shallow Sediment Samples
Comparison of Visual Inspection and Laser Grain-Size Analytical Technique

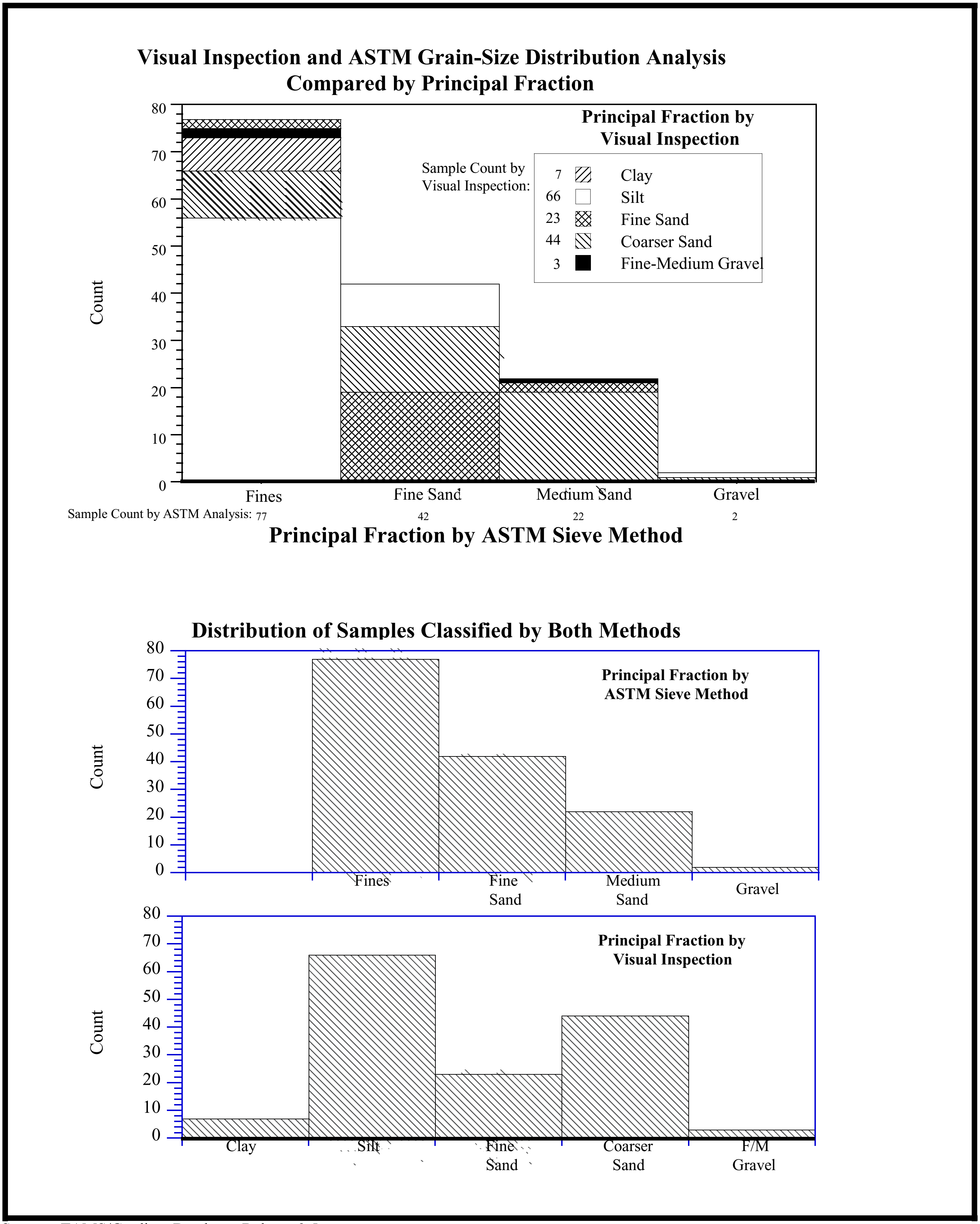


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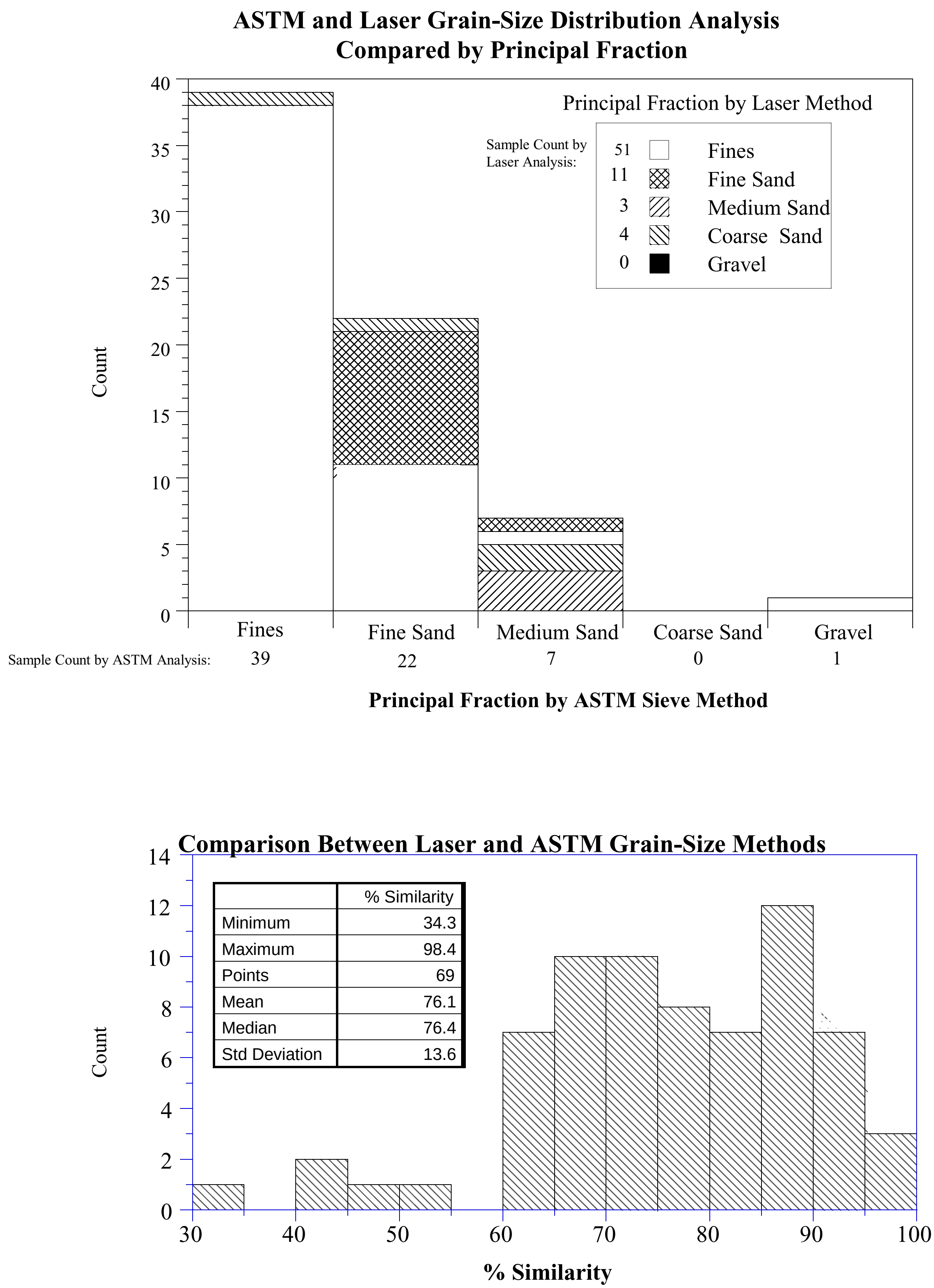
Figure B-2
Classification of Sediment Samples
Comparison of Visual Inspection and ASTM Grain-Size Analytical Techniques



Source: TAMS/Gradient Database, Release 3.5

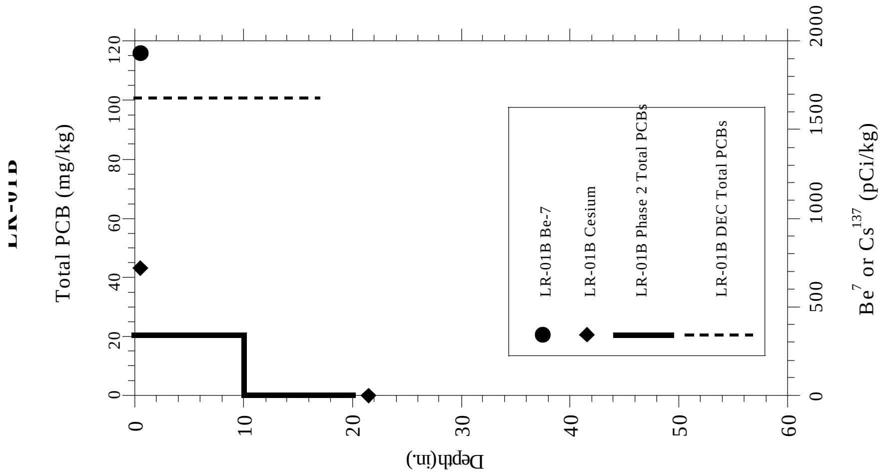
TAMS

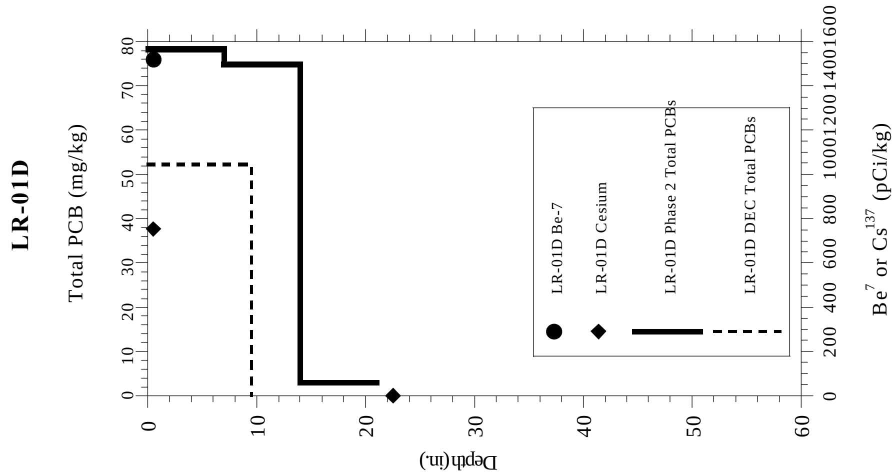
Figure B-3
Classification of Sediment Samples
Comparison of Grain-Size Analytical Techniques (ASTM and Laser Methods)

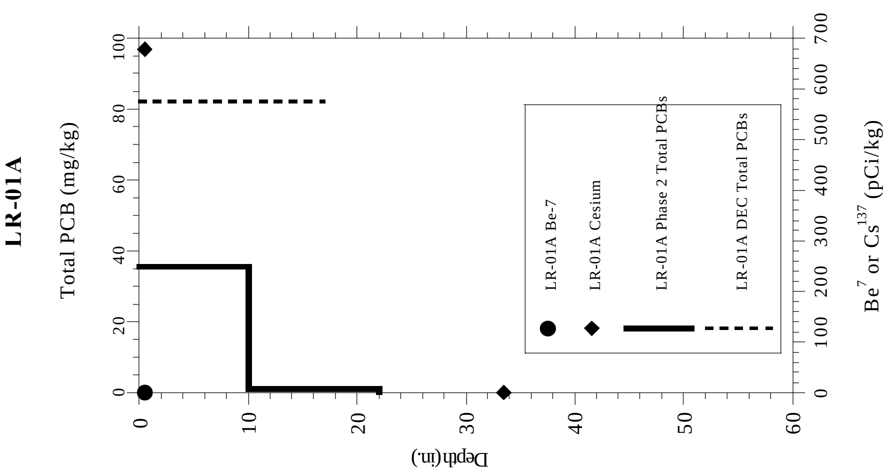
APPENDIX C

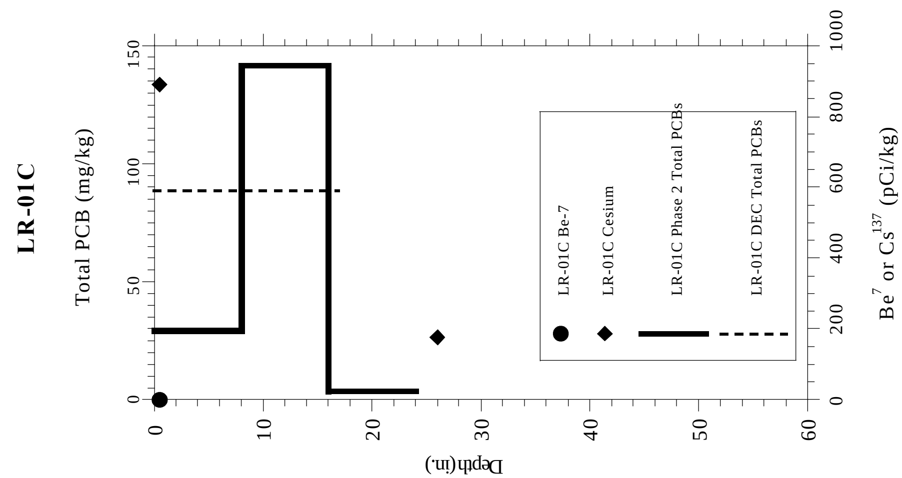
1994 LOW RESOLUTION CORE AND 1984 NYSDEC CORE PROFILES

FOR THE THOMPSON ISLAND POOL

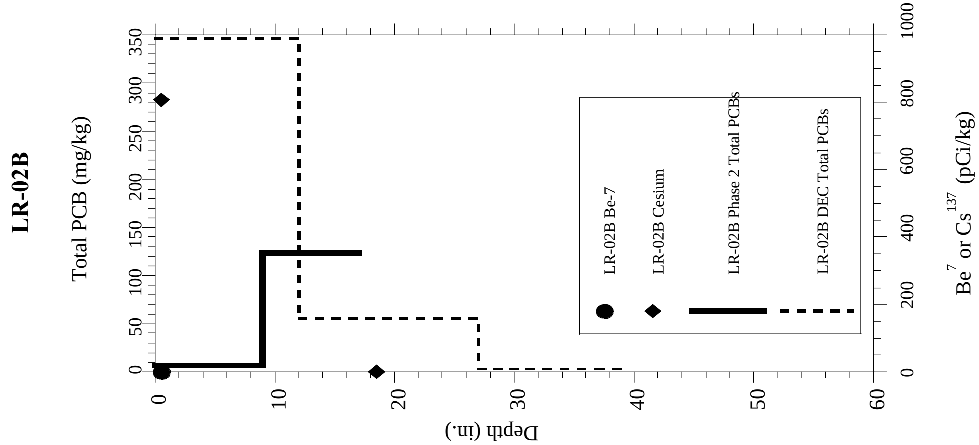


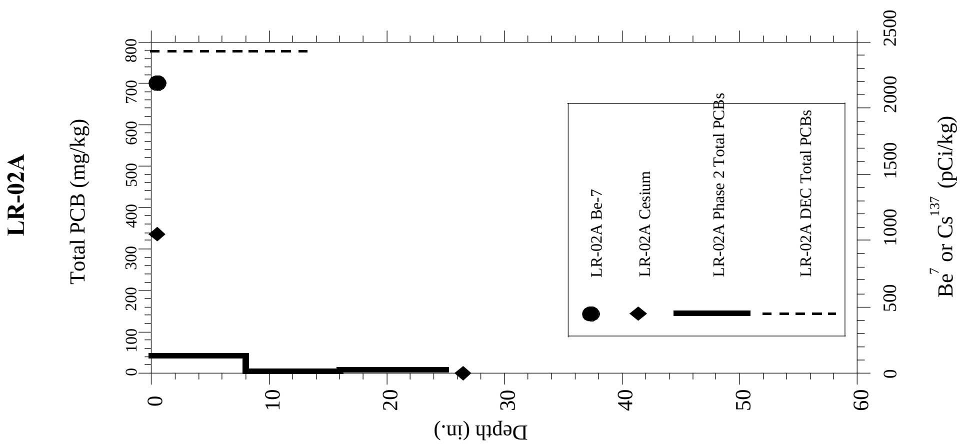


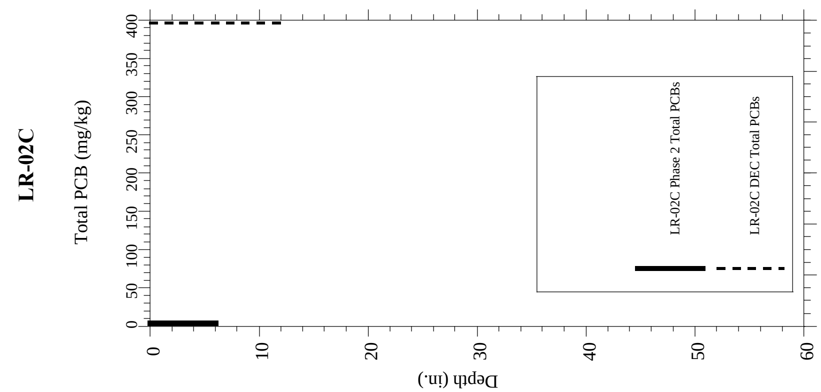




1994 Low Resolution Core and 1984 NYSDEC Core Profiles for the Thompson Island Pool







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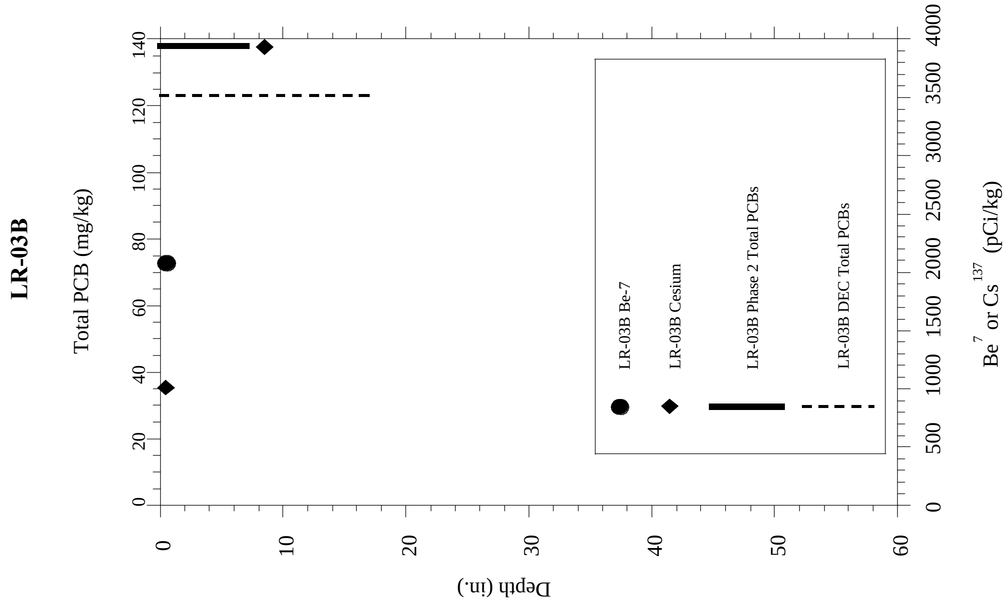

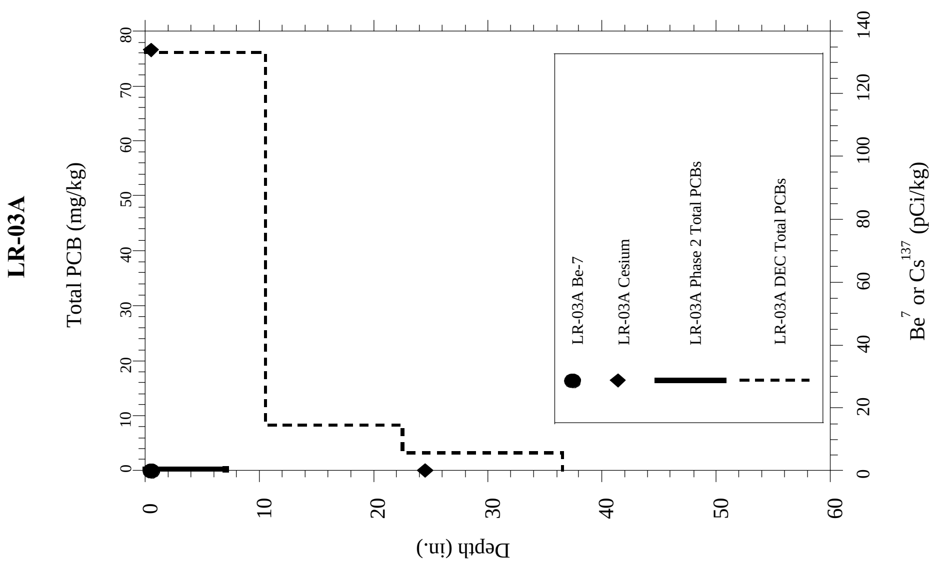

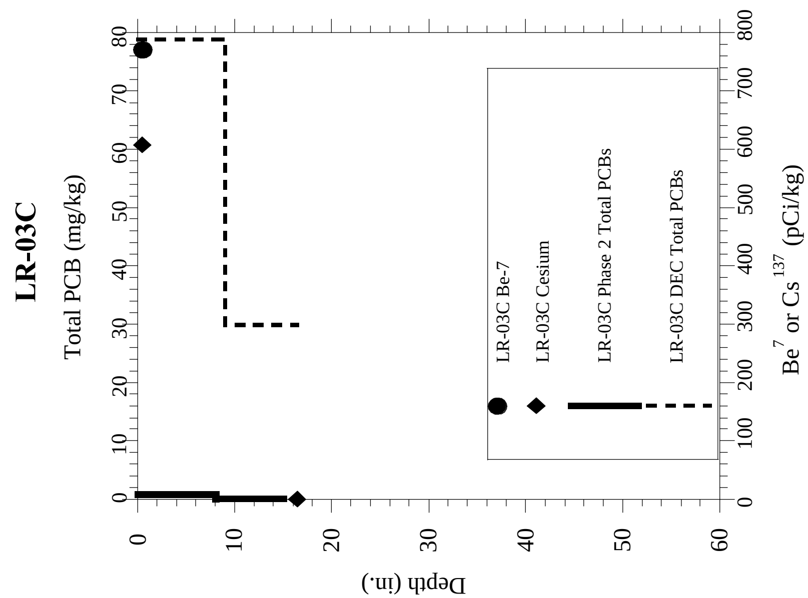

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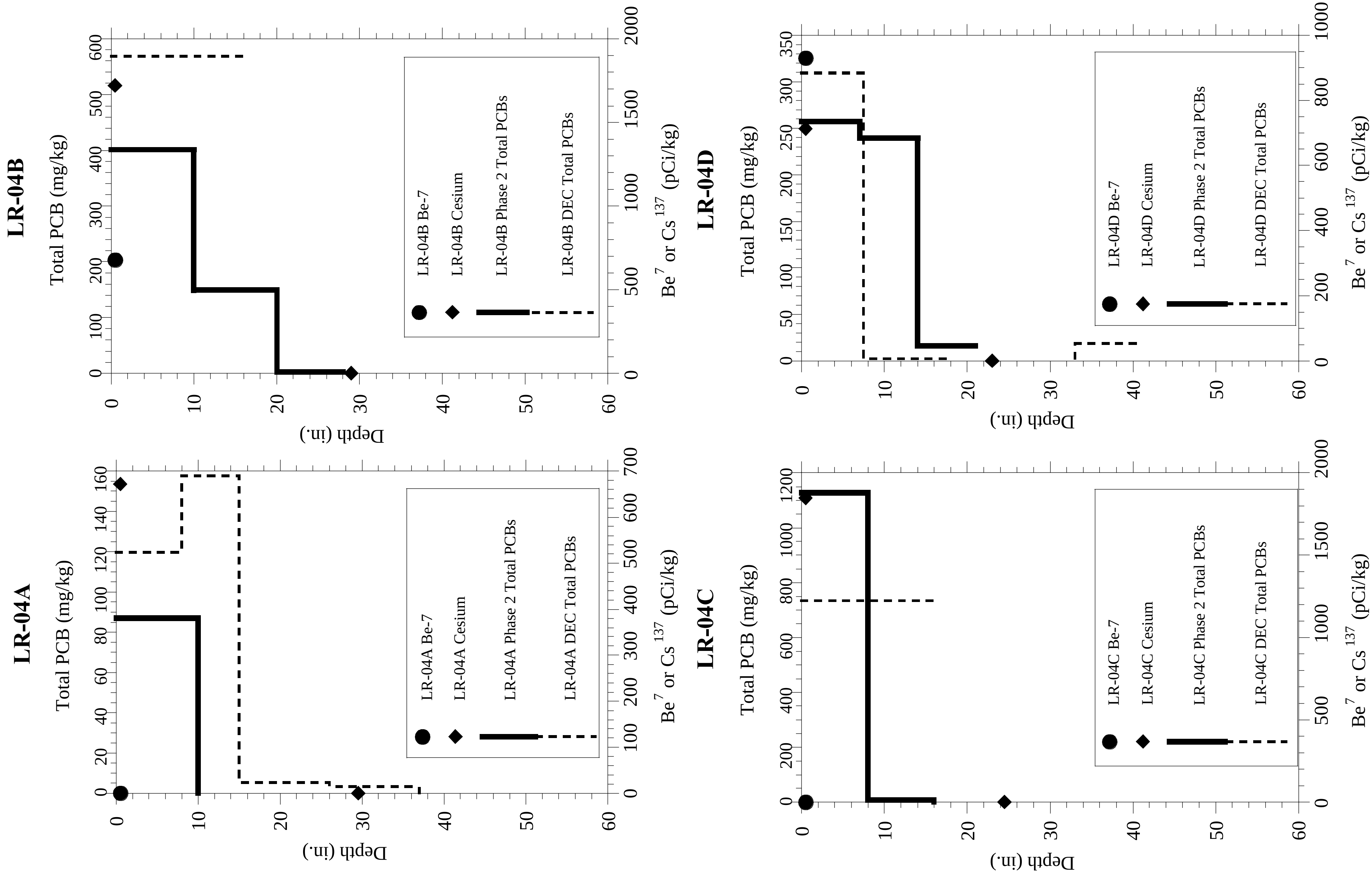

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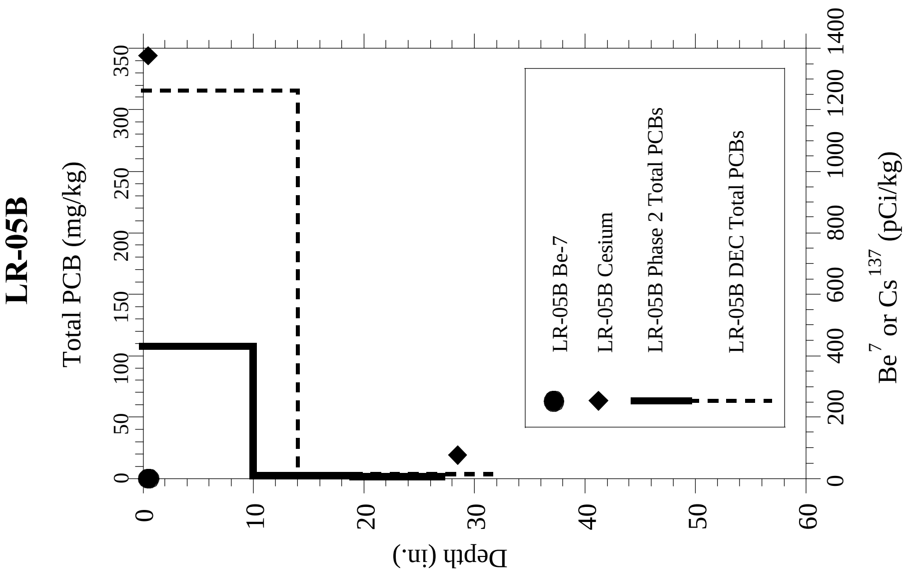

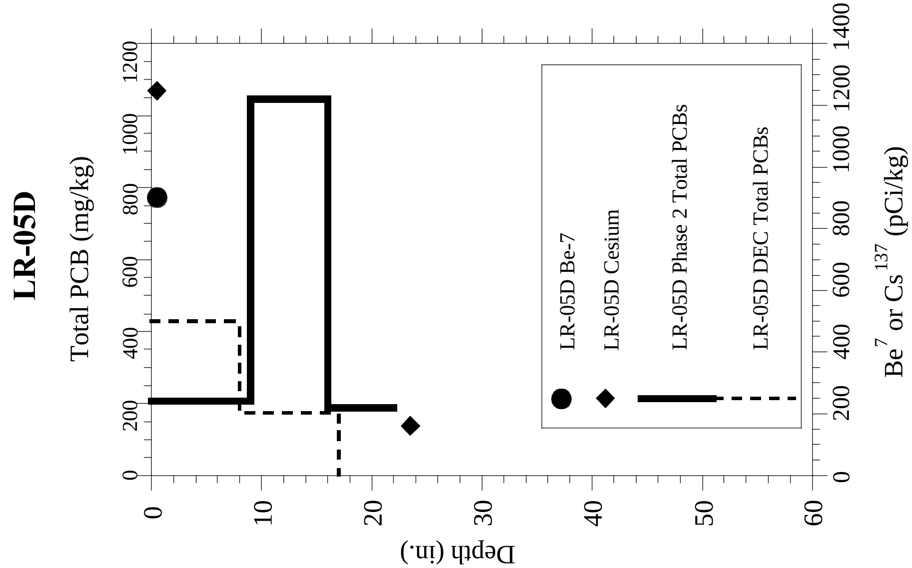

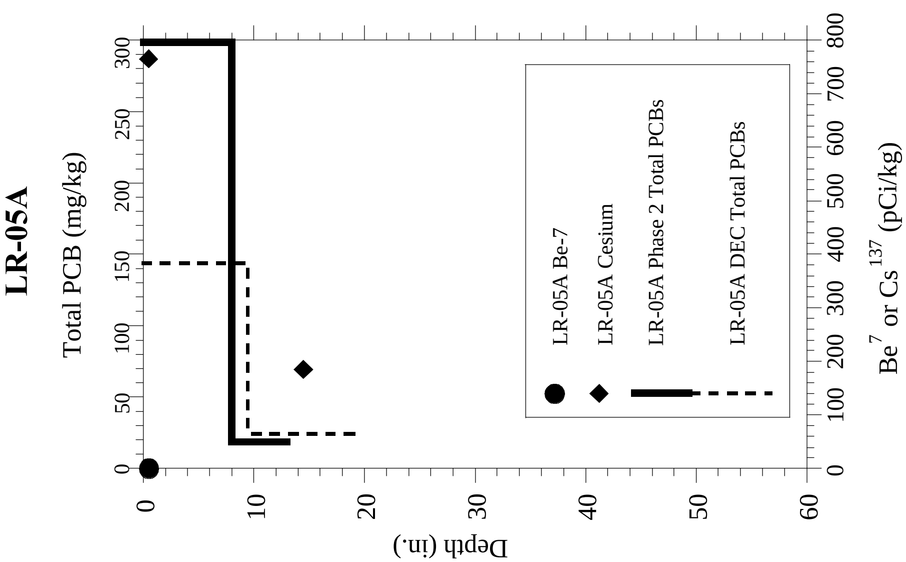

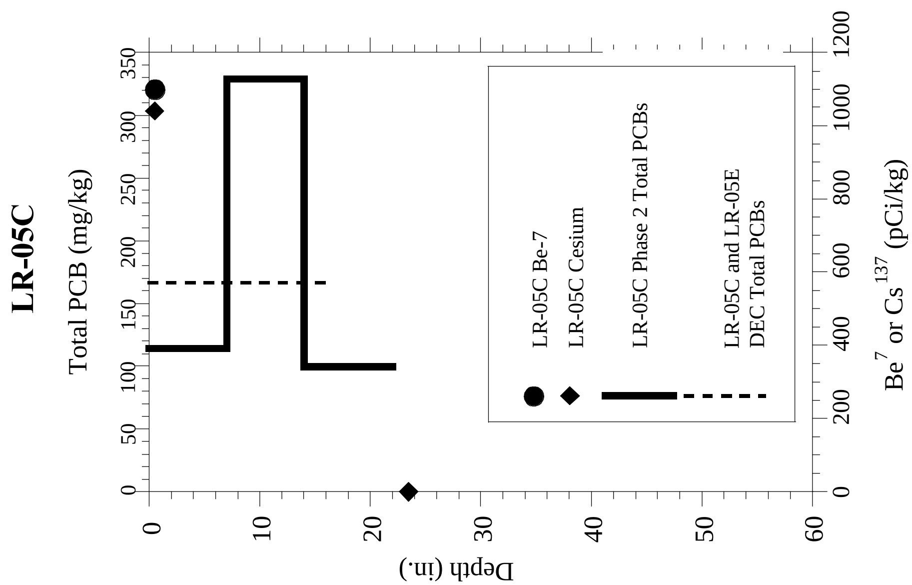

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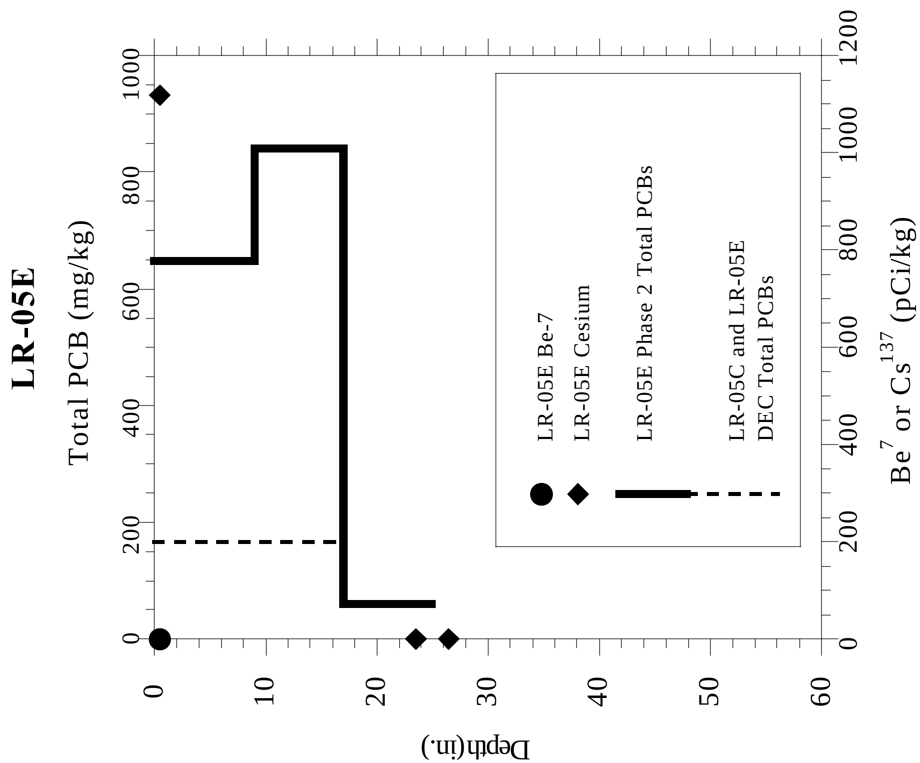

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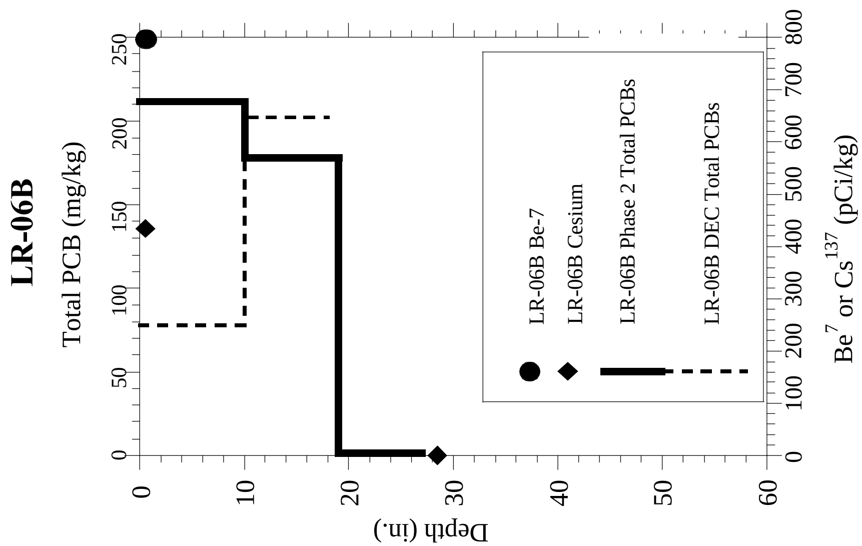

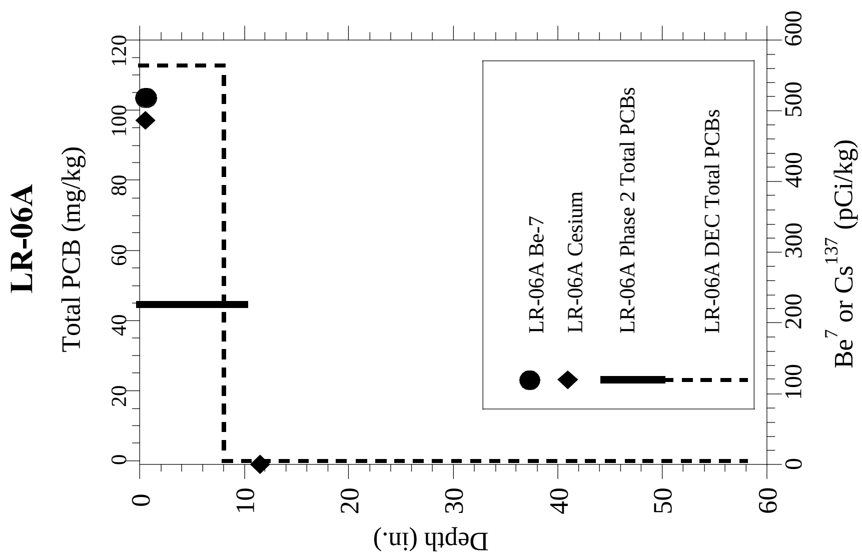

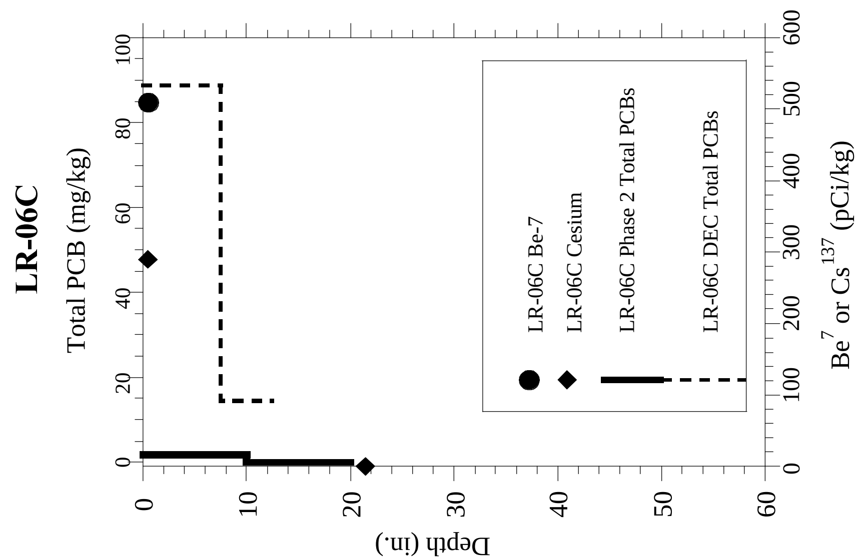

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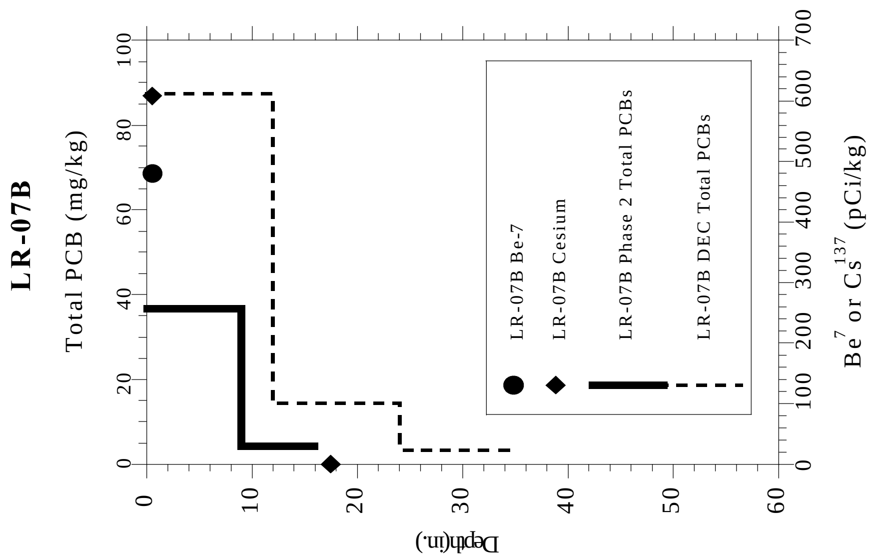

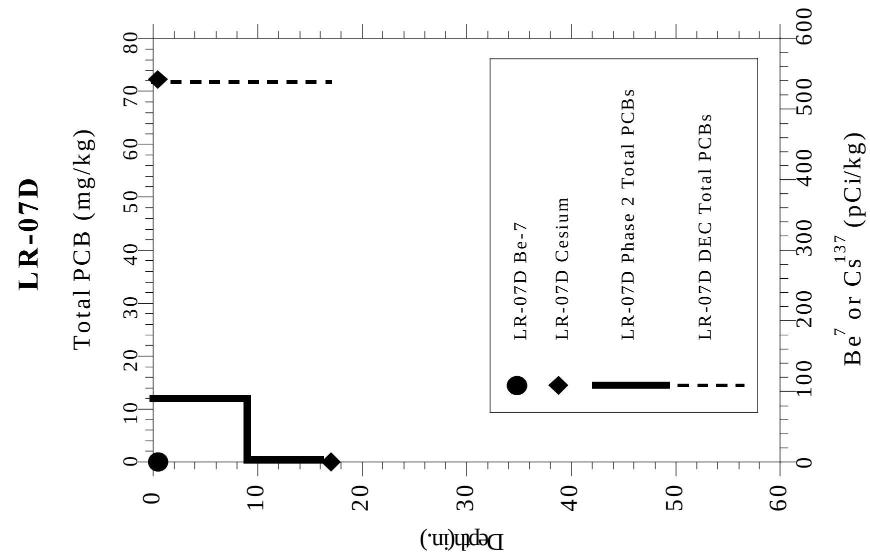

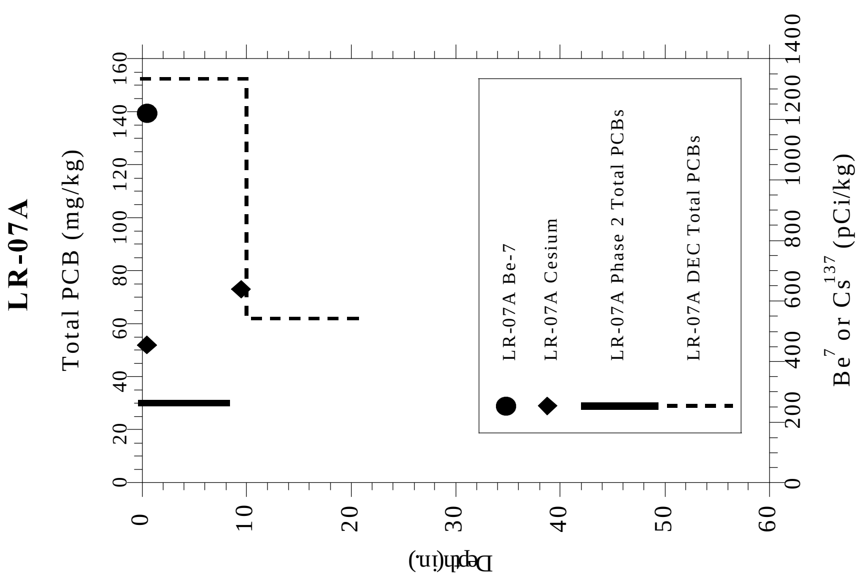

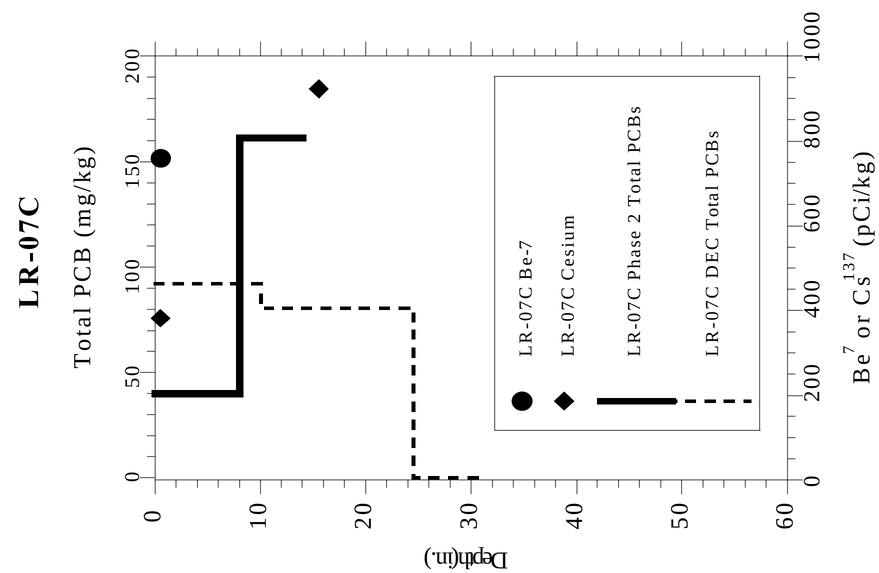

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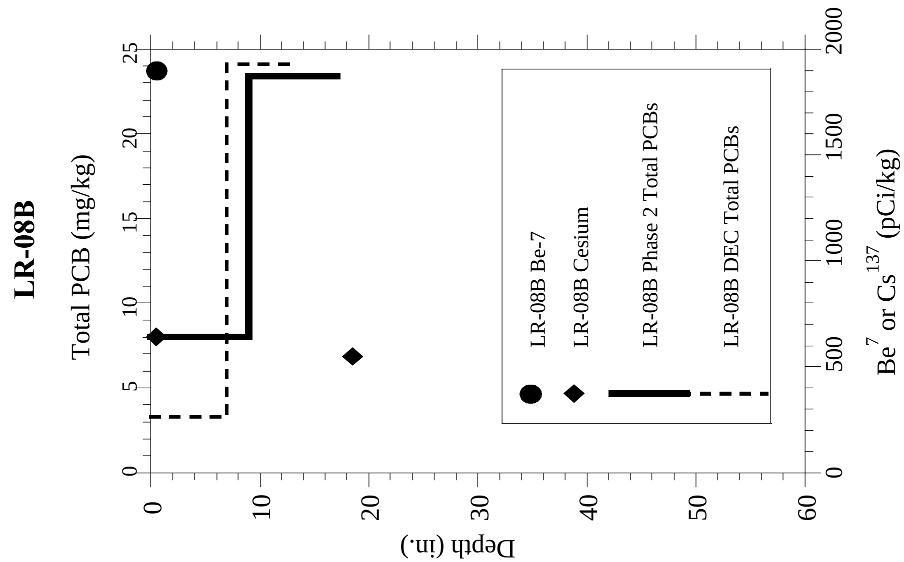

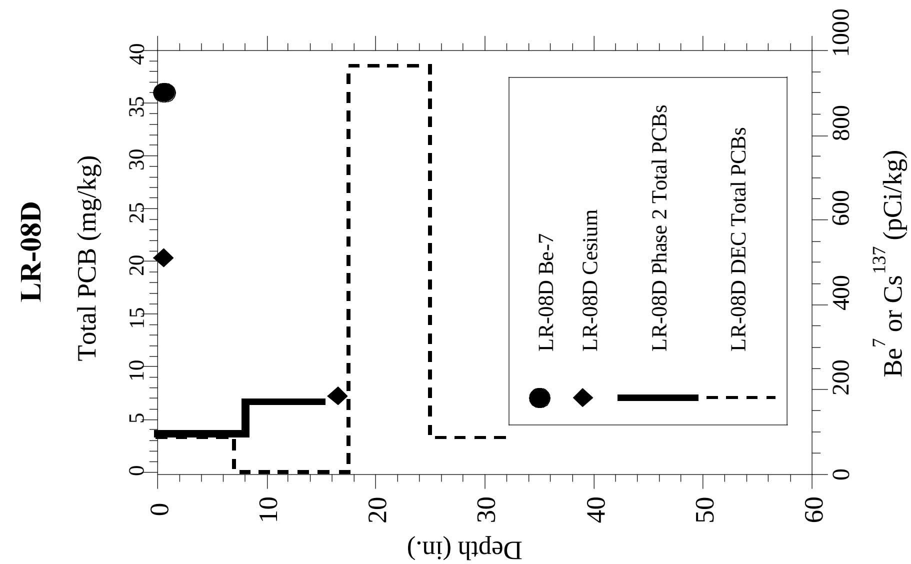

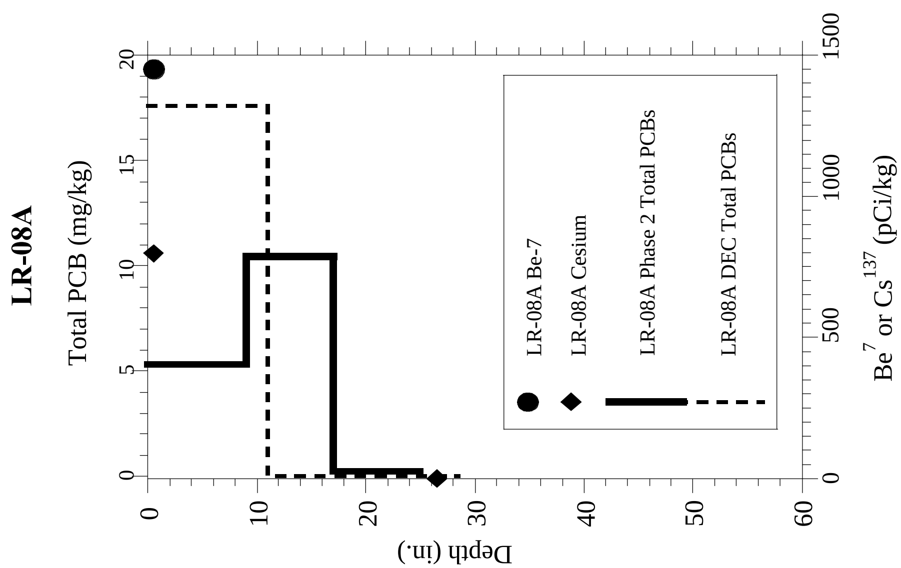

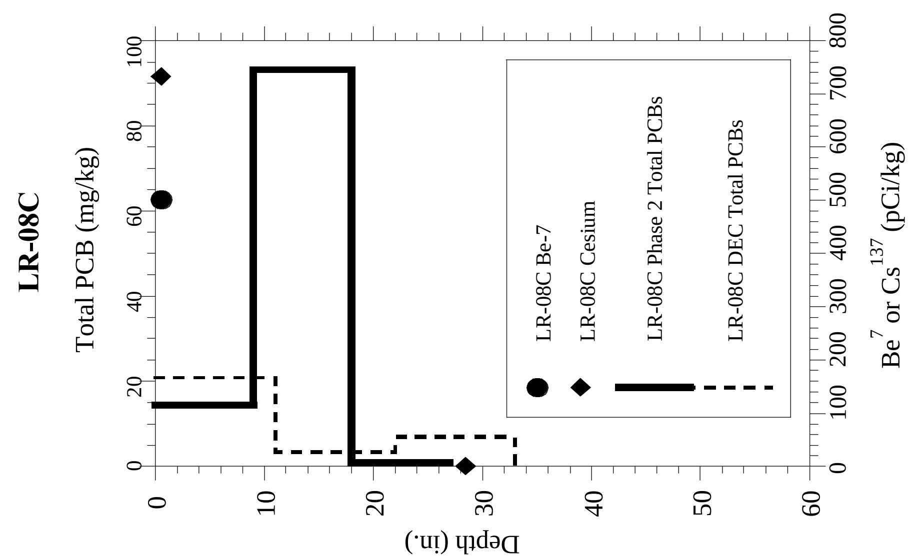

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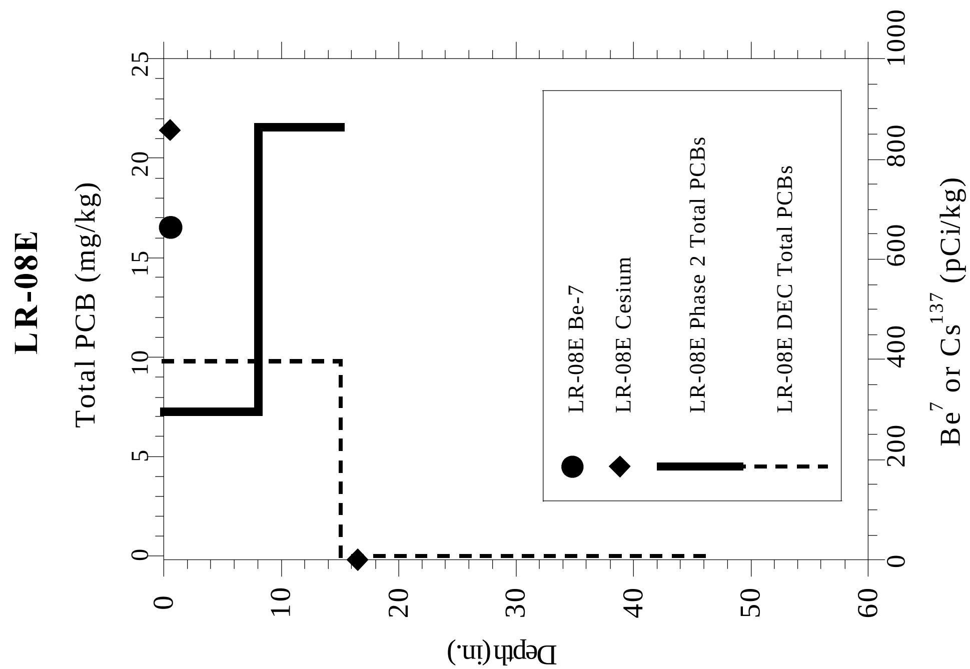

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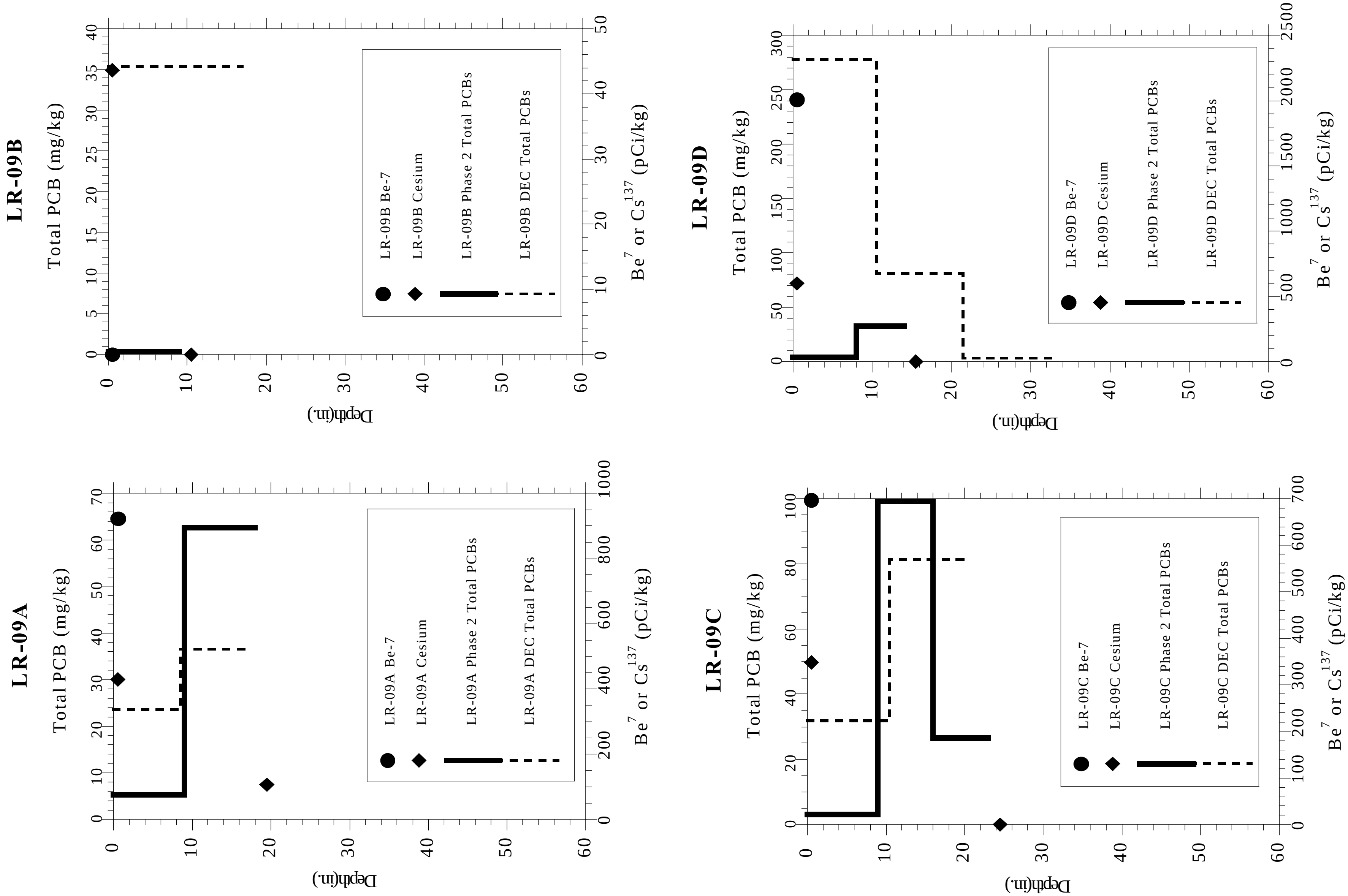

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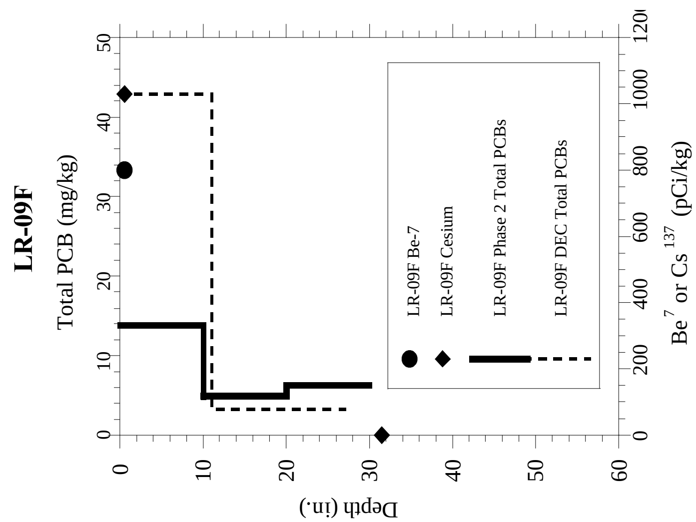

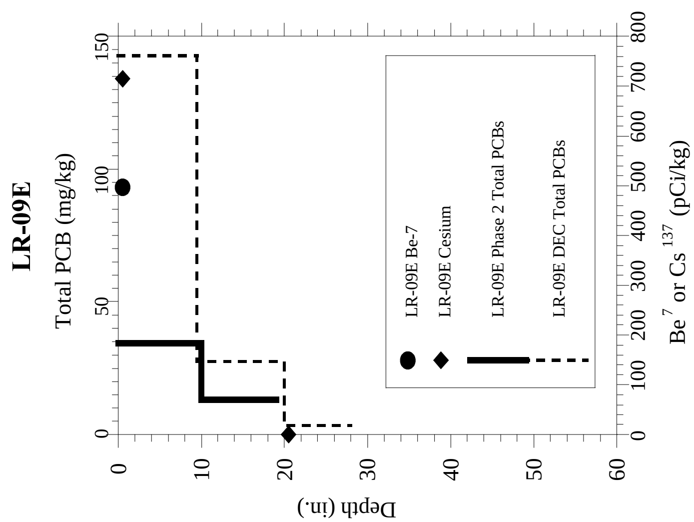

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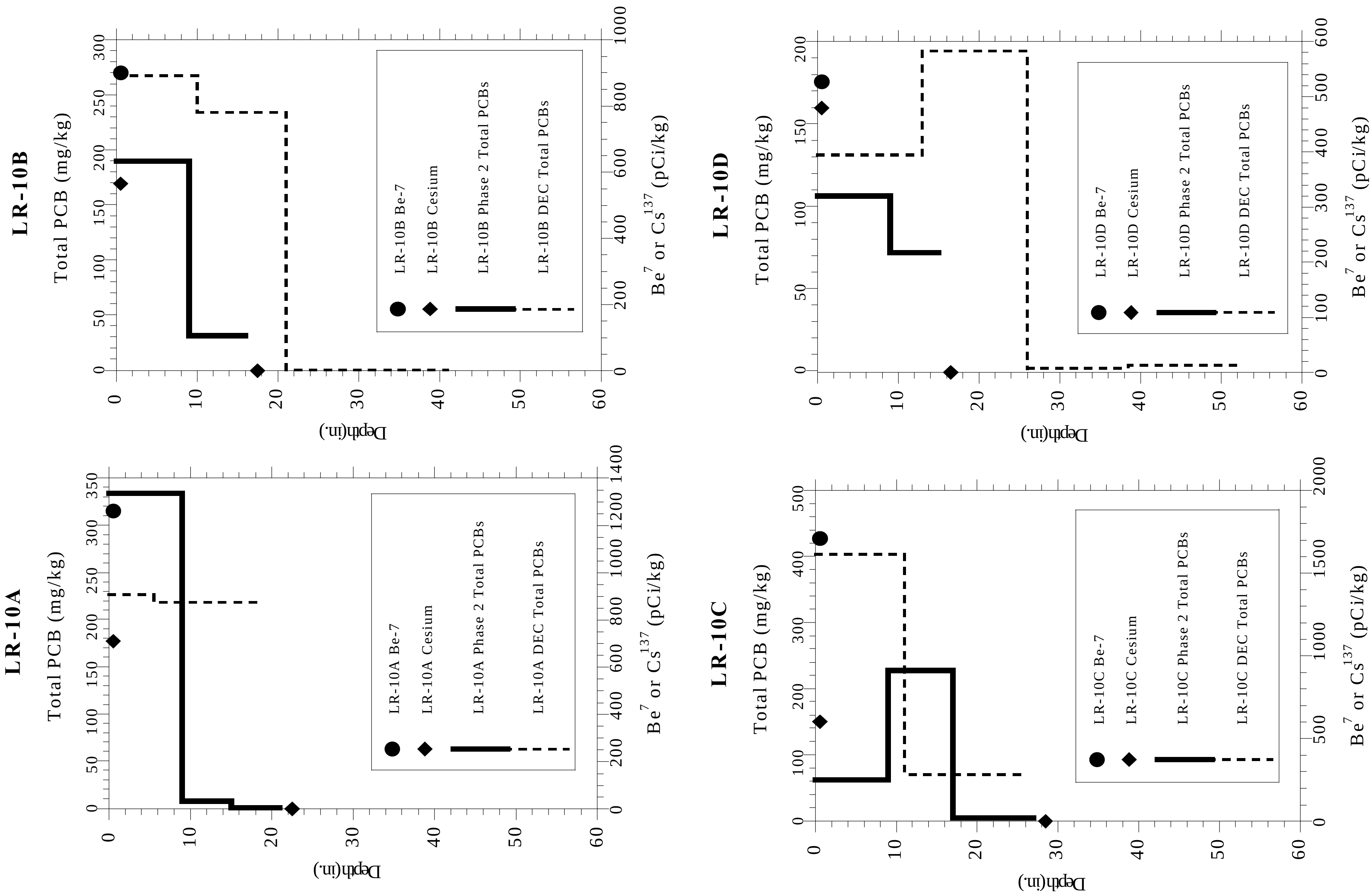

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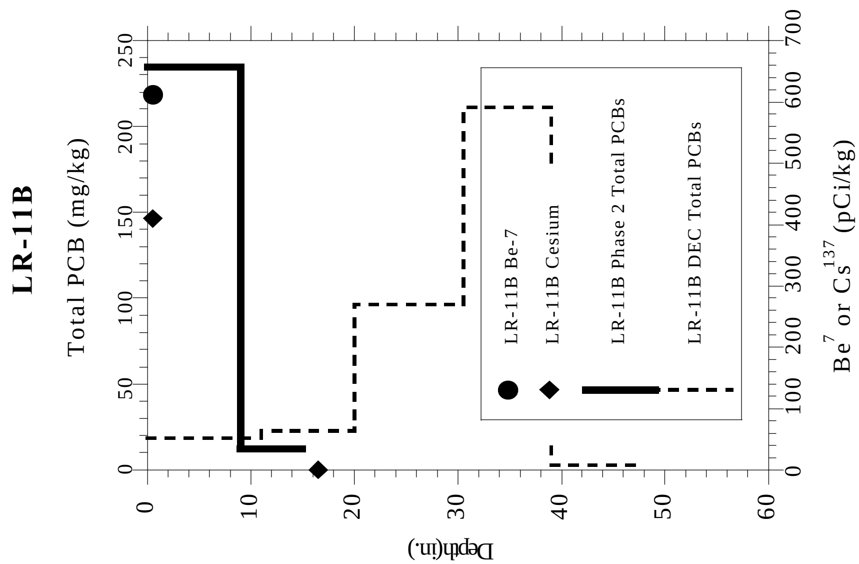

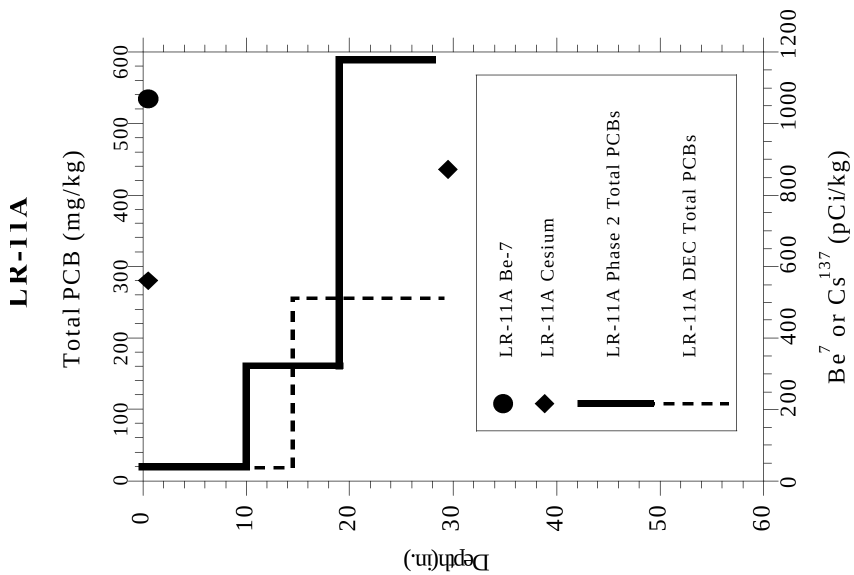

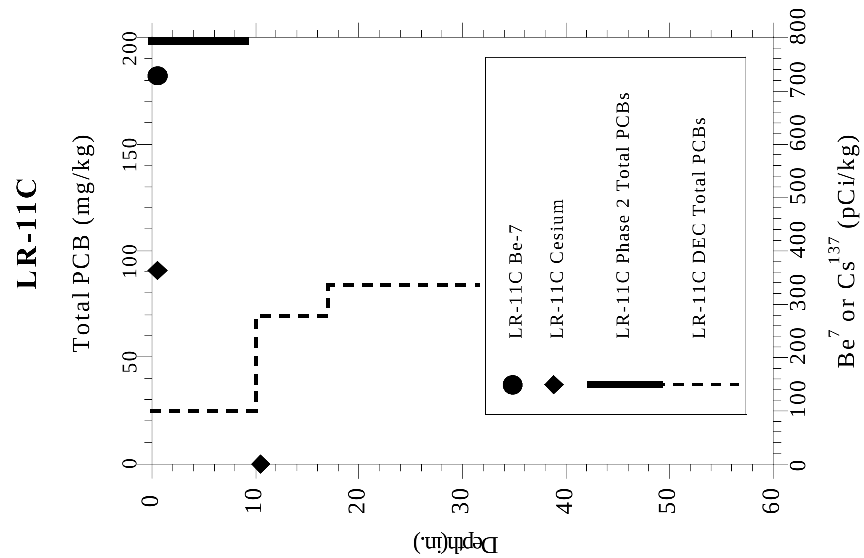

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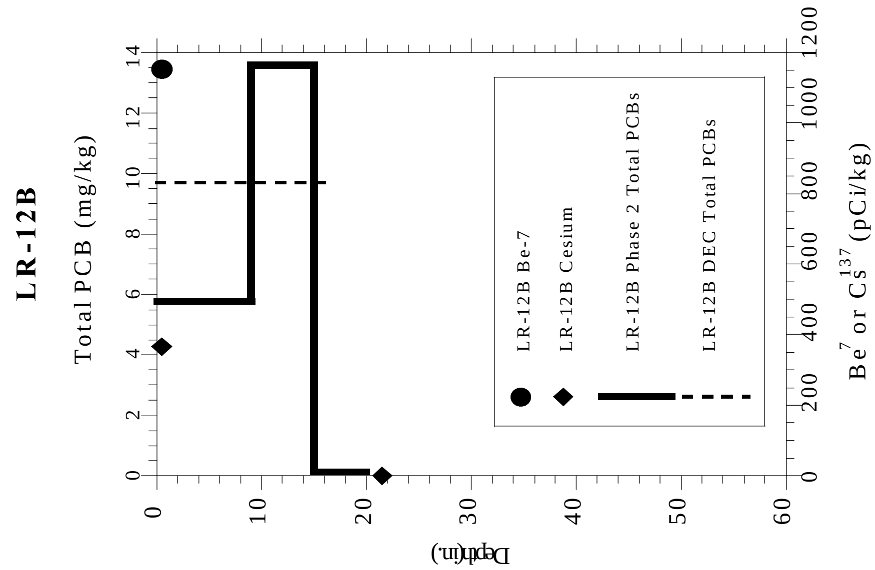
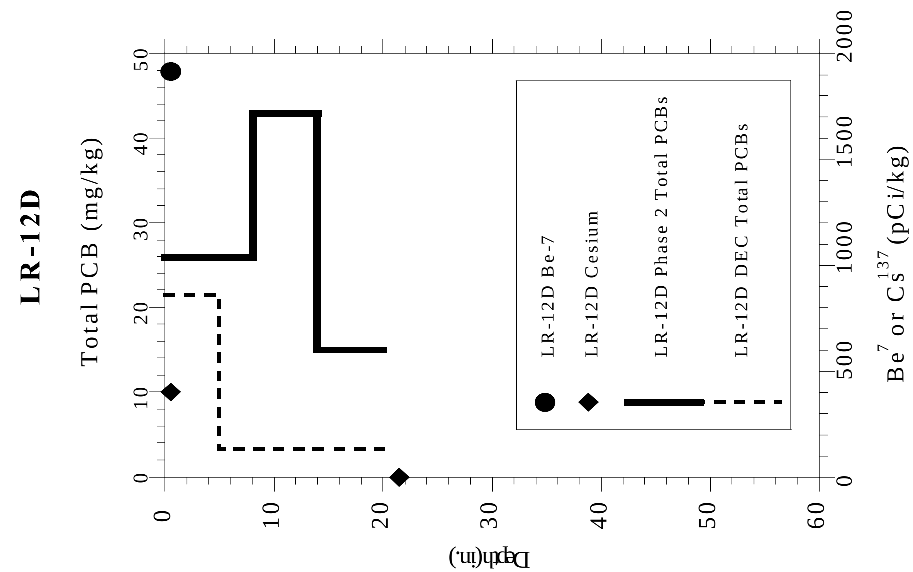
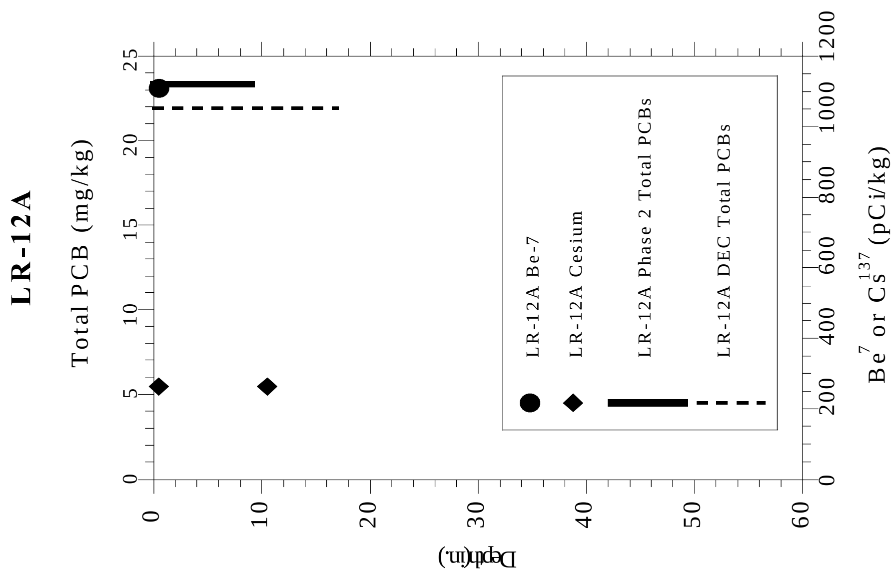
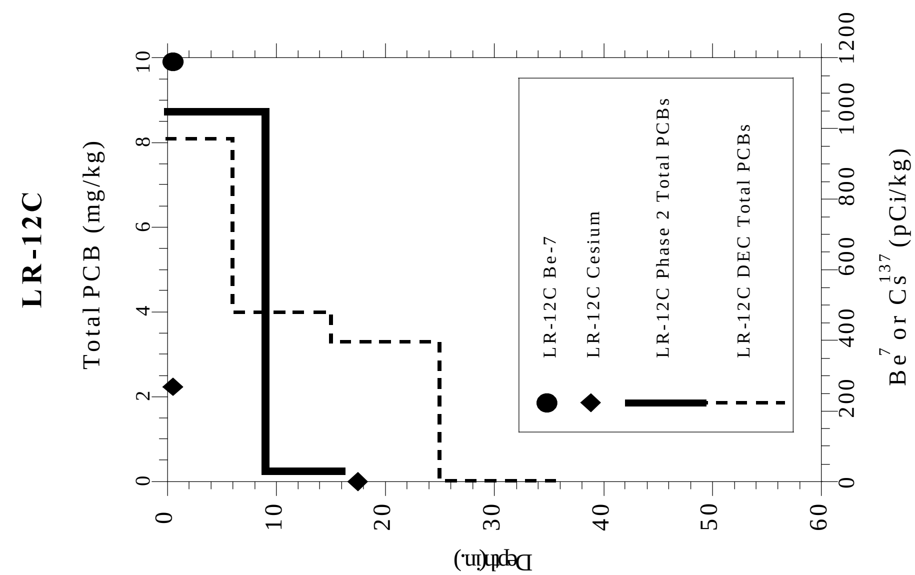
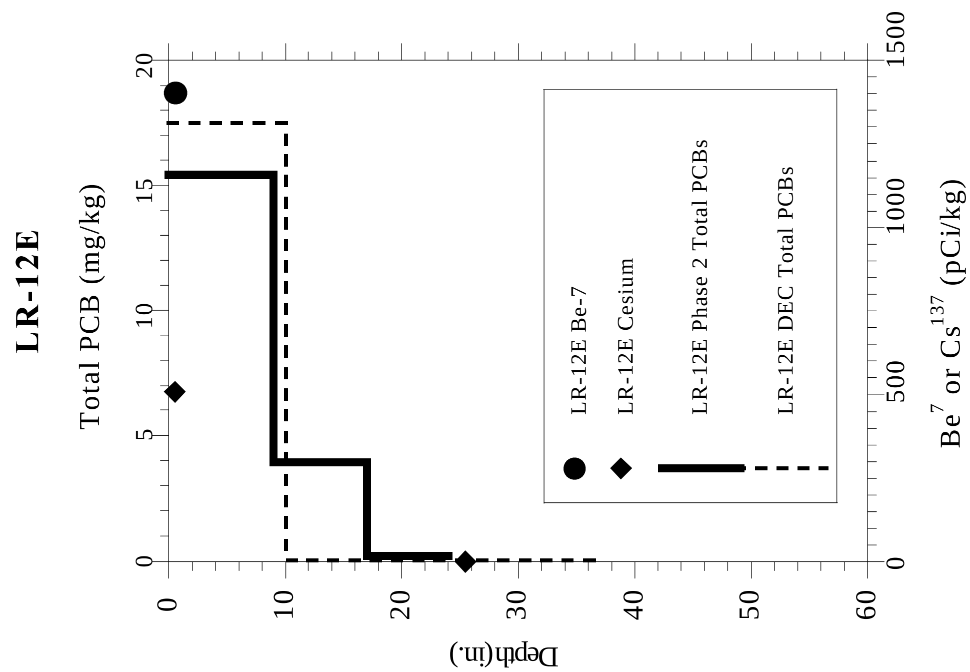




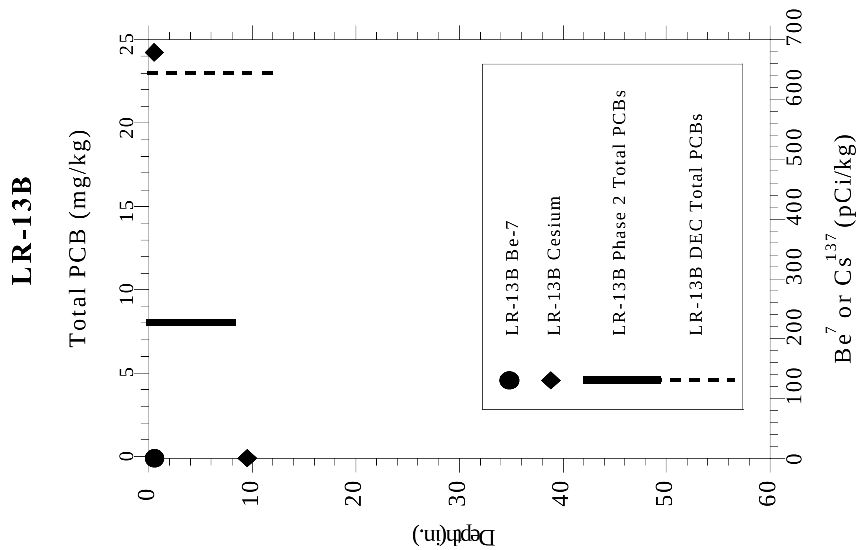


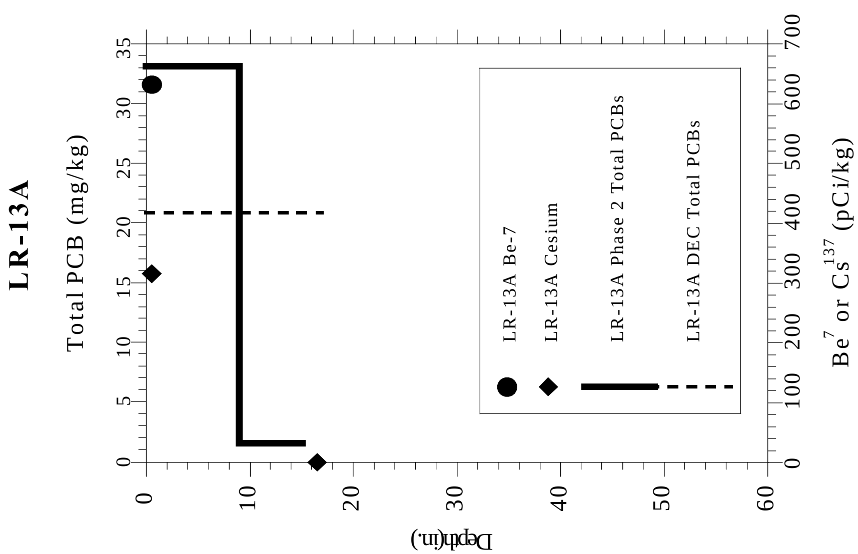


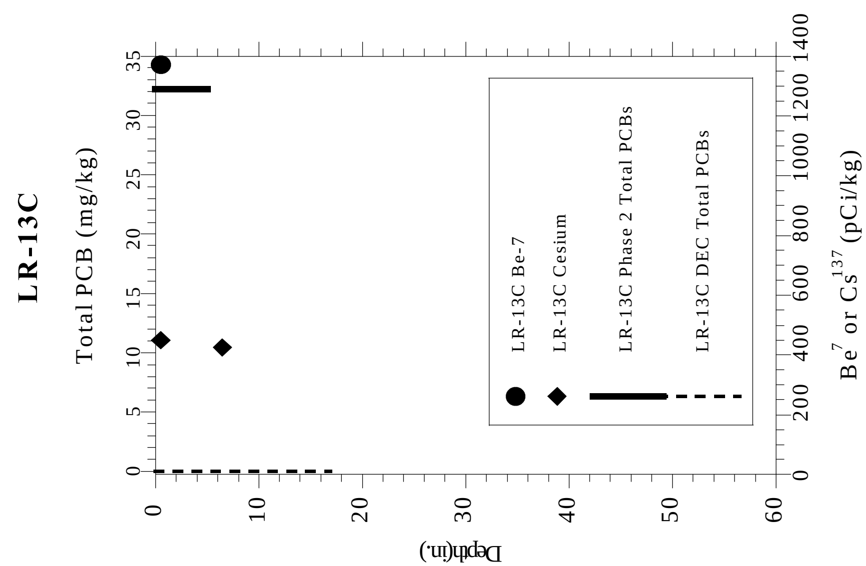
1994 Low Resolution Core and 1984 NTSDEC Core Profiles for the Thompson Island Pool



1994 Low Resolution Core and 1984 NTSDEC Core Profiles for the Thompson Island Pool







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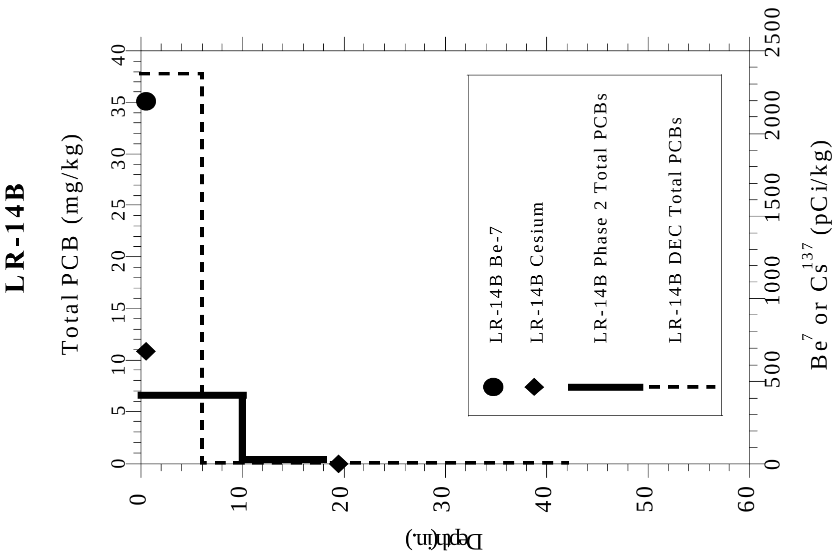

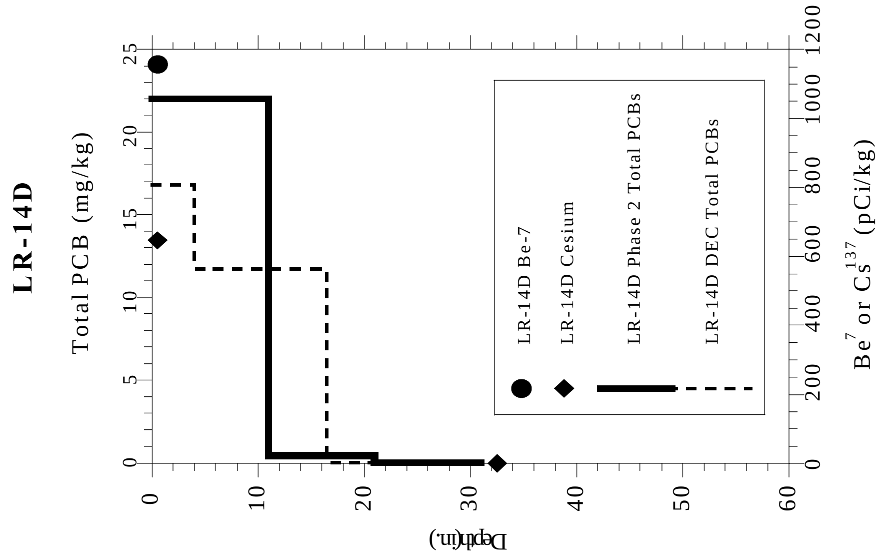

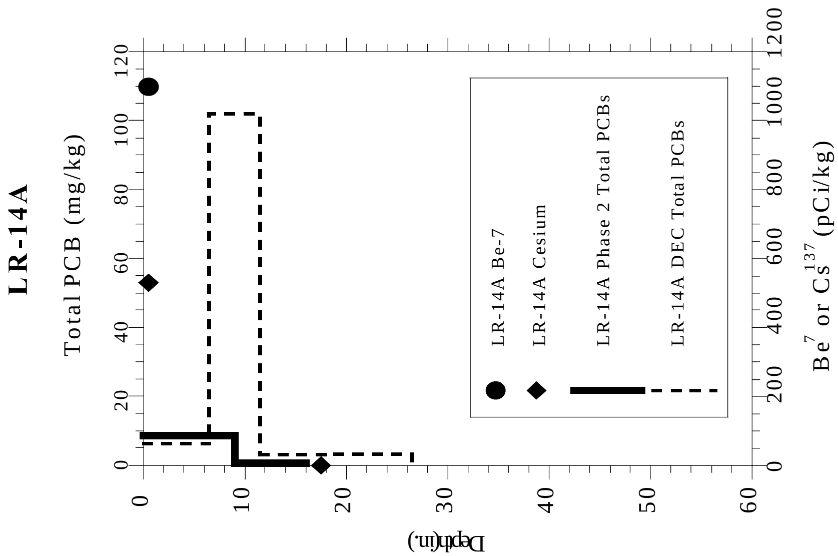

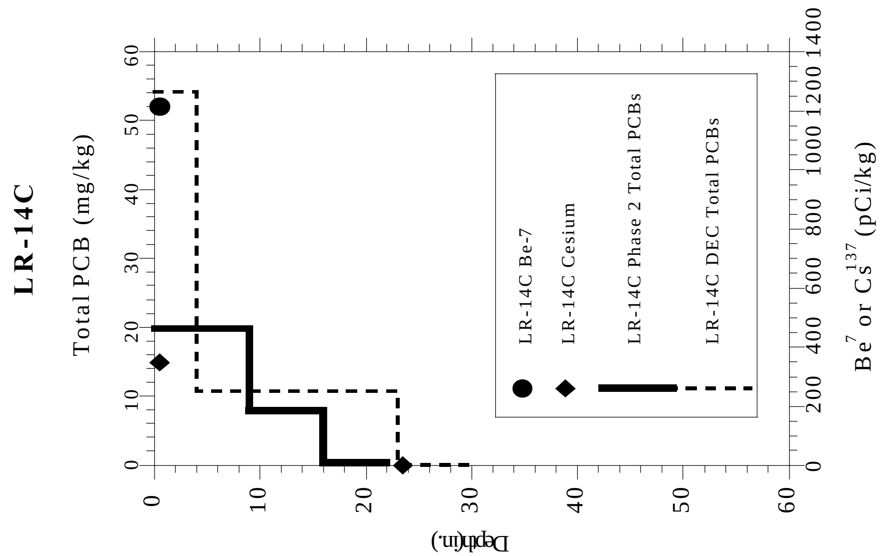

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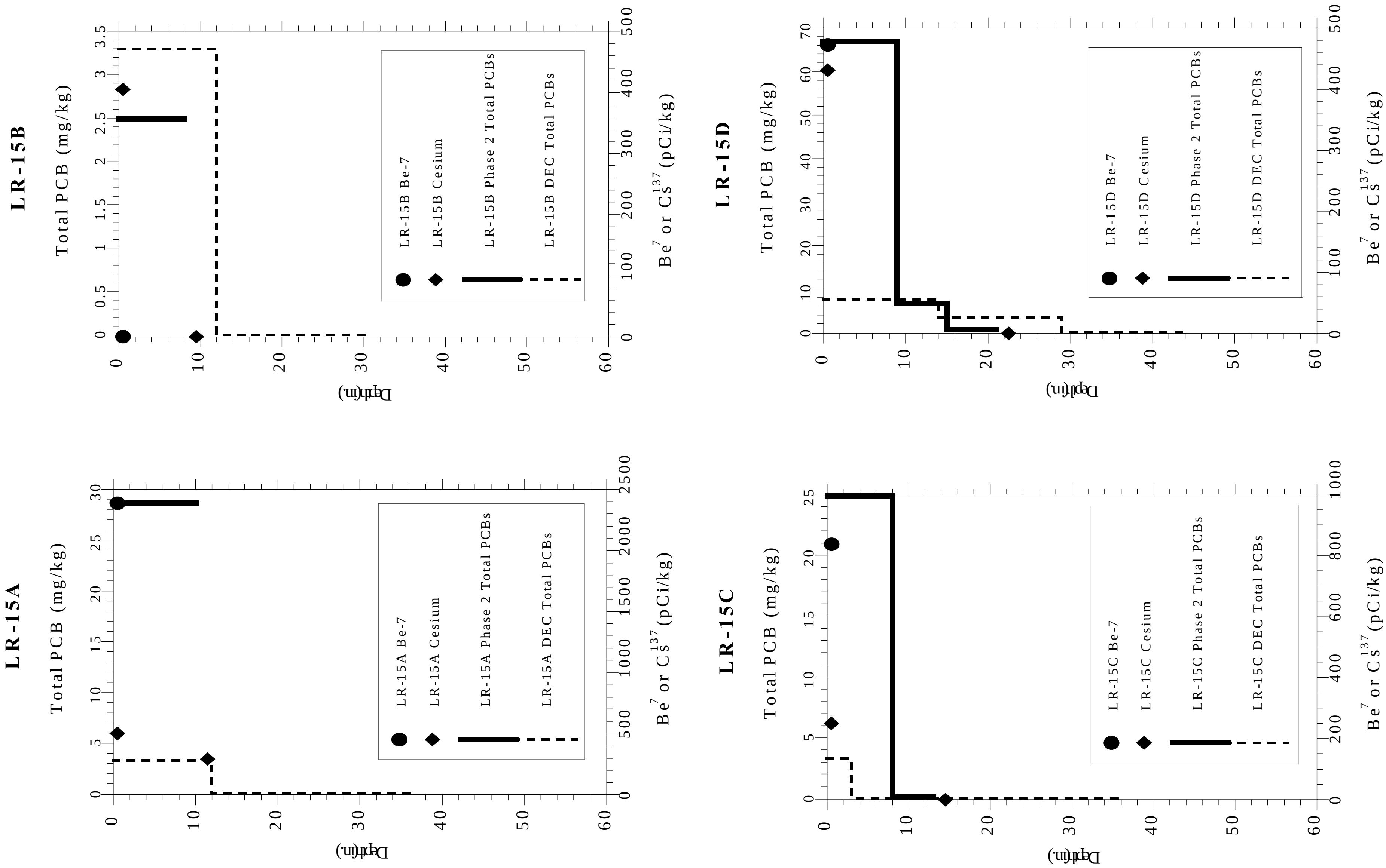

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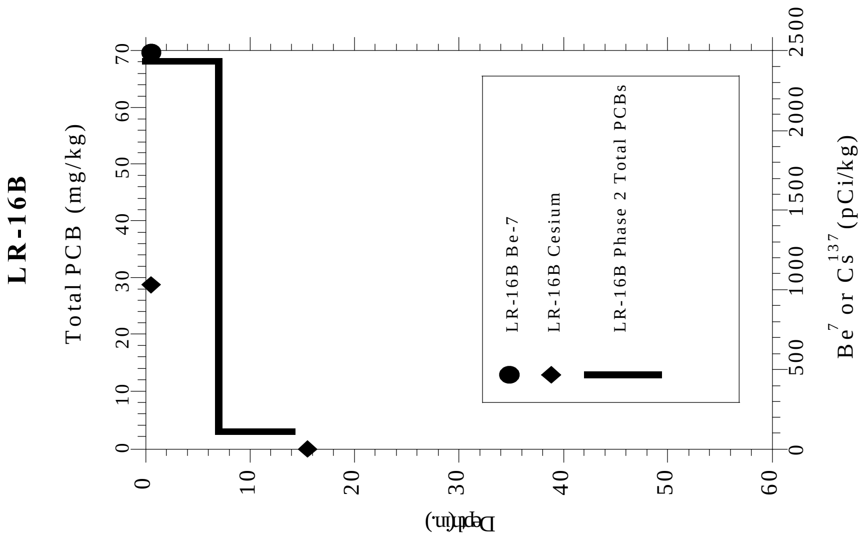

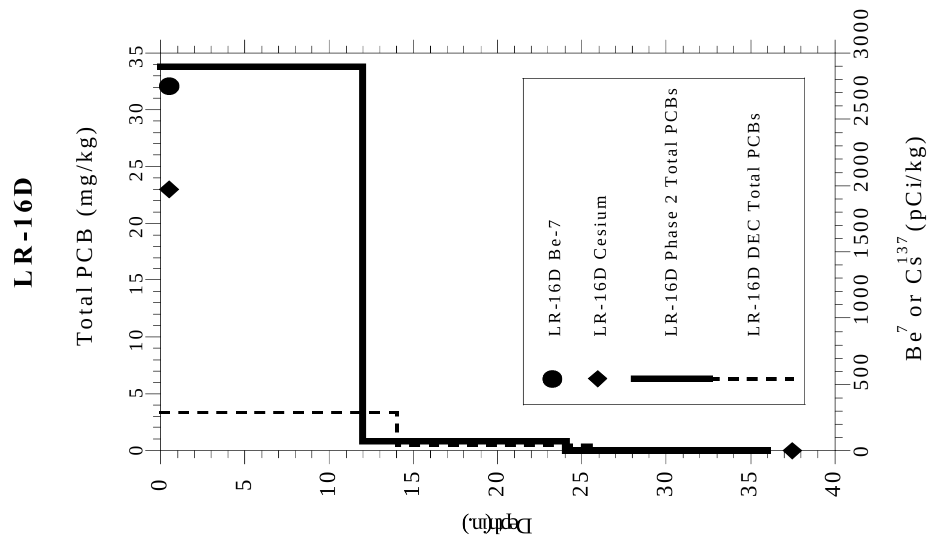

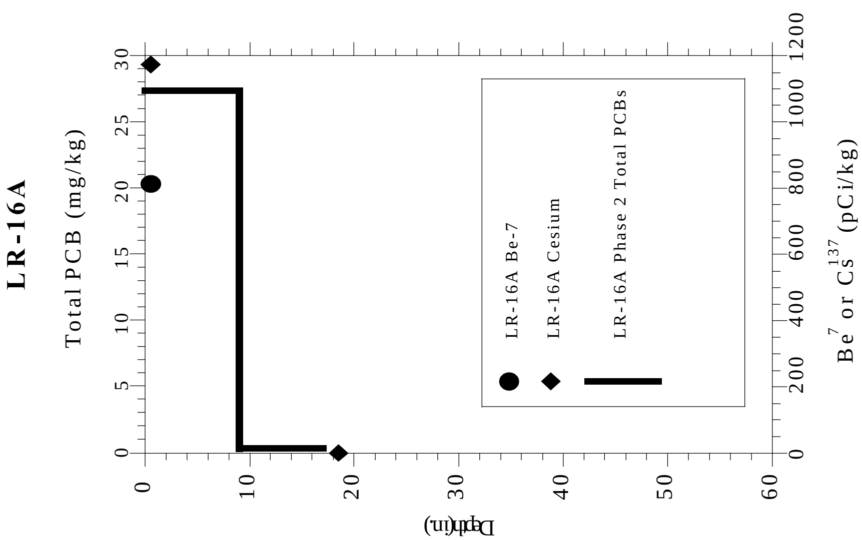

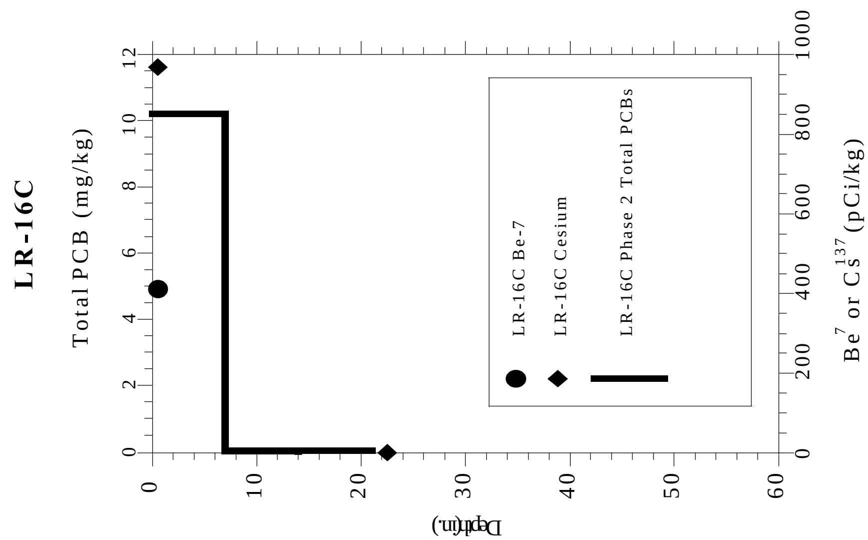

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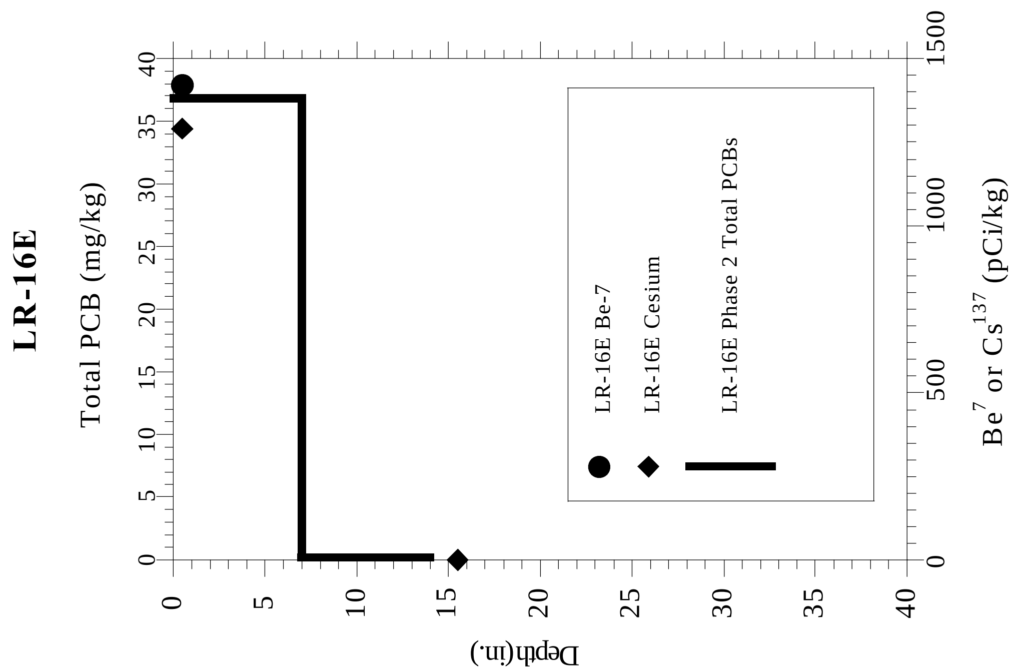

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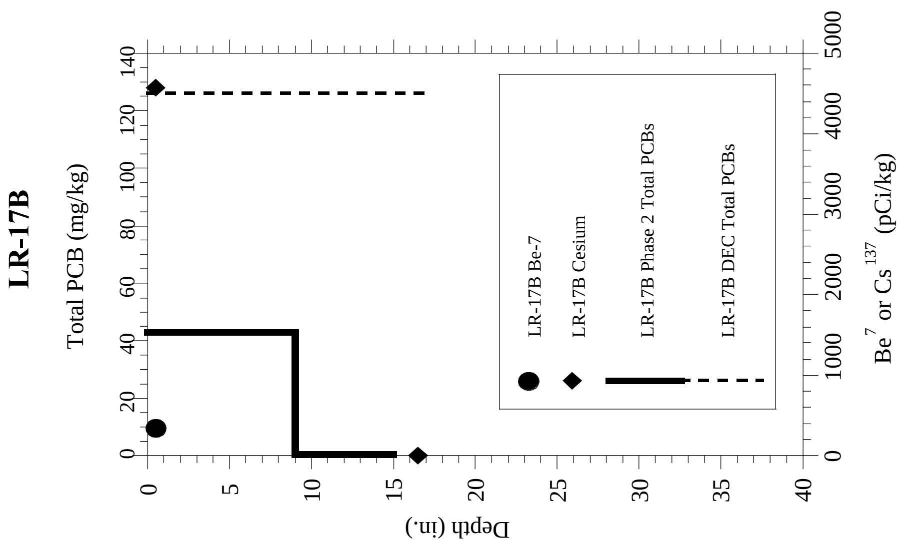

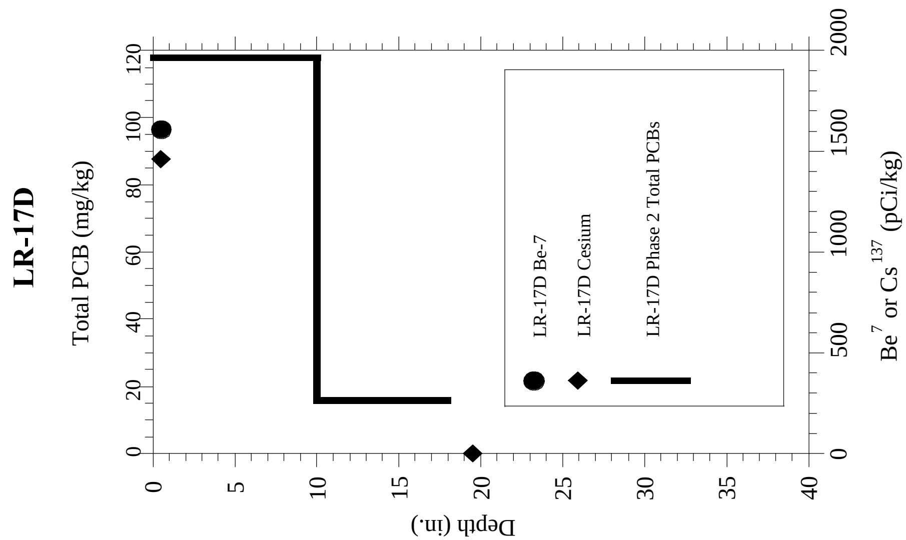

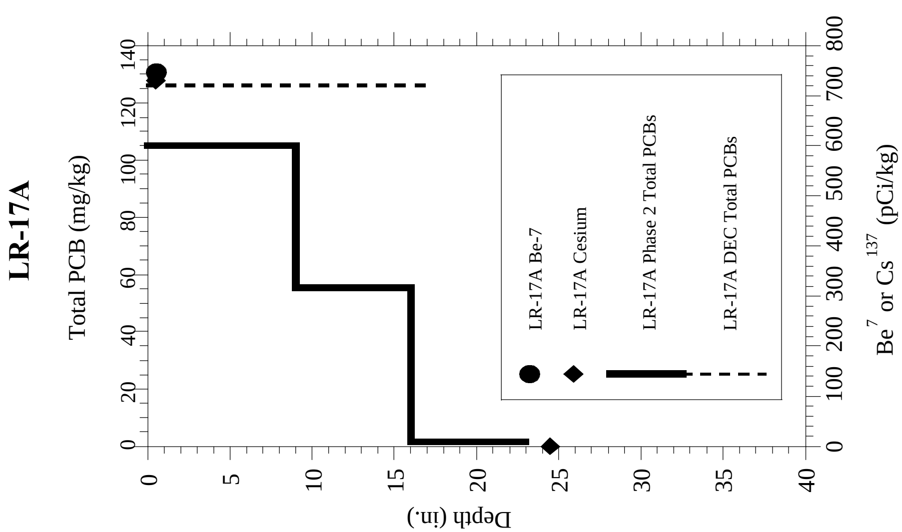

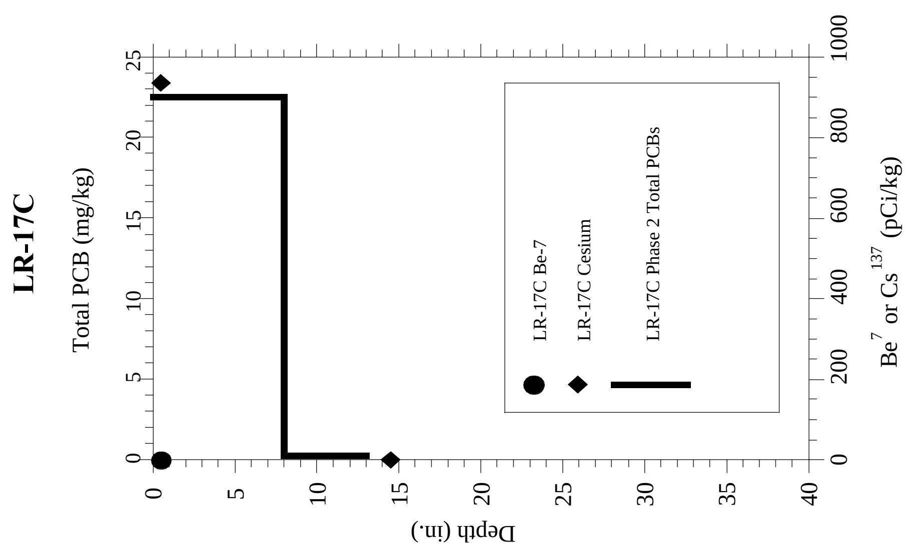

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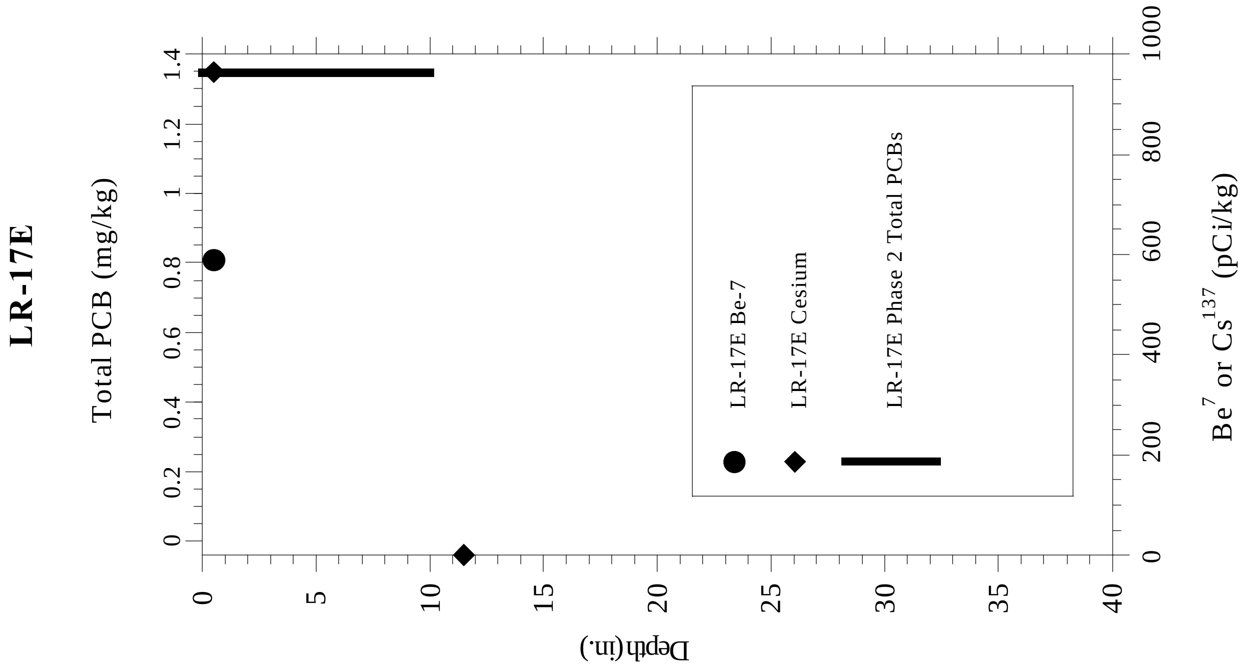

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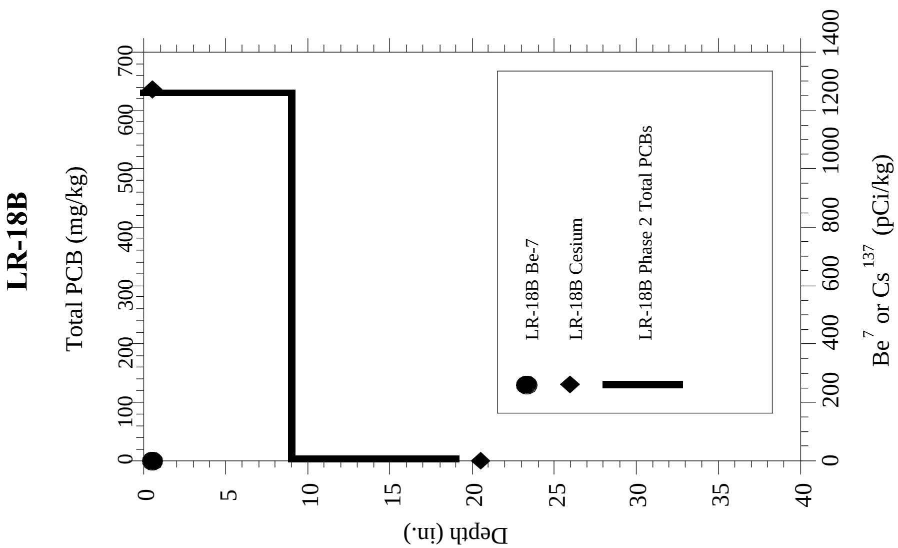
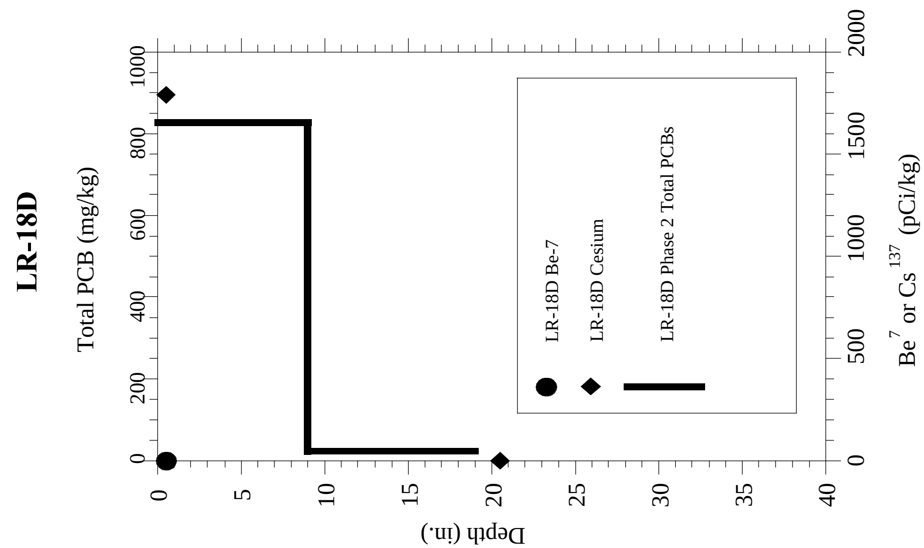
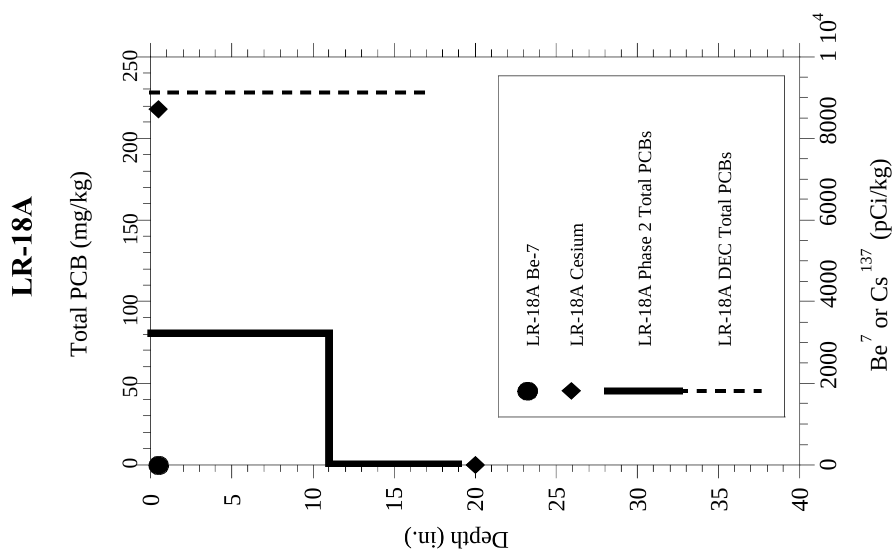
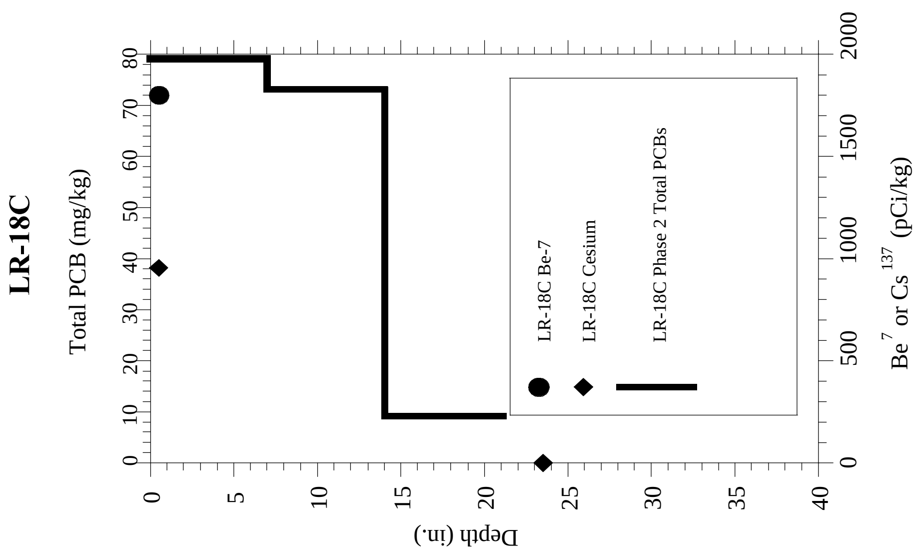
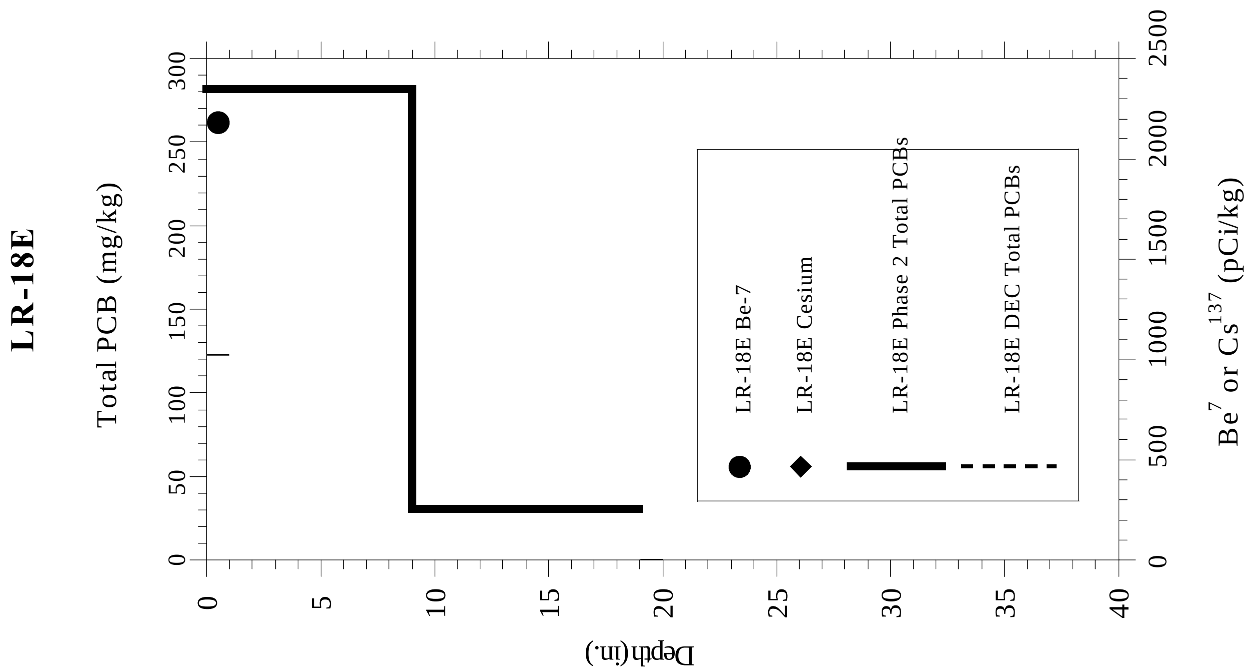






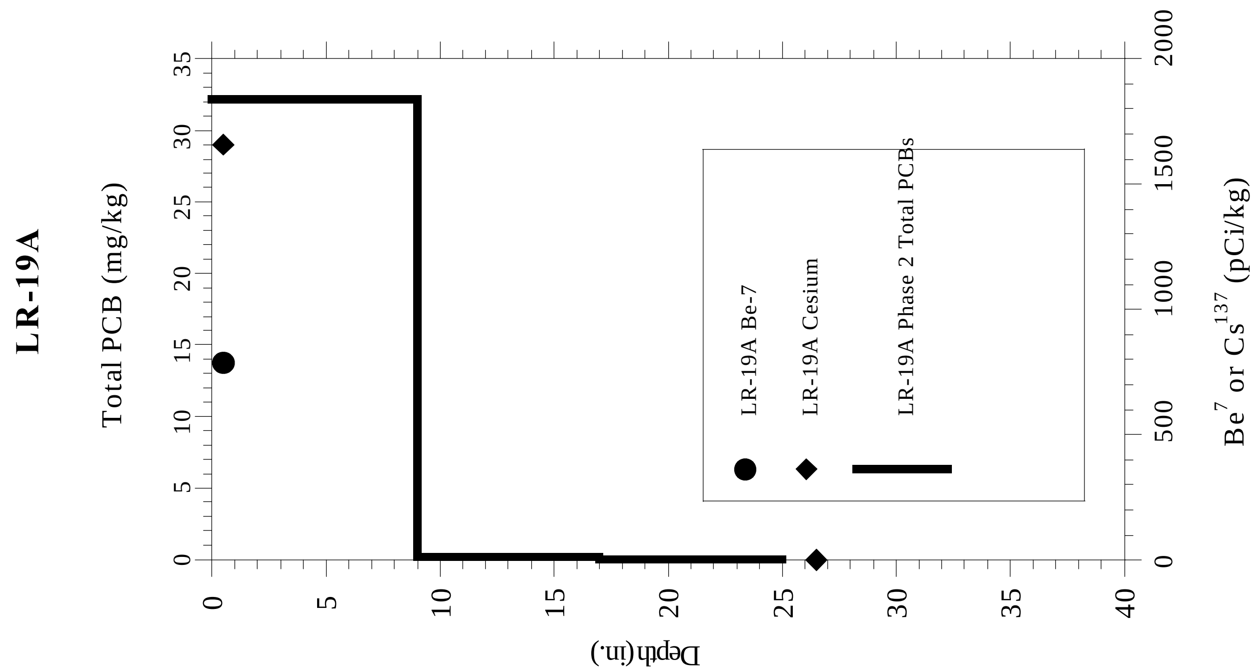


1994 Low Resolution Core and 1984 NYSDEC Core Profiles for the Thompson Island Pool



1994 Low Resolution Core and 1984 NYSDEC Core Profiles for the Thompson Island Pool

C-25



1994 Low Resolution Core and 1984 NYSDEC Core Profiles for the Thompson Island Pool

APPENDIX D

1994 LOW RESOLUTION CORE PROFILES

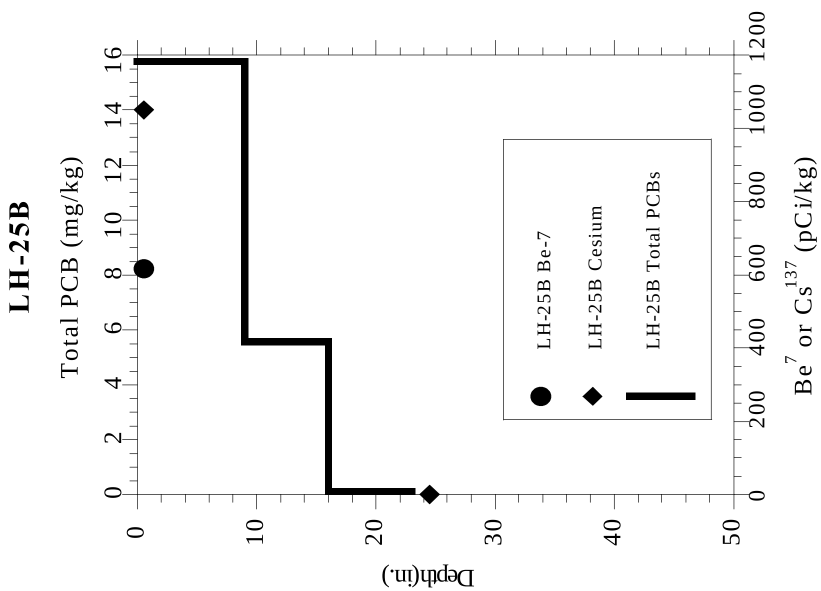
BELOW THE THOMPSON ISLAND POOL

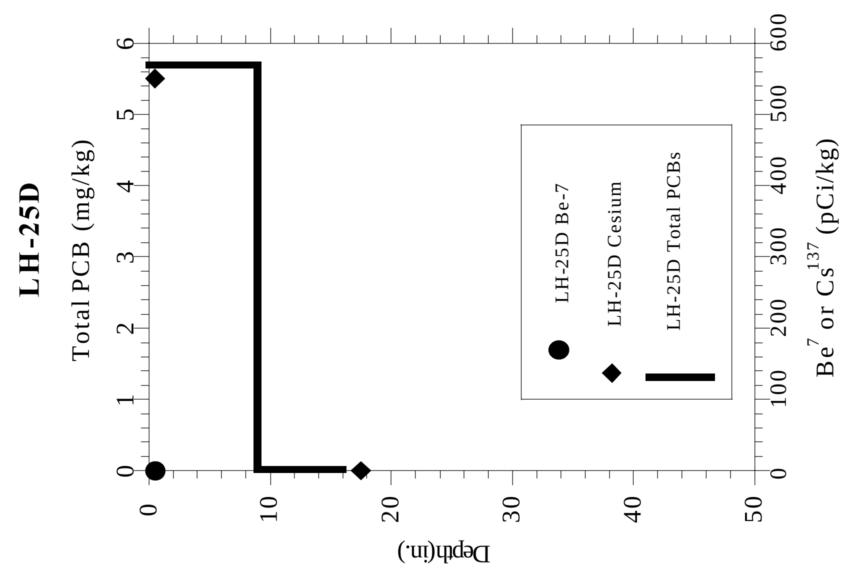
Table D-1
Assignment of Low Resolution Cores to Hot Spot Areas

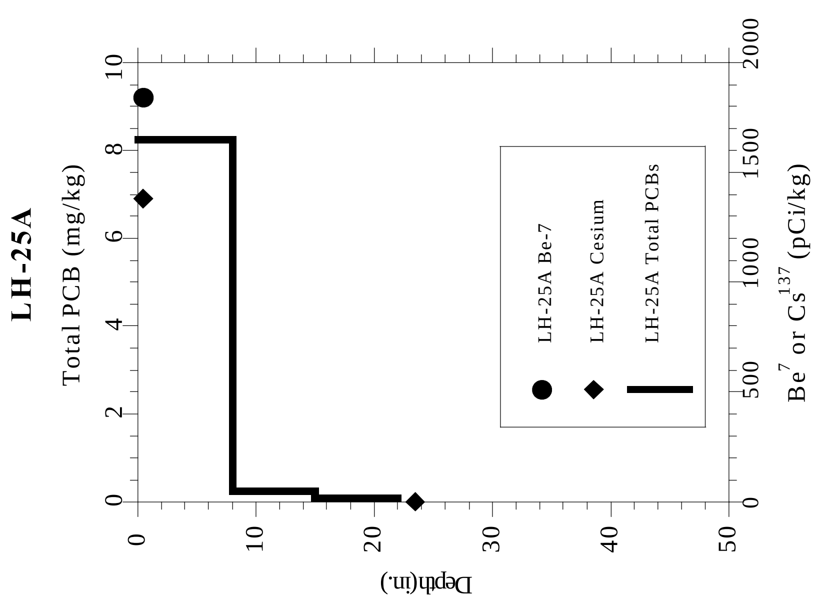
Hot Spot [1]	*Cores* [2]													
25	LH-25A	LH-25B	LH-25C	LH-25D	LH-25E	LH-25G	LH-25H	LH-25I	LH-25J					
28	LH-28C	LH-28D	LH-28E	LH-28F	LH-28H	LH-28I	LH-28J	LH-28K	LH-28M	LH-28N				
31	LH-31D	LH-31E	LH-31F	LH-31G	LH-31I									
34	LH-34B	LH-34C	LH-34E	LH-34F	LH-34H	LH-34I	LH-34J	LH-34K	LH-34M					
35	LH-35A	LH-35B	LH-35C	LH-35D										
37	LH-37A	LH-37B	LH-37C	LH-37D	LH-37E	LH-37G	LH-37H	LH-37J	LH-37K	LH-37M	LH-37N	LH-37O		
39	LH-39A	LH-39B	LH-39D	LH-39E	LH-39F	LH-39G	LH-39H	LH-39I	LH-39J	LH-39K	LH-39L	LH-39M	LH-39N	LH-39O
DL 182	LH-42C	LH-42D												

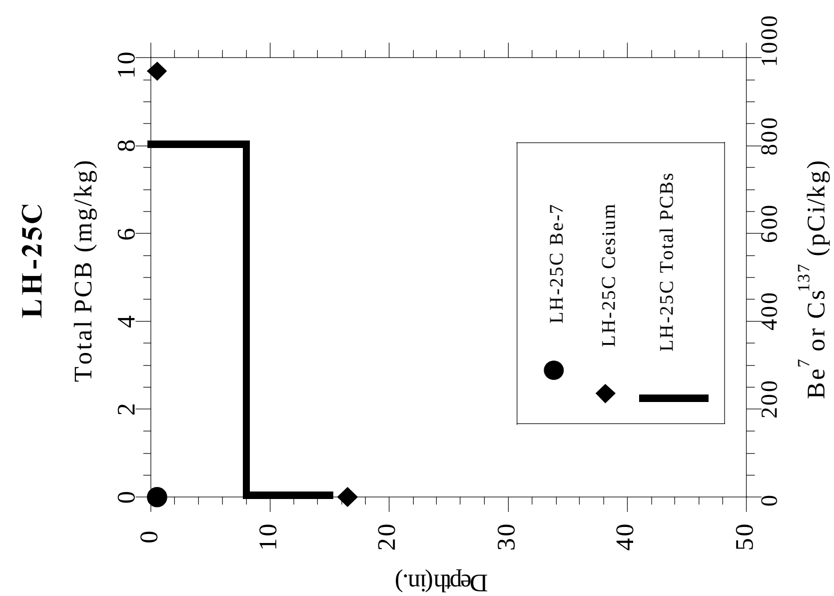
Notes: 1. Hot spot numbers are as assigned by Tofflemire and Quinn (1979). DL 182 represents dredge location 182 from MPI (1992)

2. The cores listed were located within the dredge location boundaries defined by Malcome Pirnie (MPI, 1992). Typically, hot spots as deifned by Tofflemire and Quinn (1979) are represented by 1 to 4 of these dredge locations.

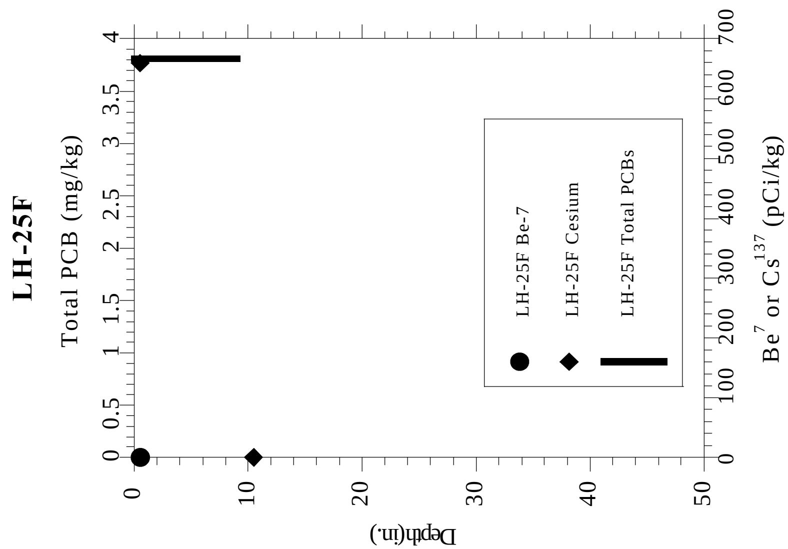


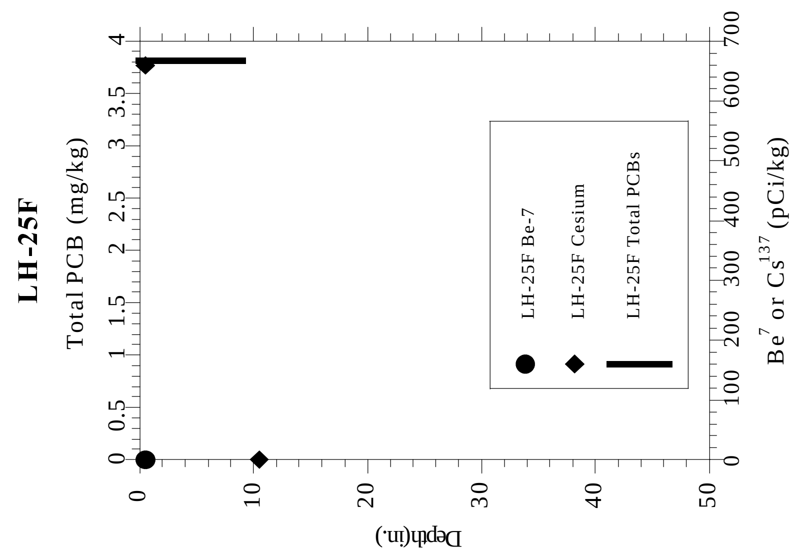


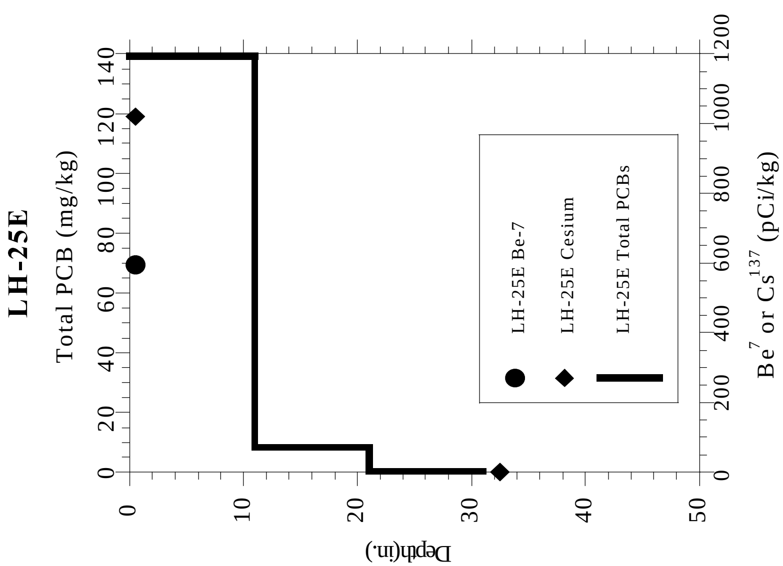


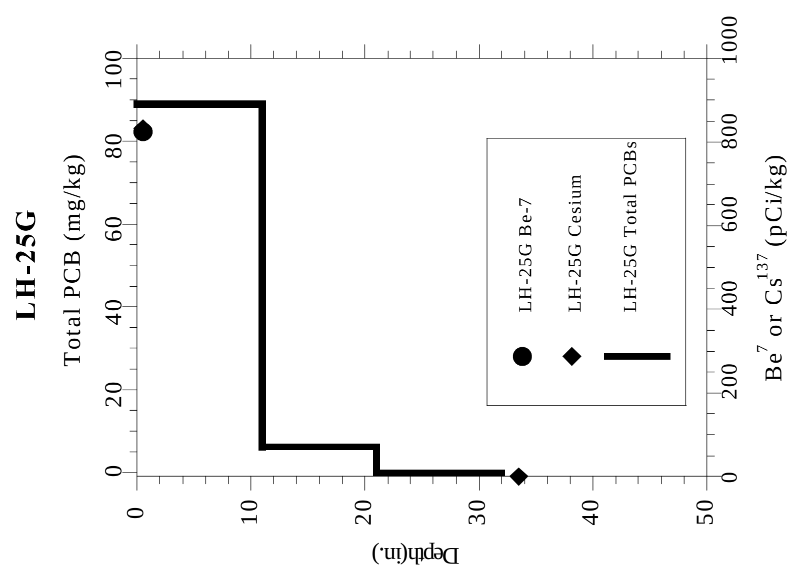


1994 Low Resolution Core Profiles below the Thompson Island Pool



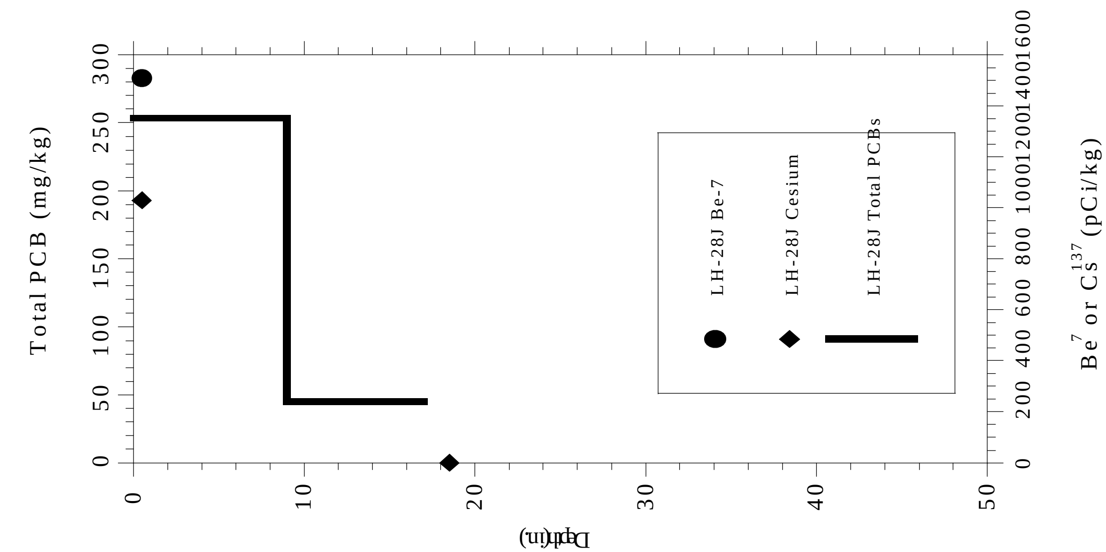




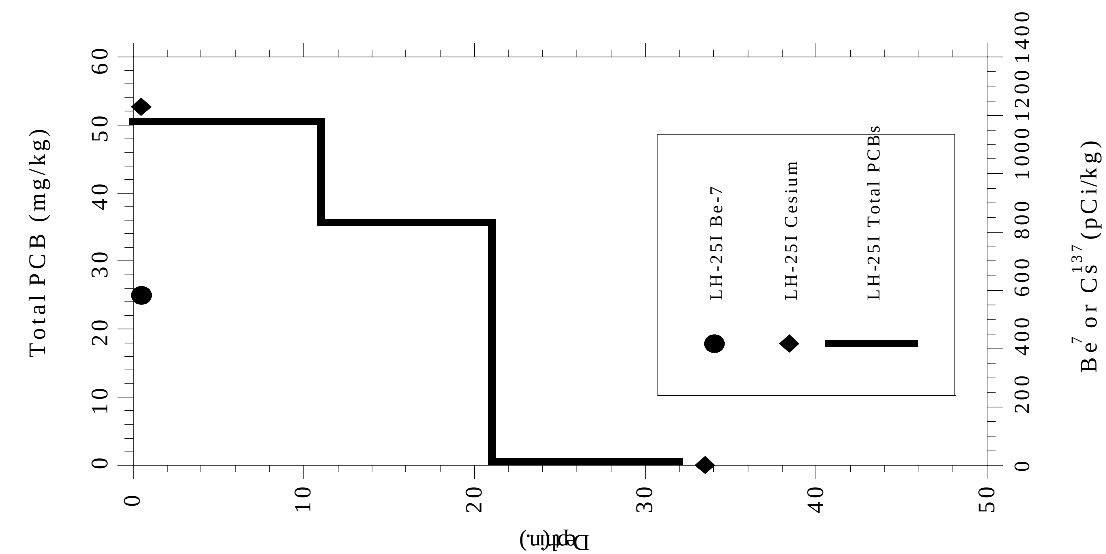


1994 Low Resolution Core Profiles below the Thompson Island Pool

LH-25J



LH-25I



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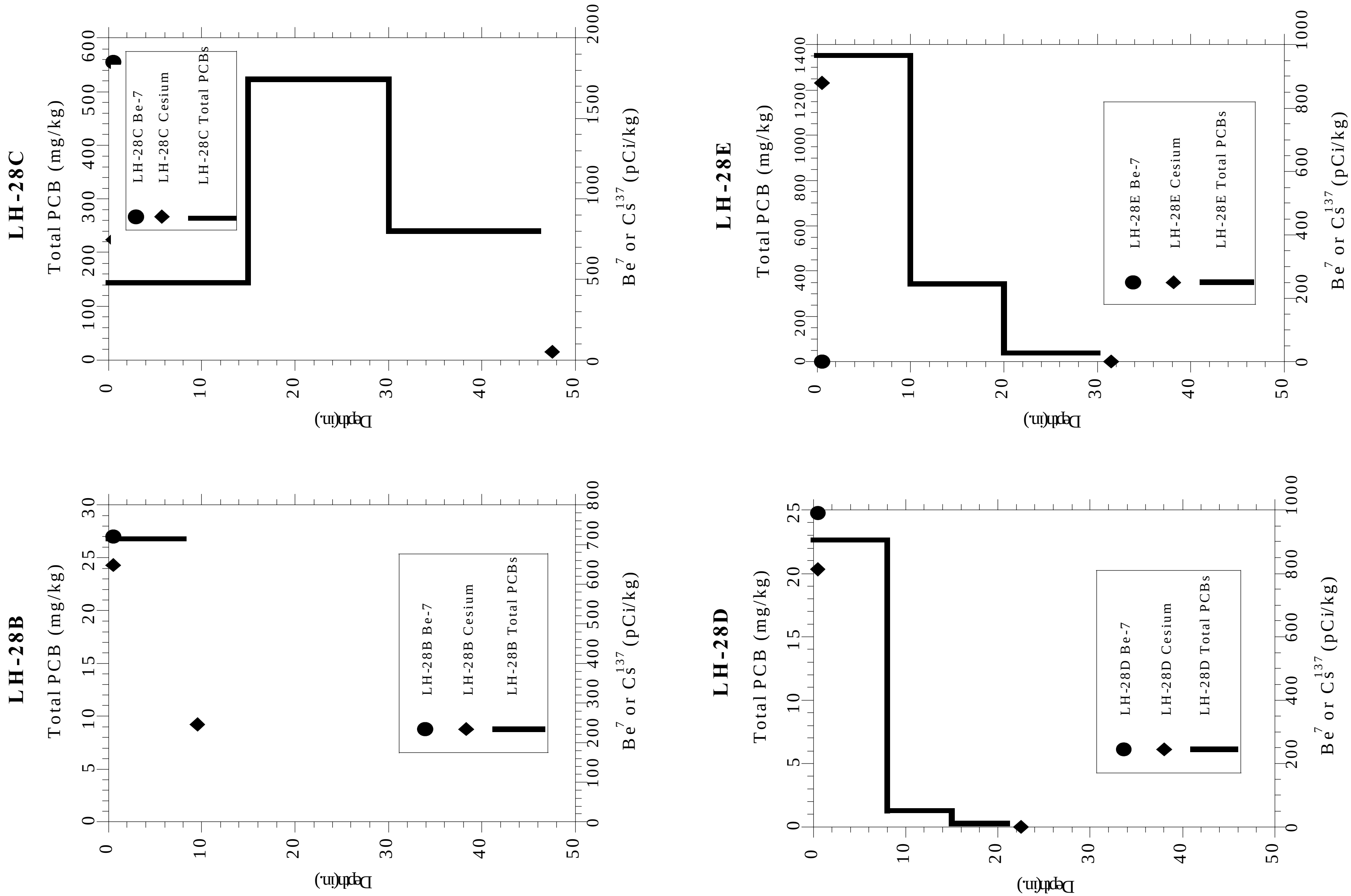

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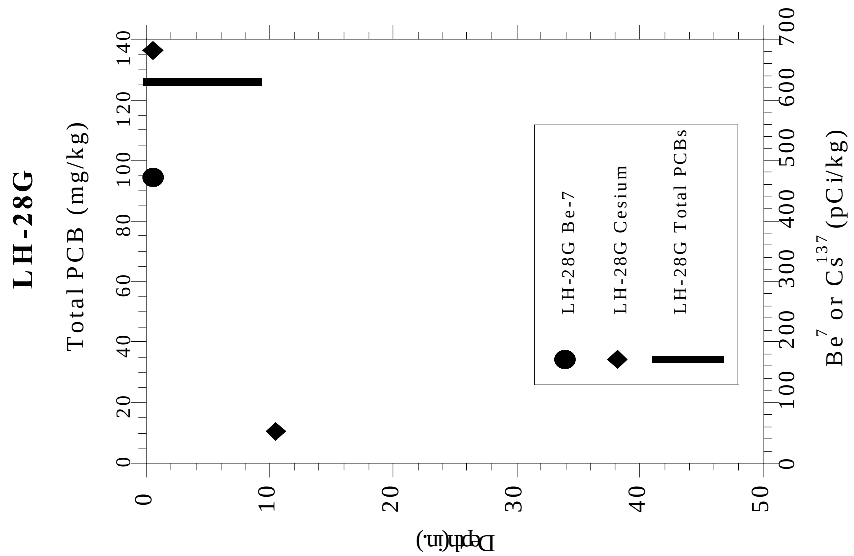

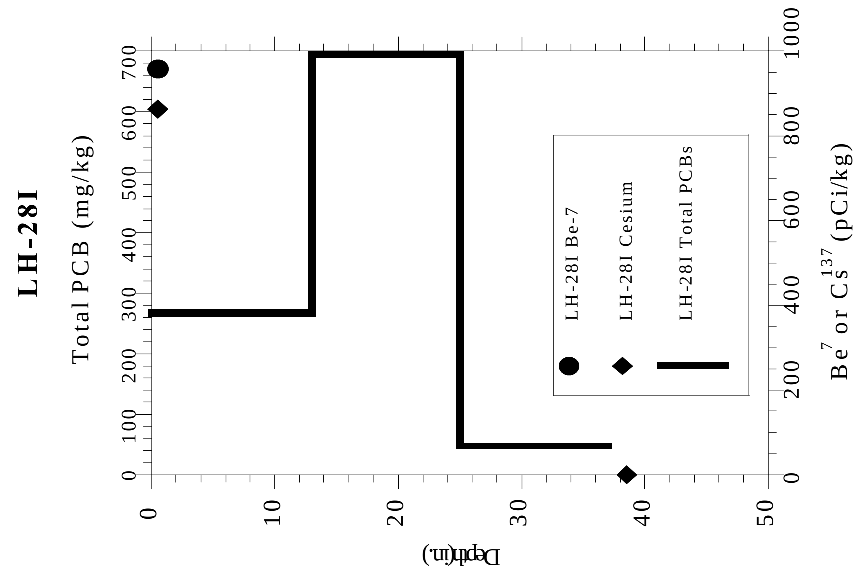

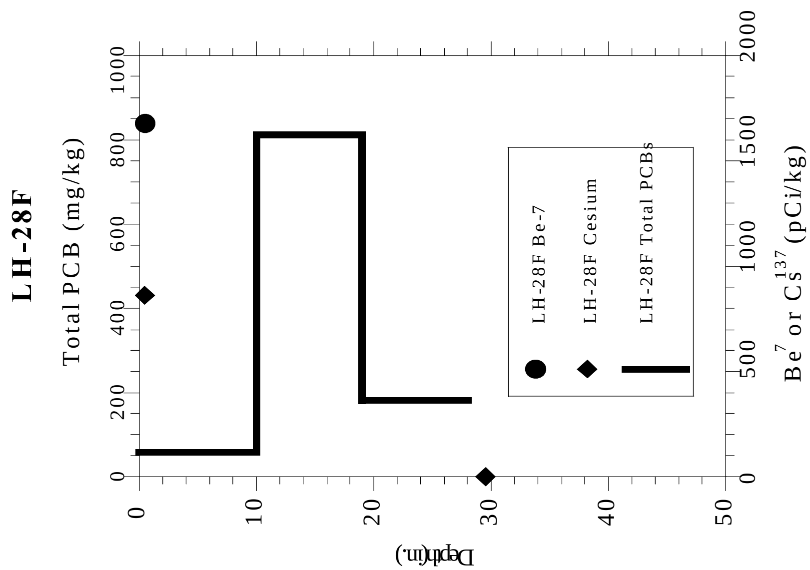

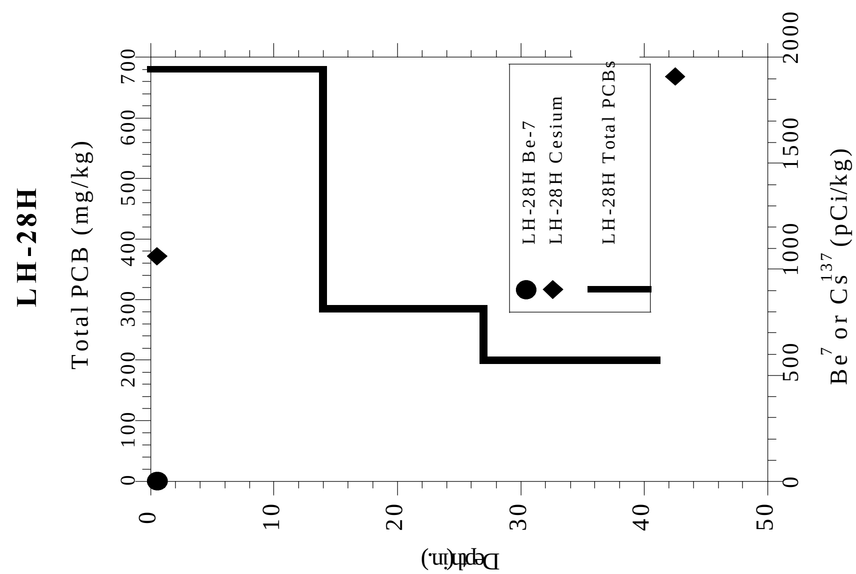

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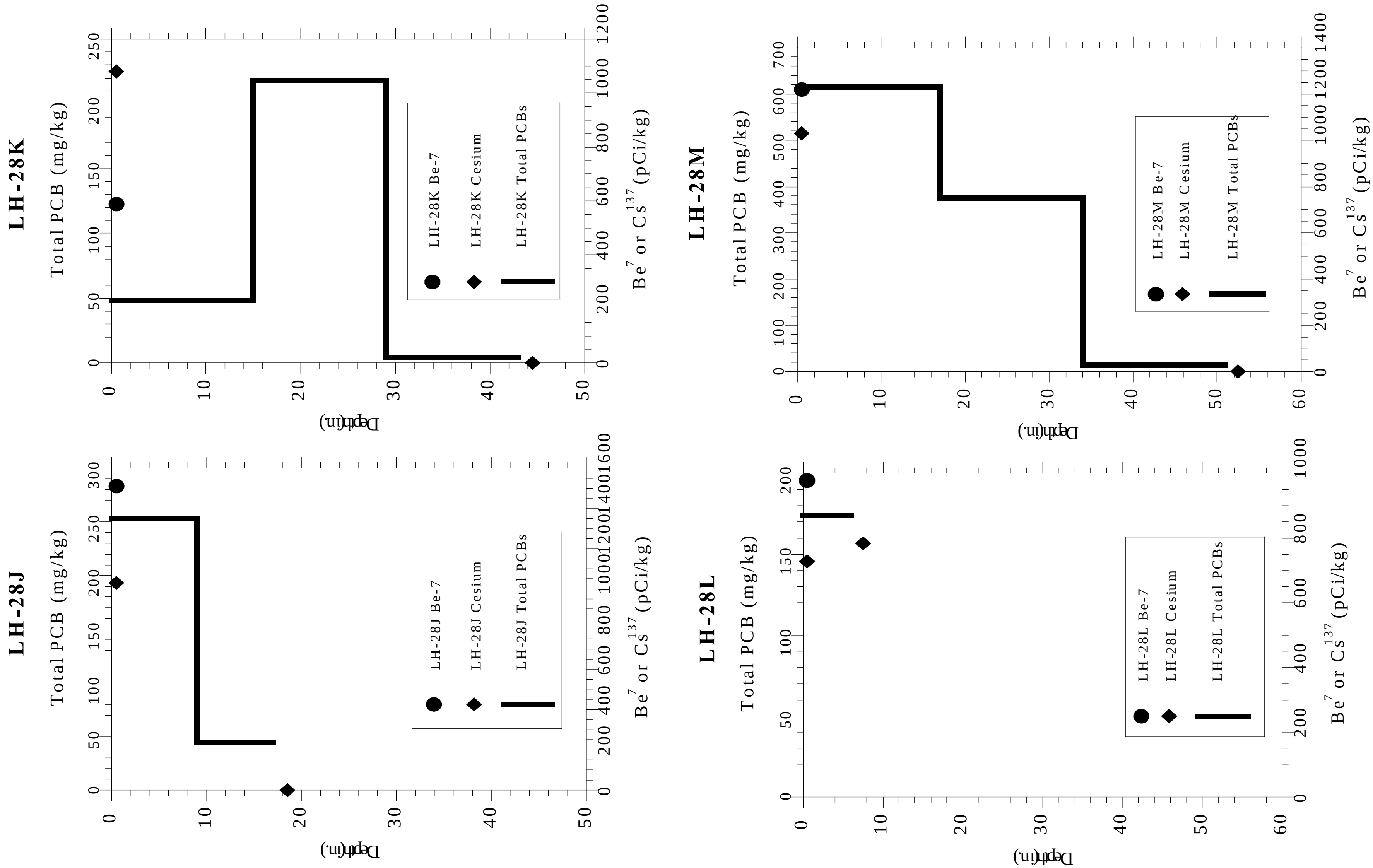

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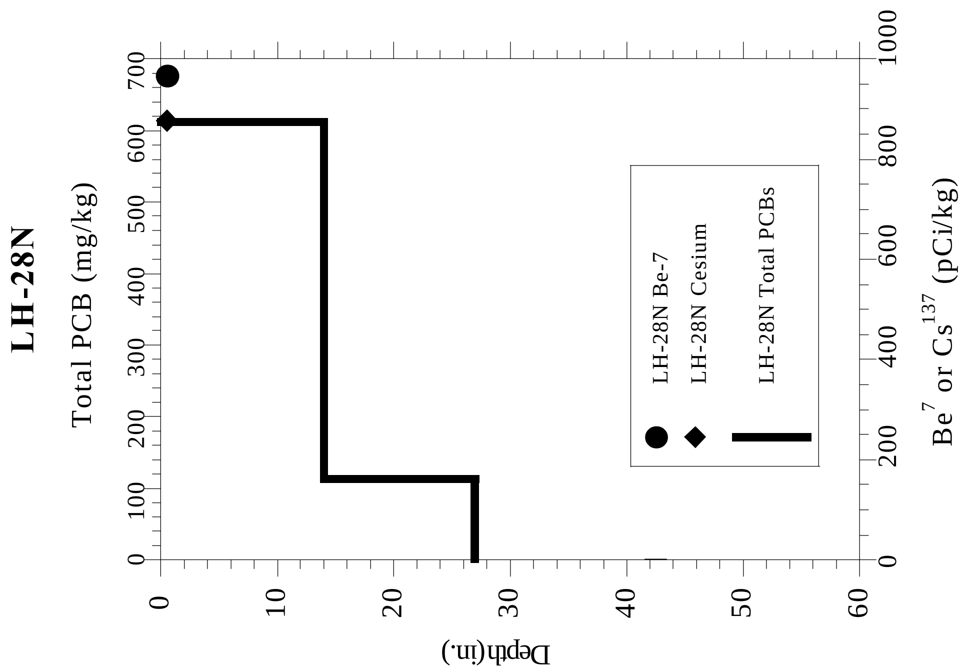

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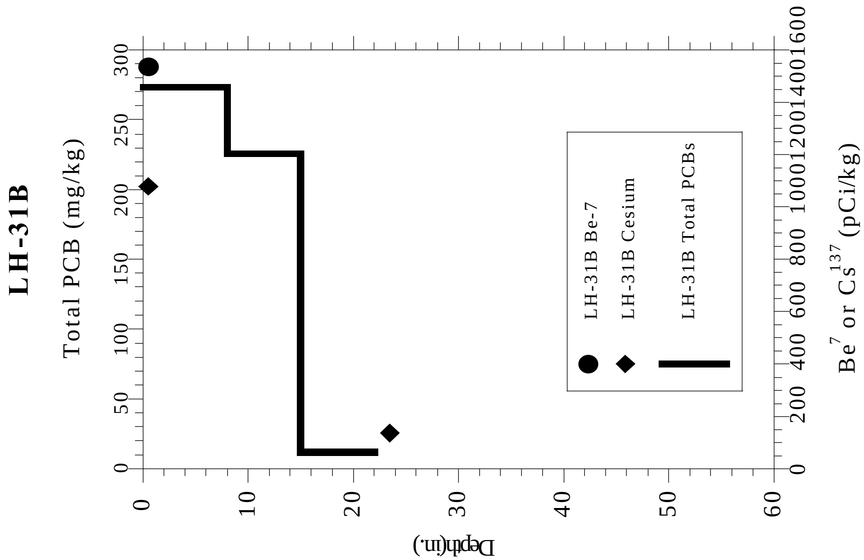

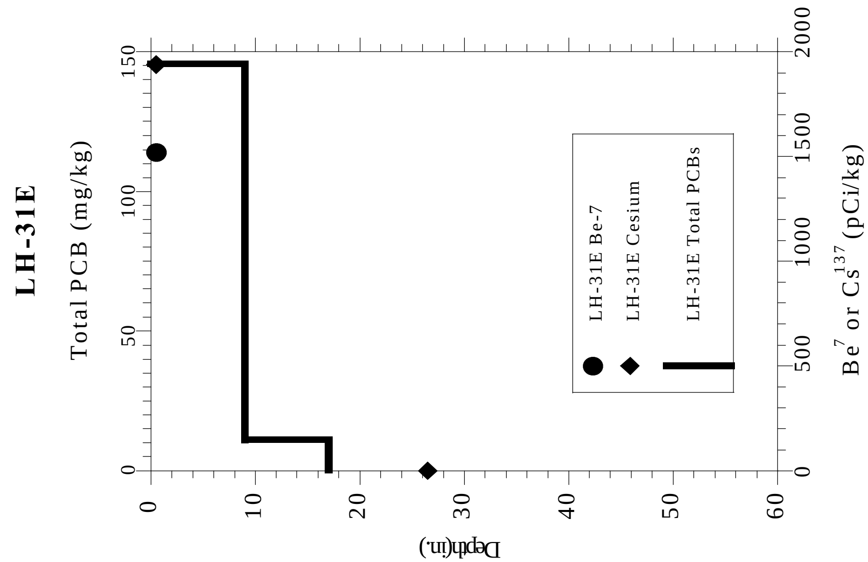

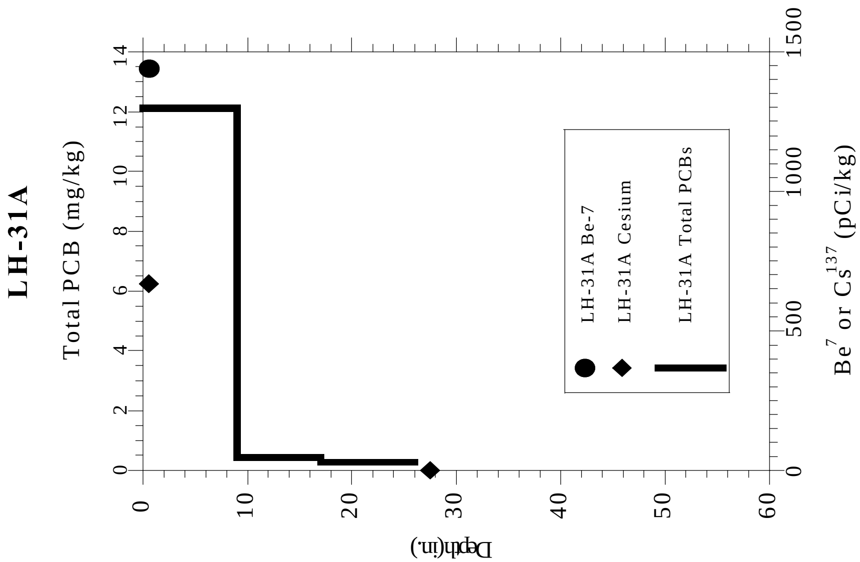

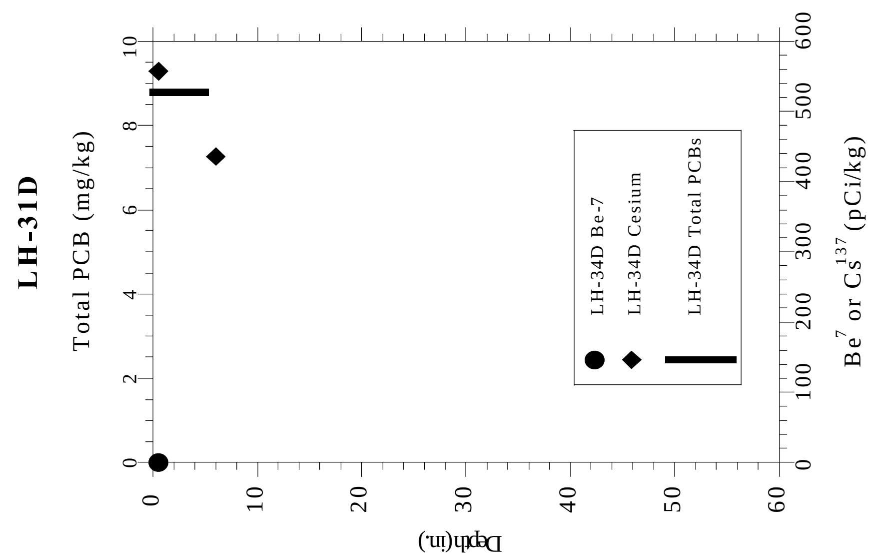

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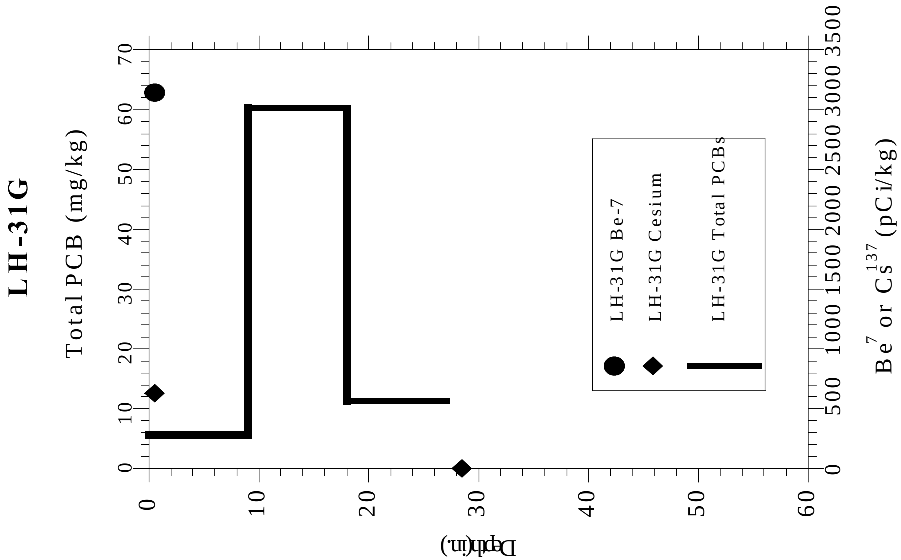

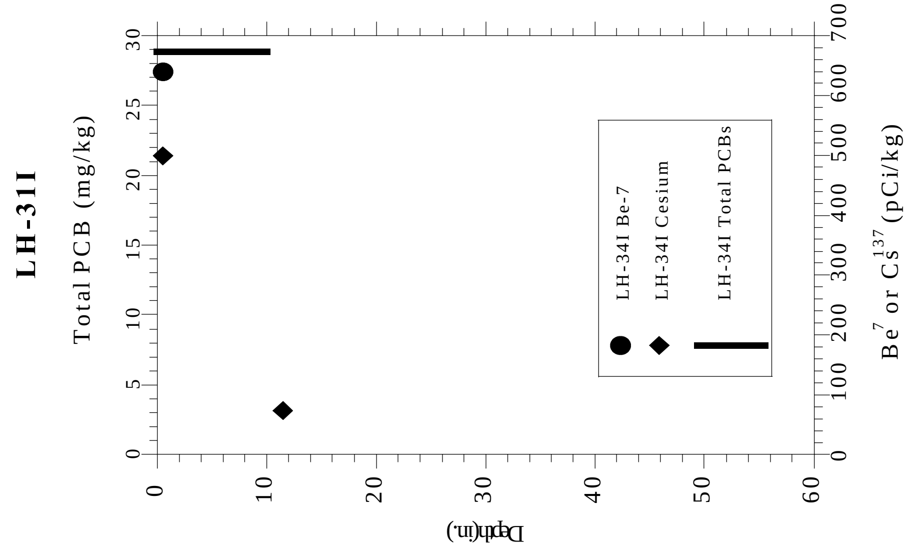

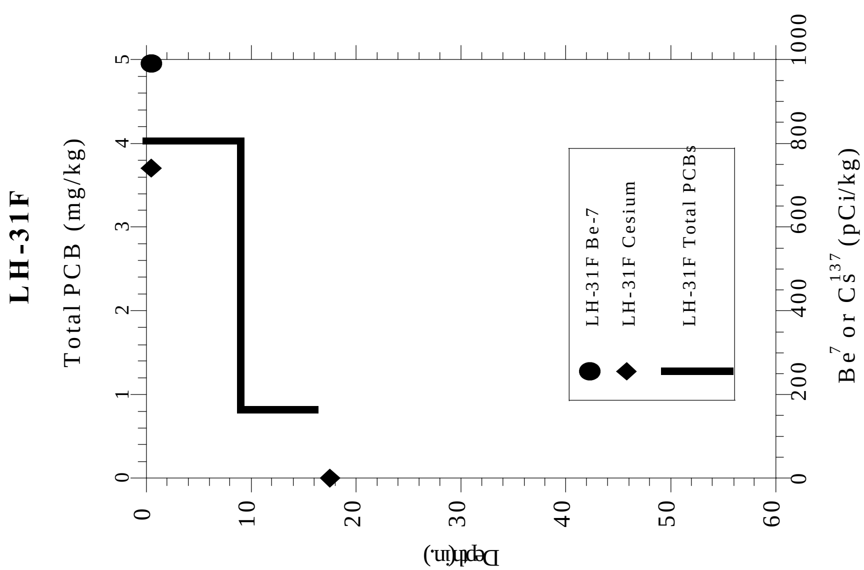

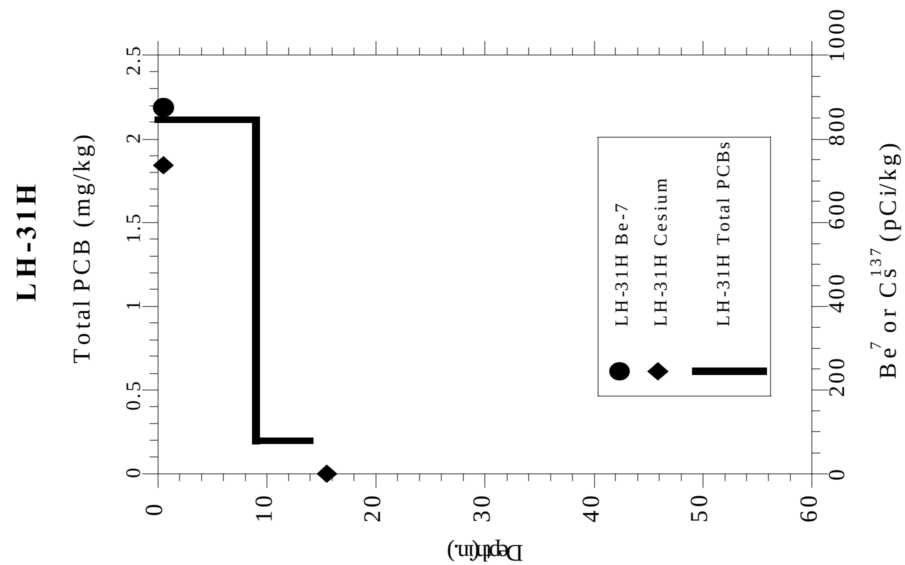

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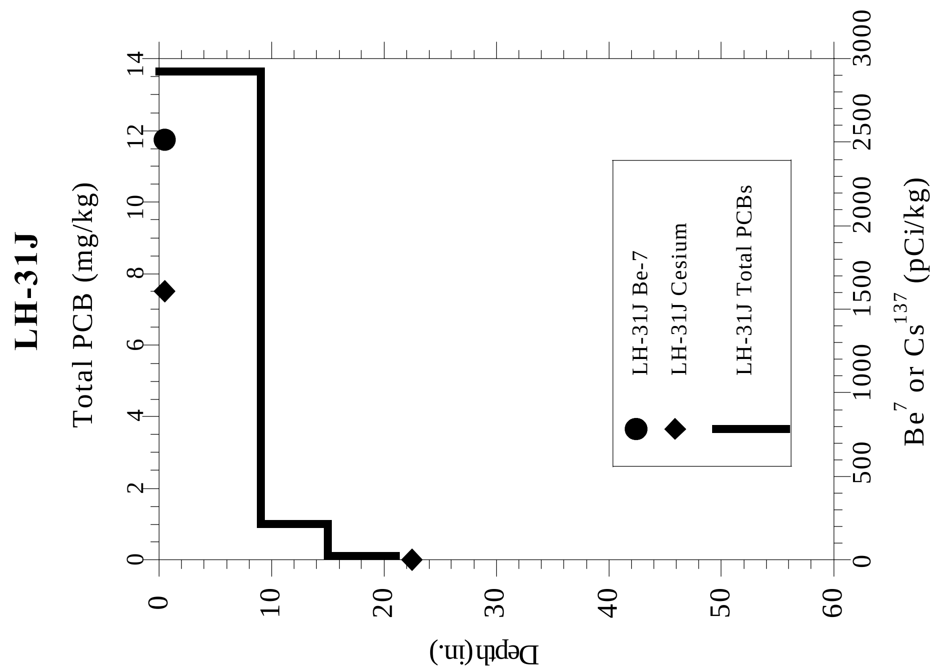

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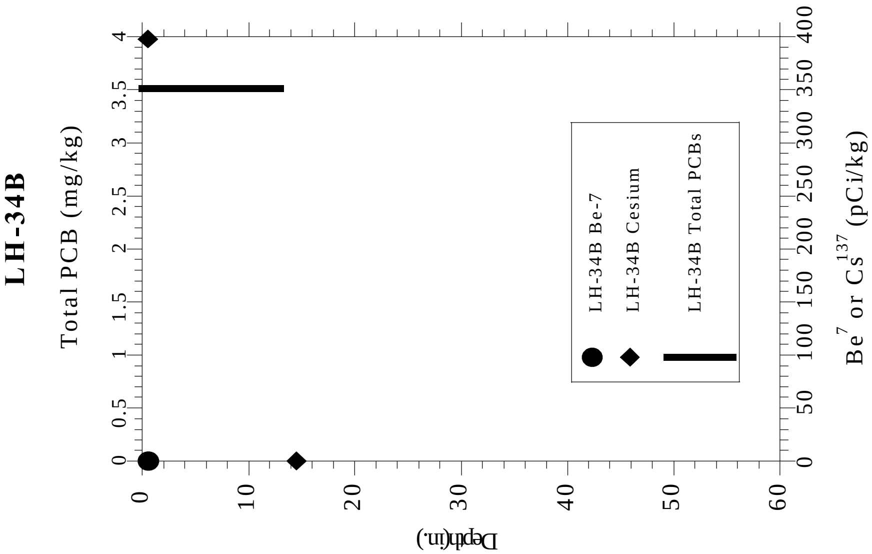

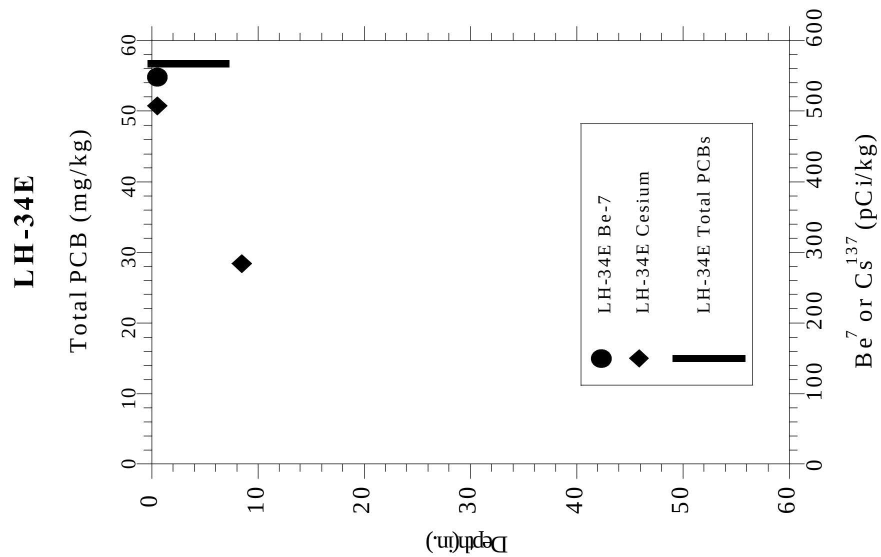

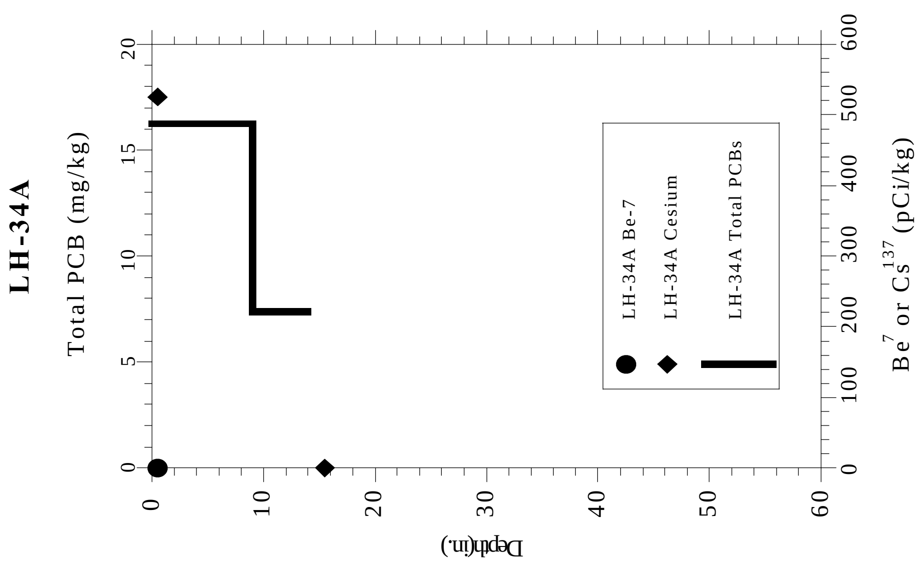

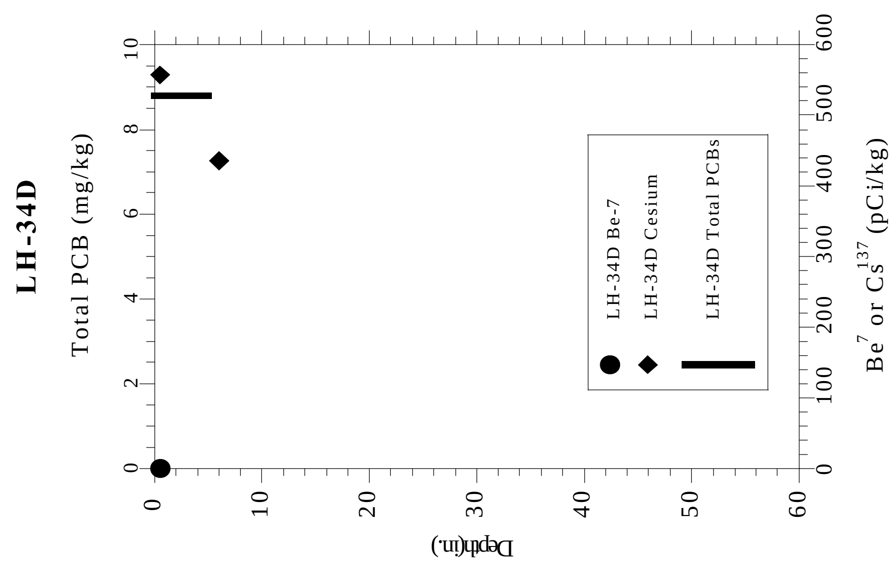

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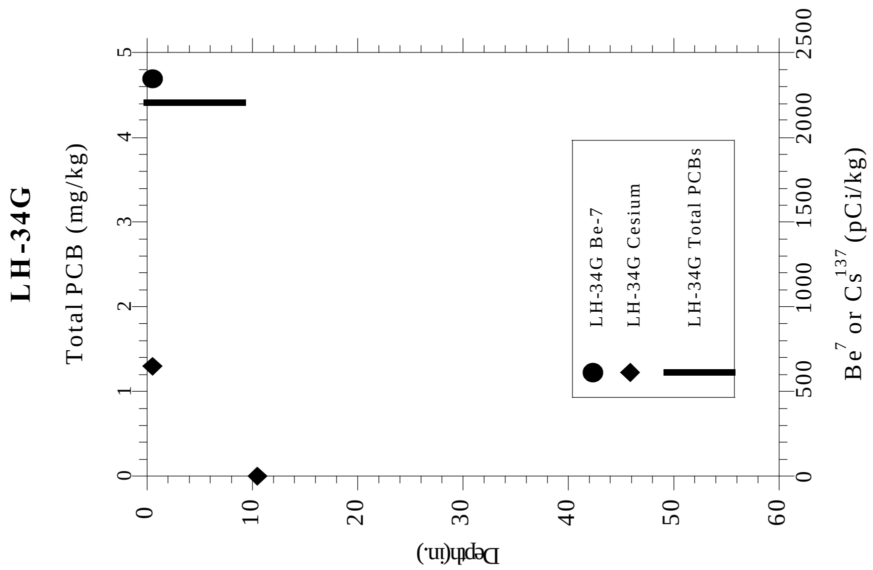

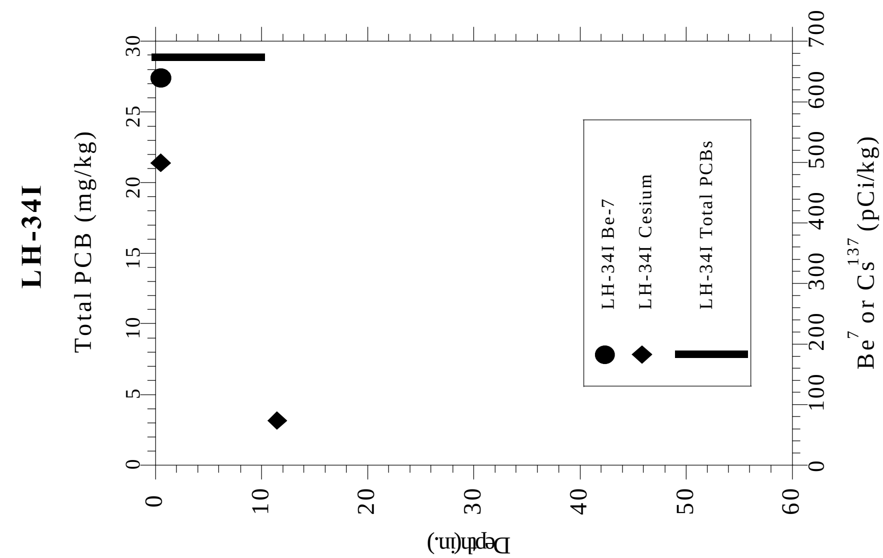

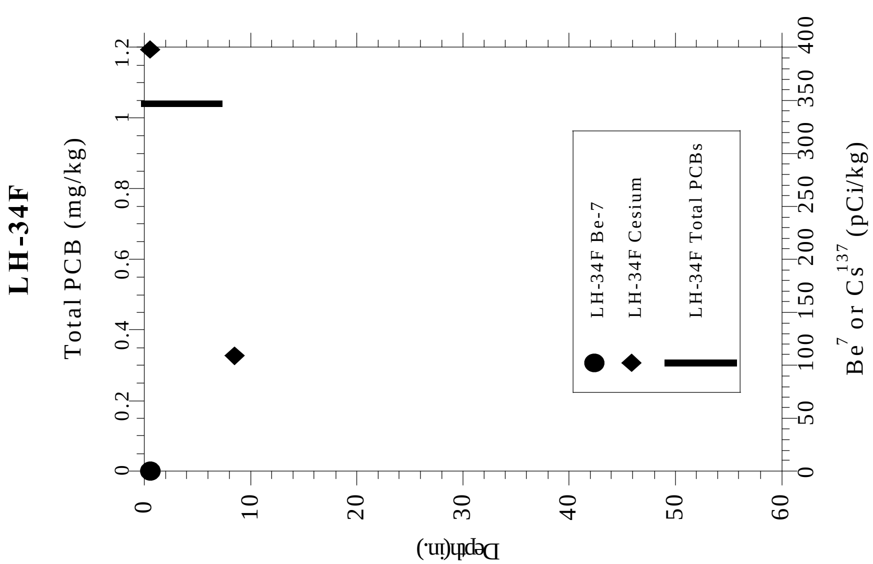

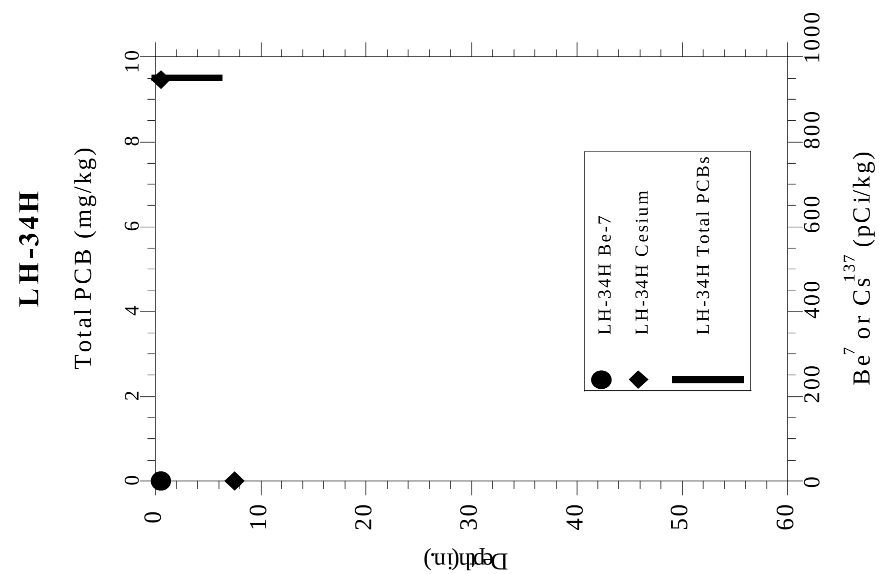

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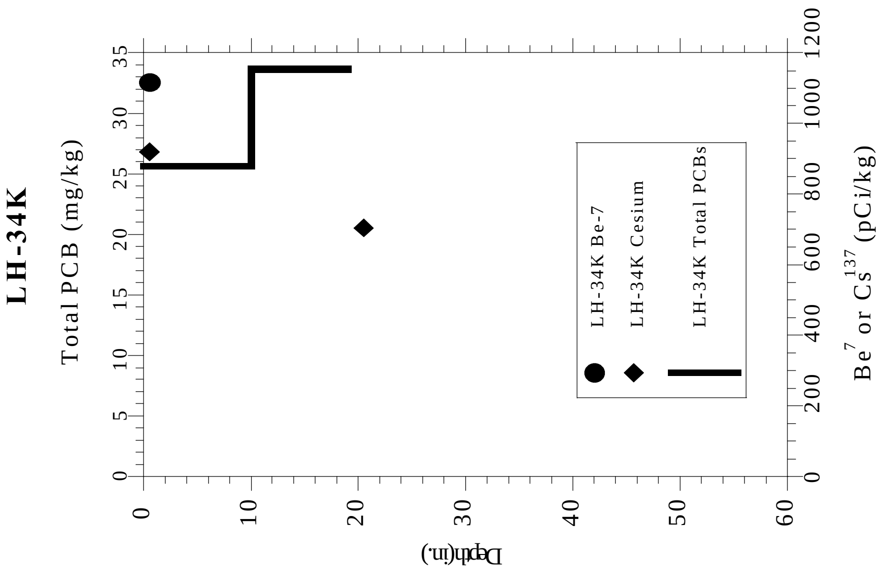

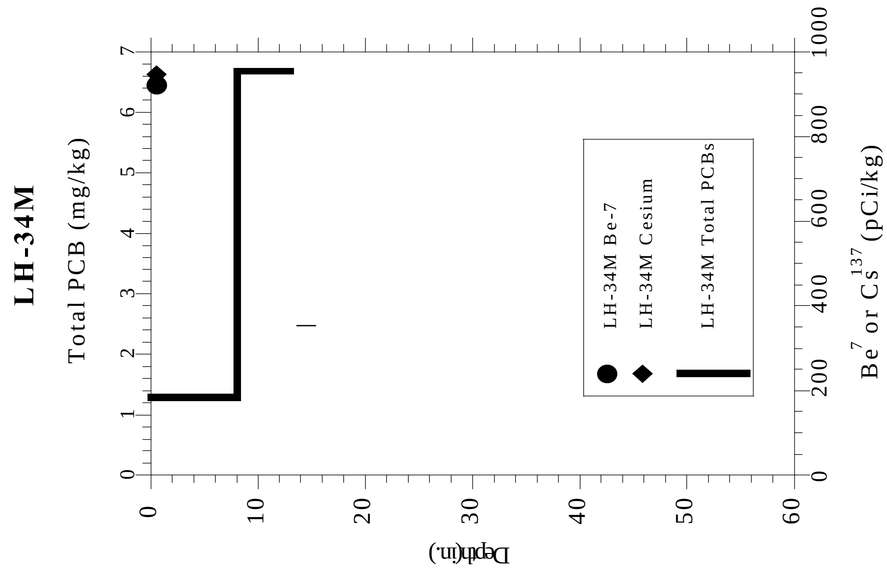

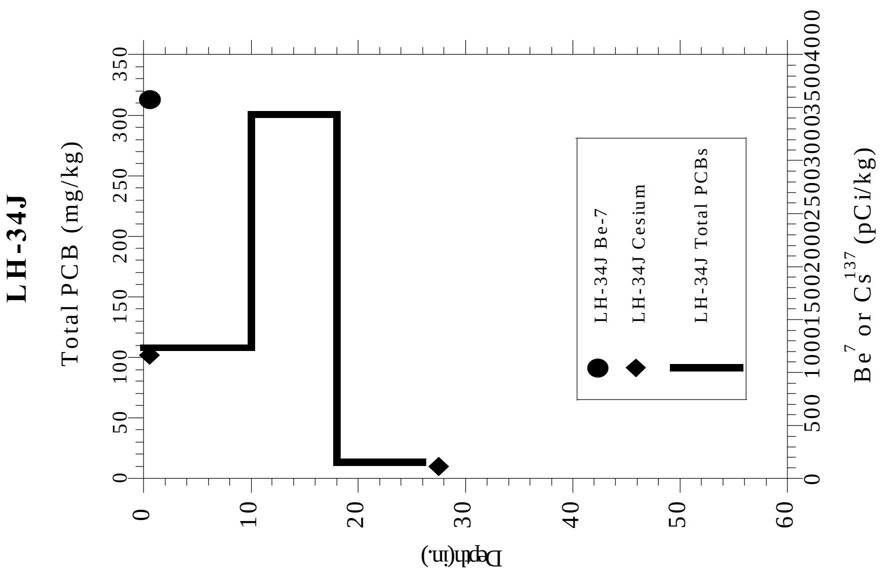

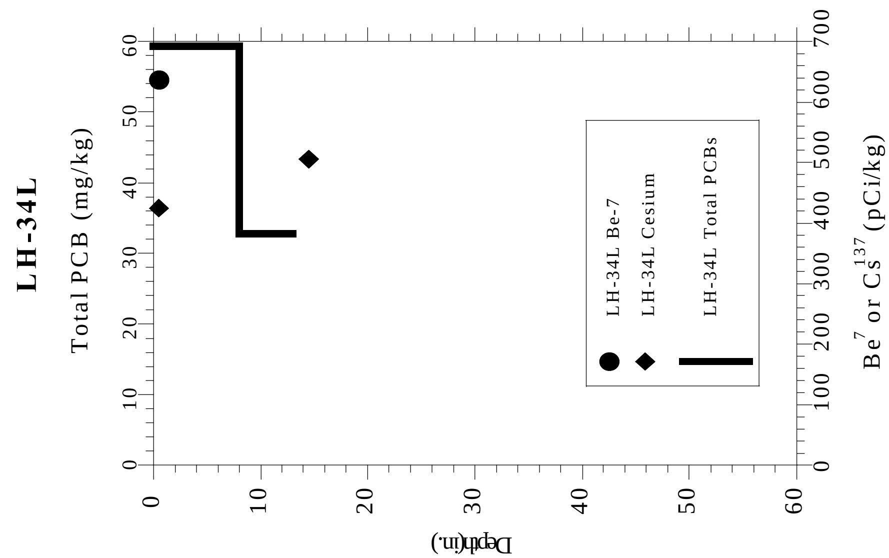

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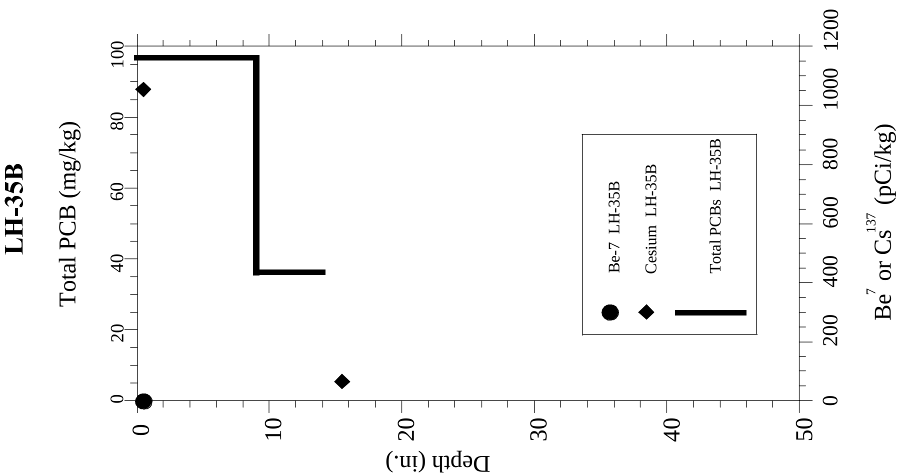
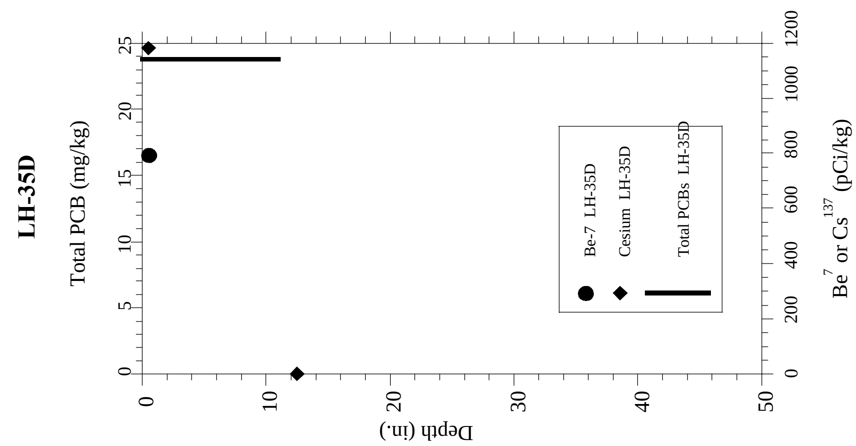
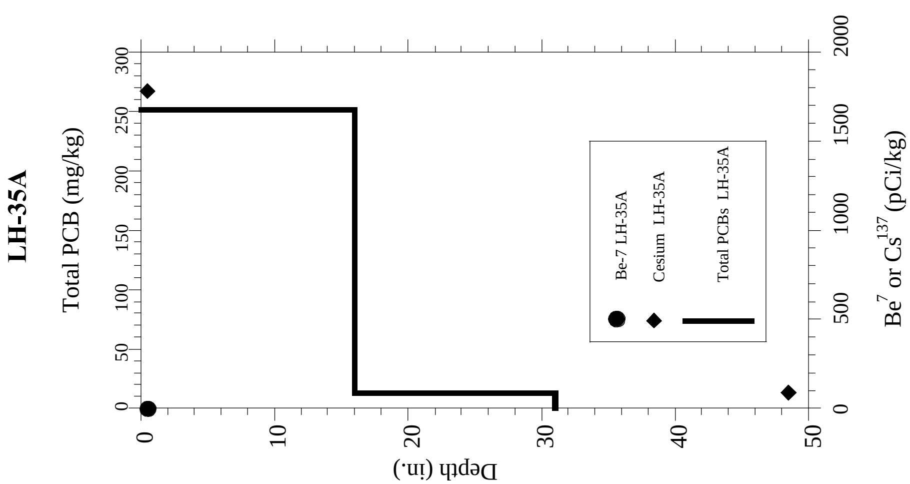
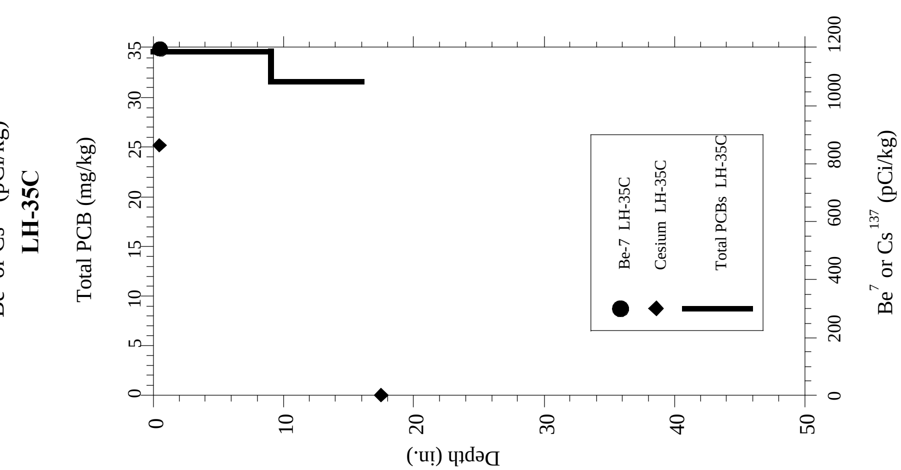
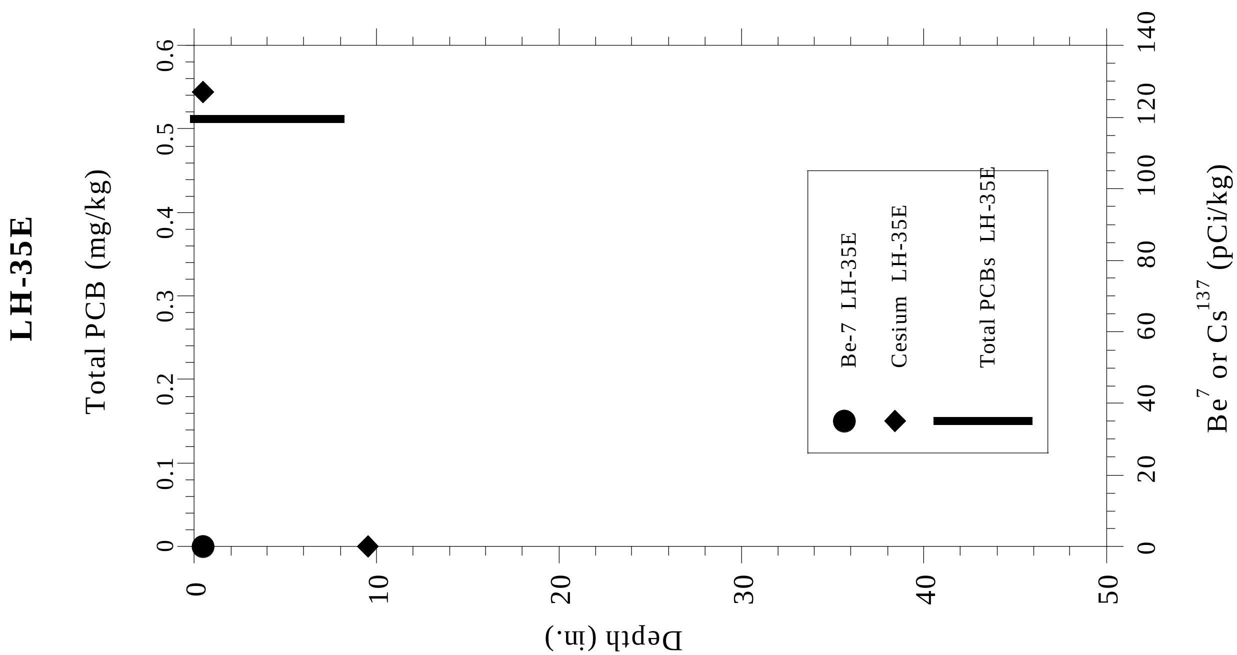




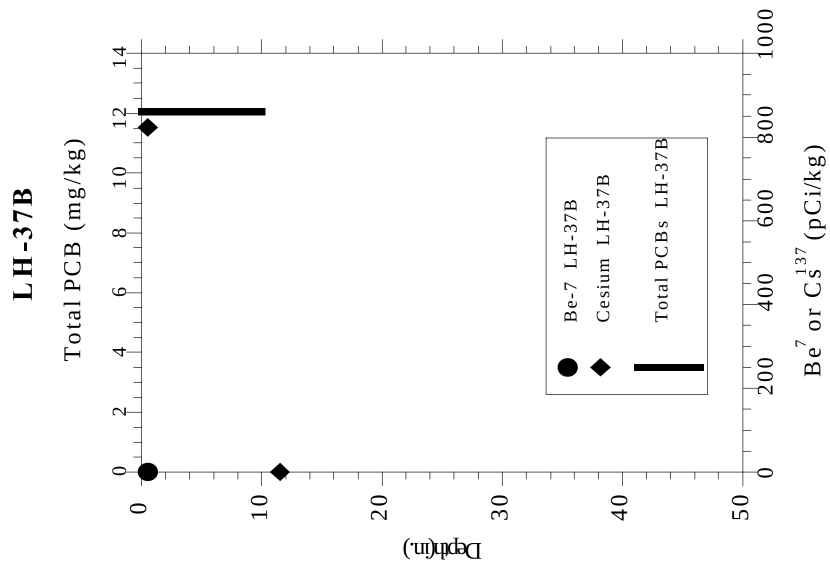


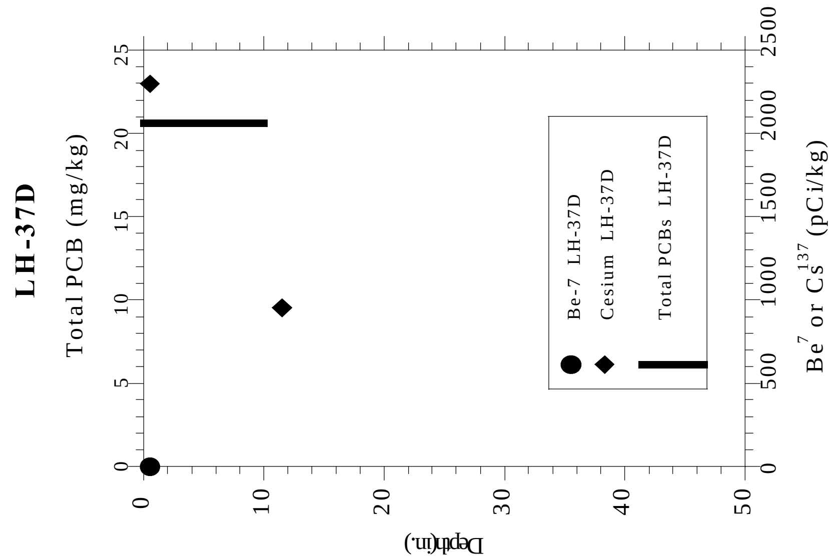


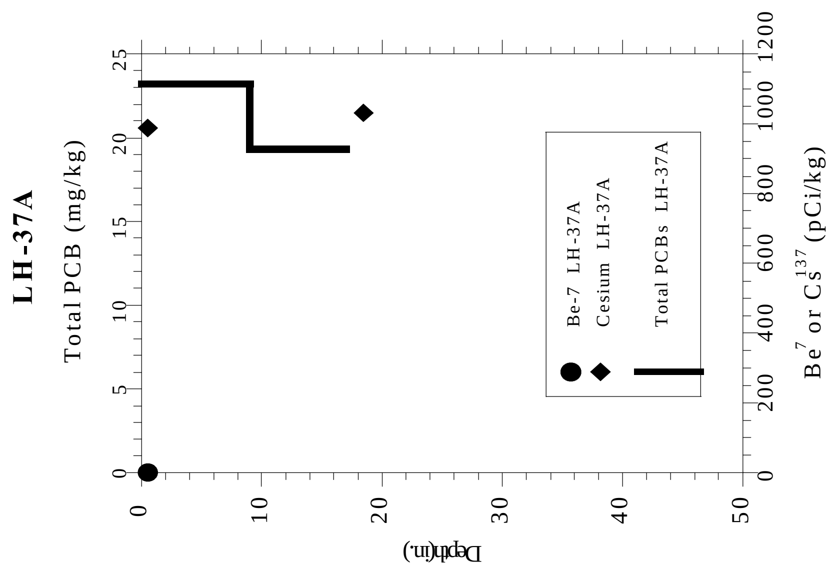
1994 Low Resolution Core Profiles Below the Thompson Island Pool

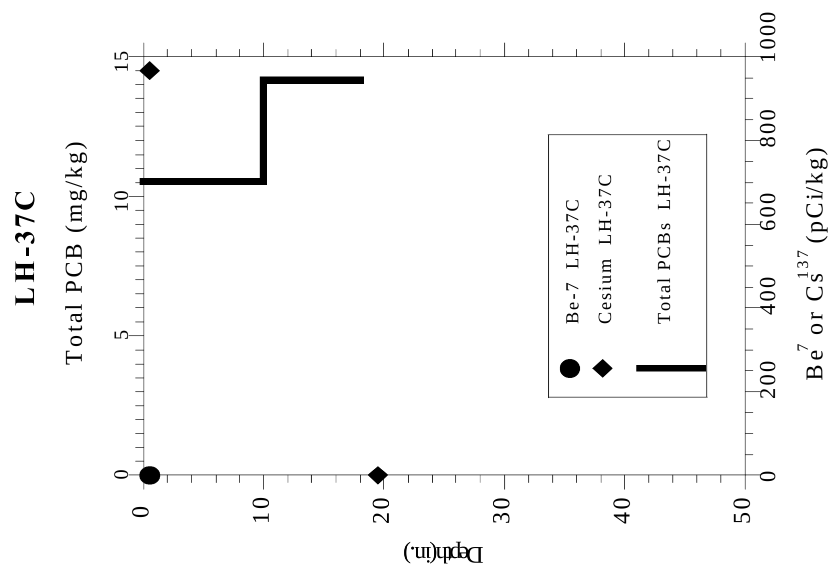


1994 Low Resolution Core Profiles Below the Thompson Island Pool

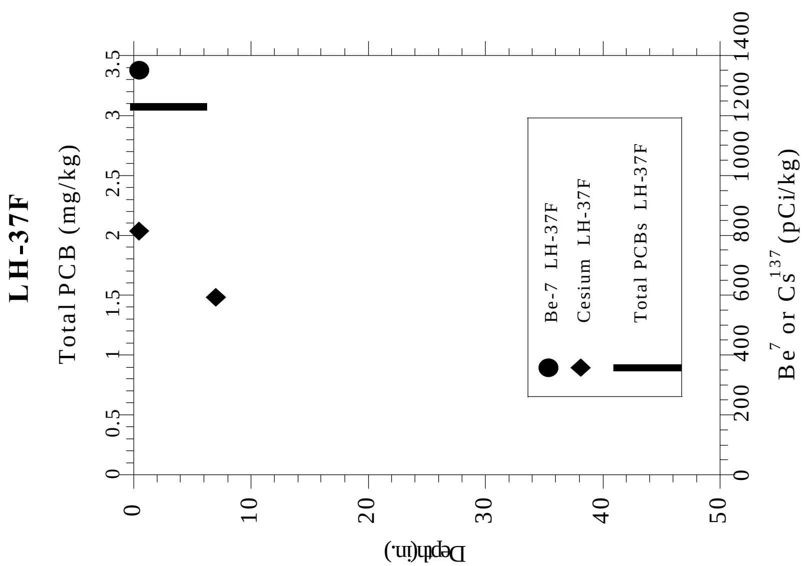


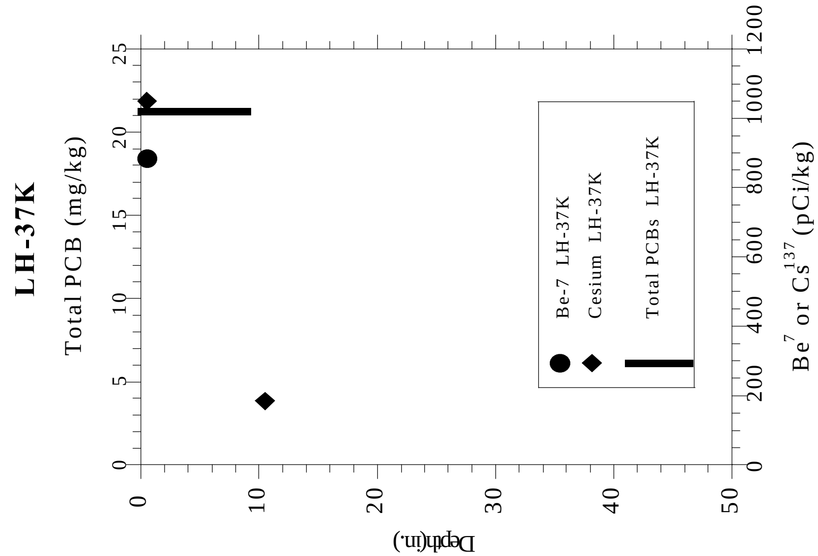


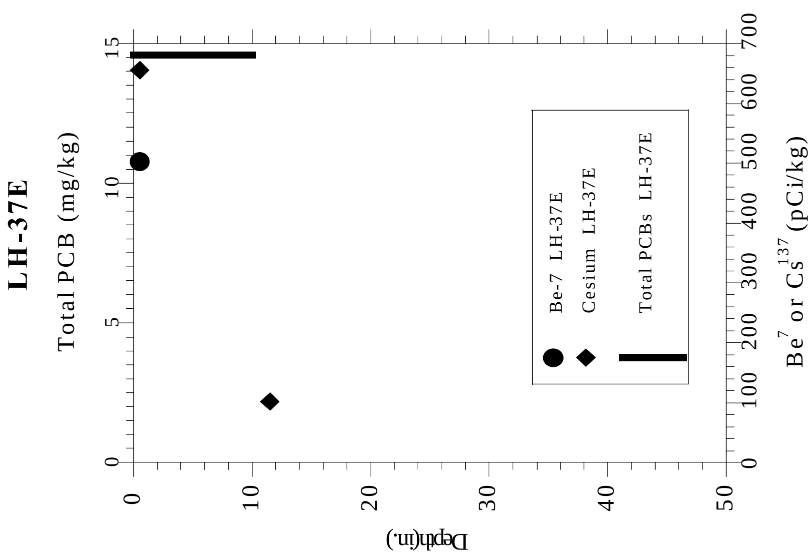


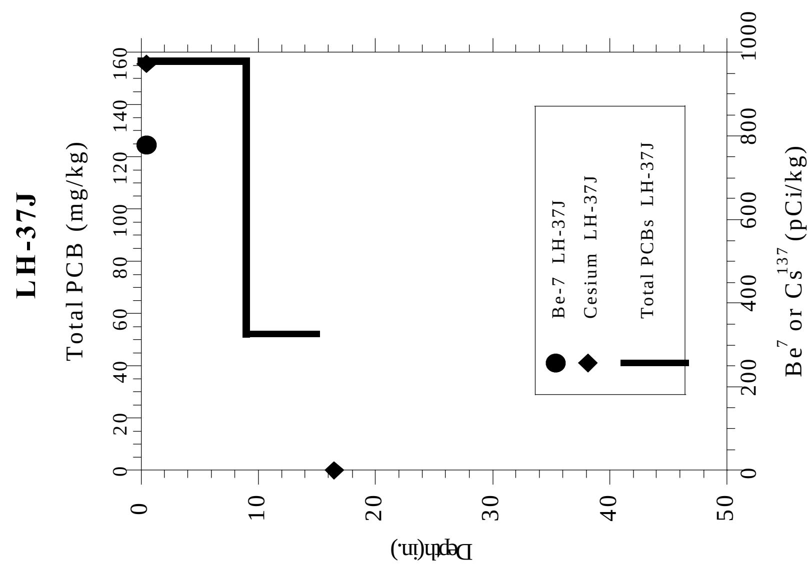


1994 Low Resolution Core Profiles below the Thompson Island Pool









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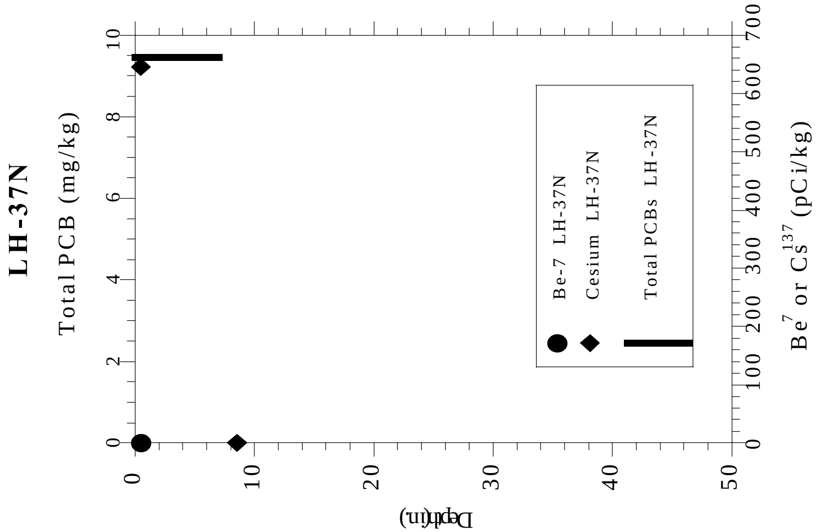

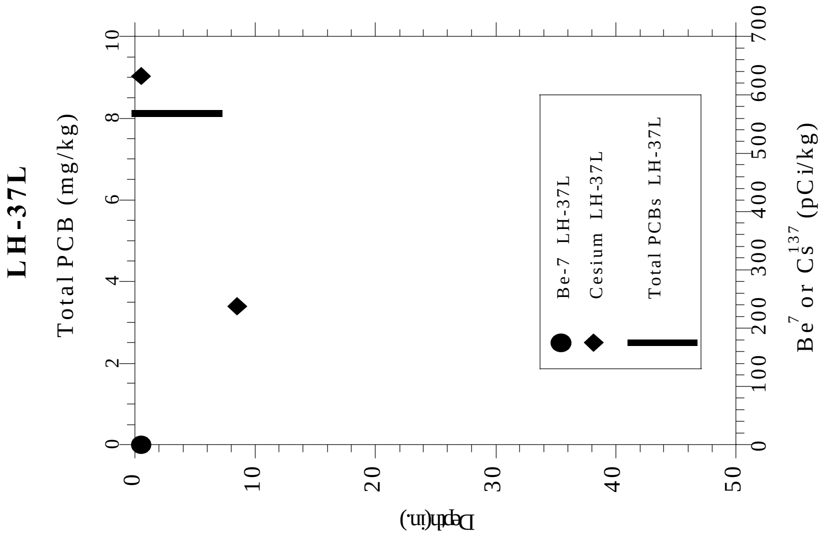

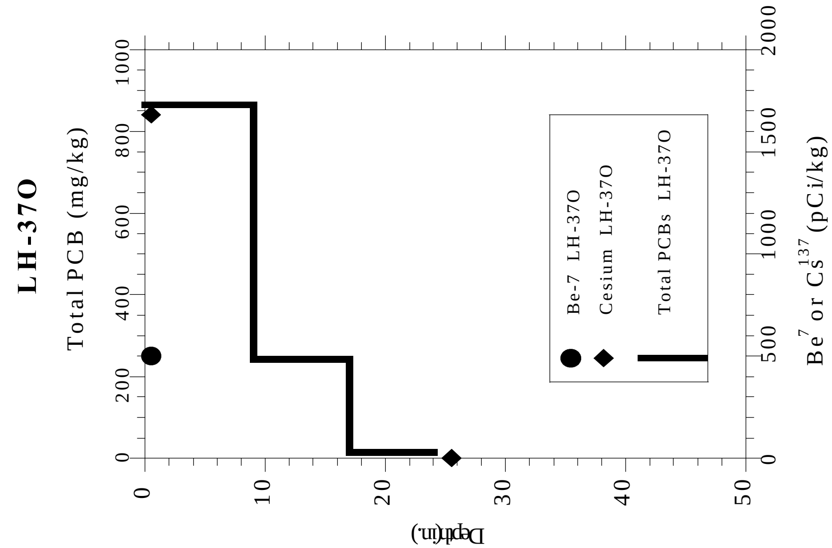

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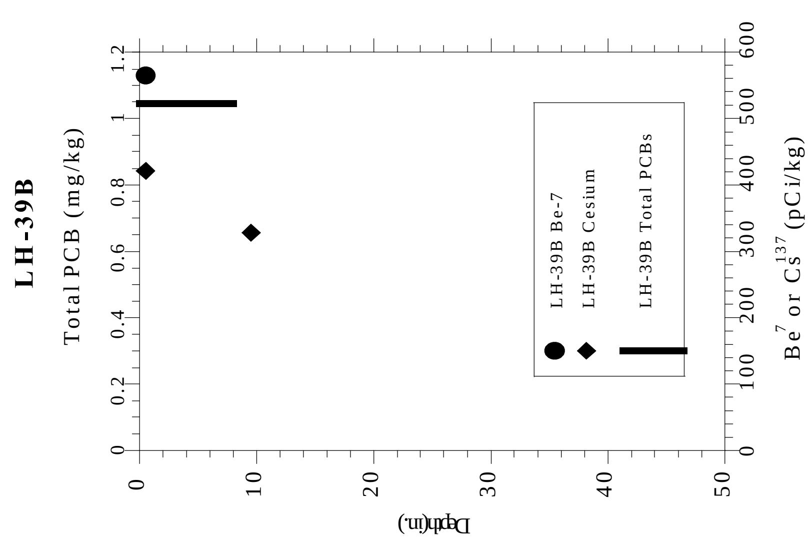

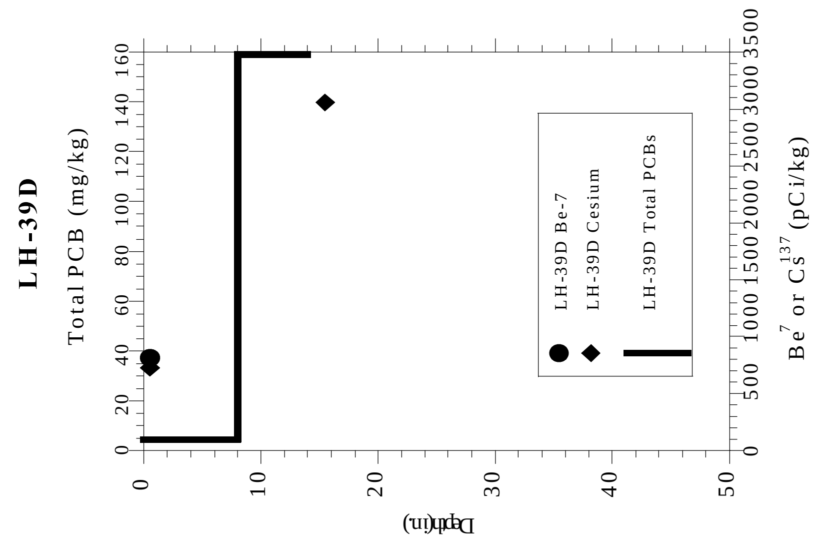

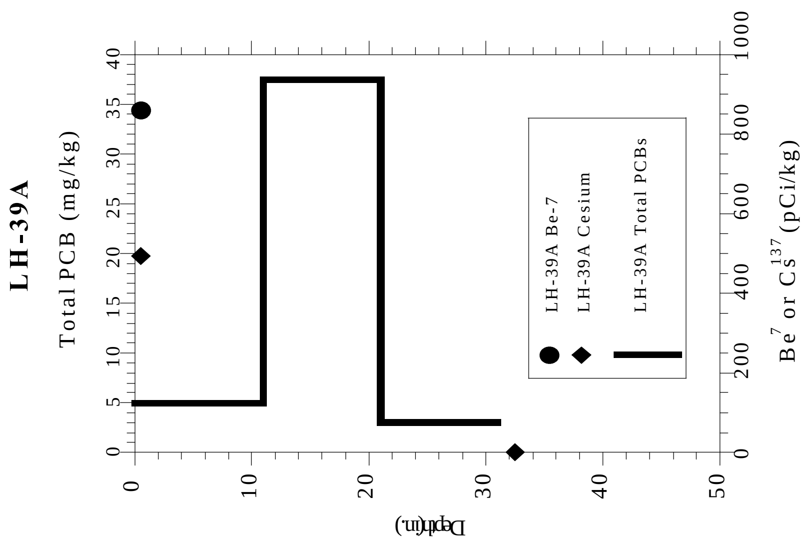

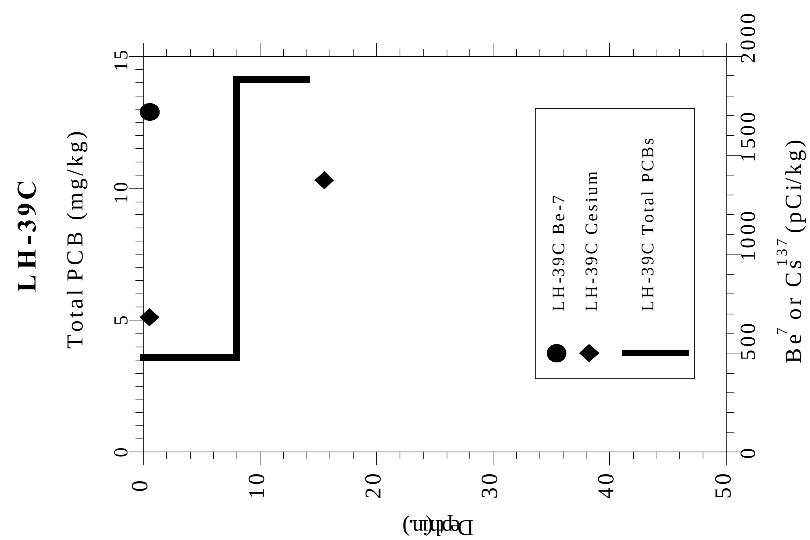

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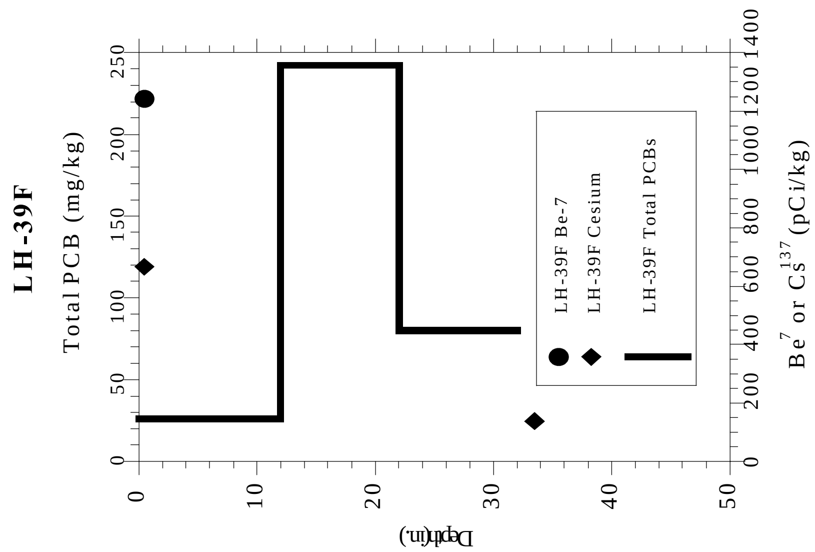

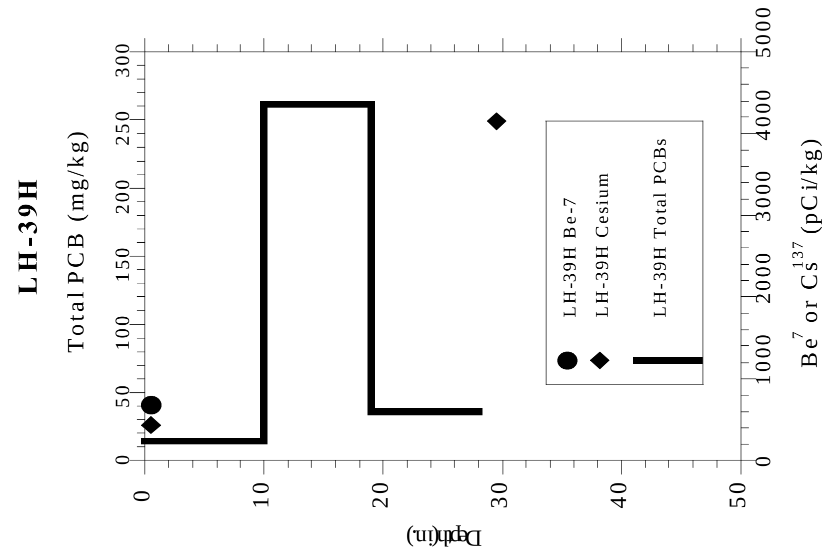

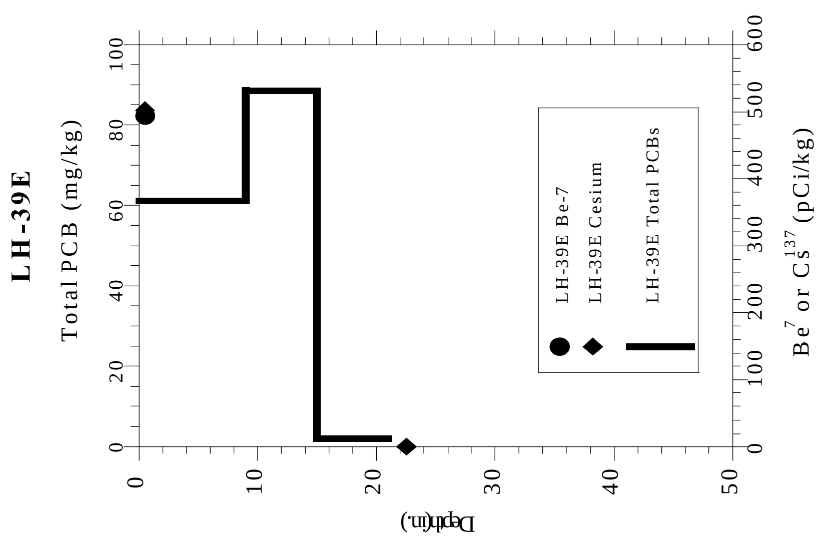

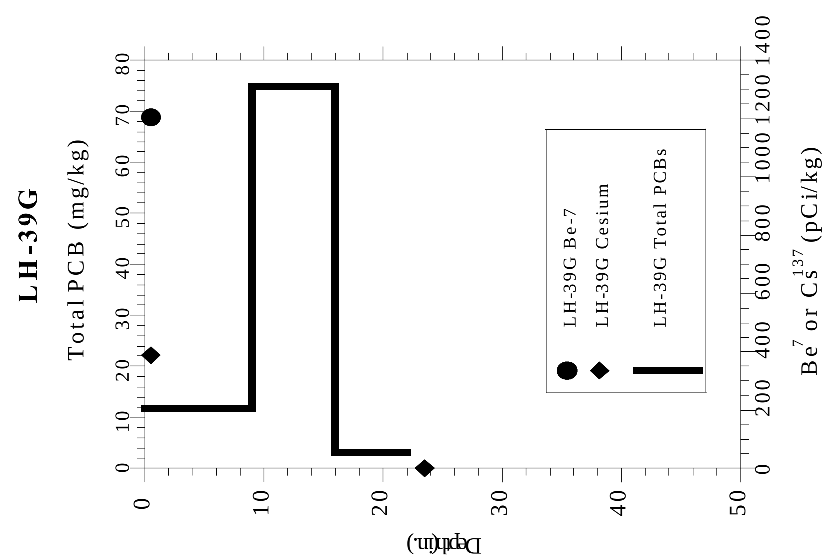

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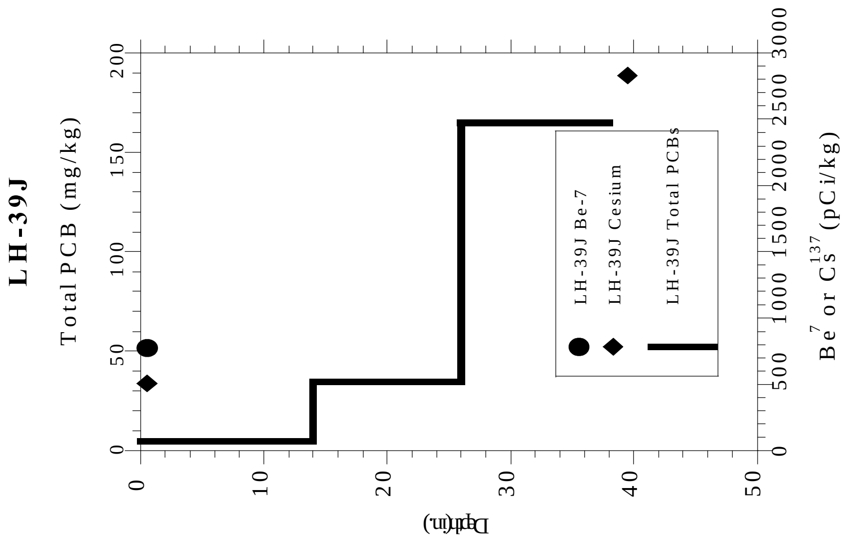

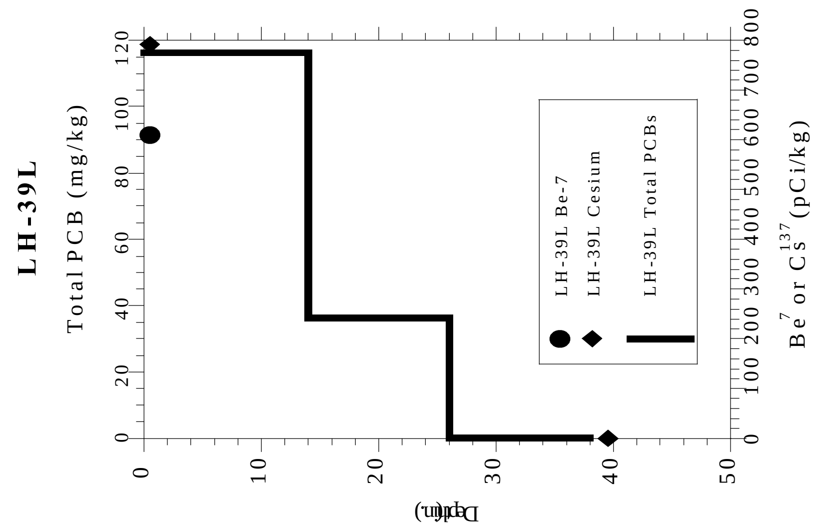

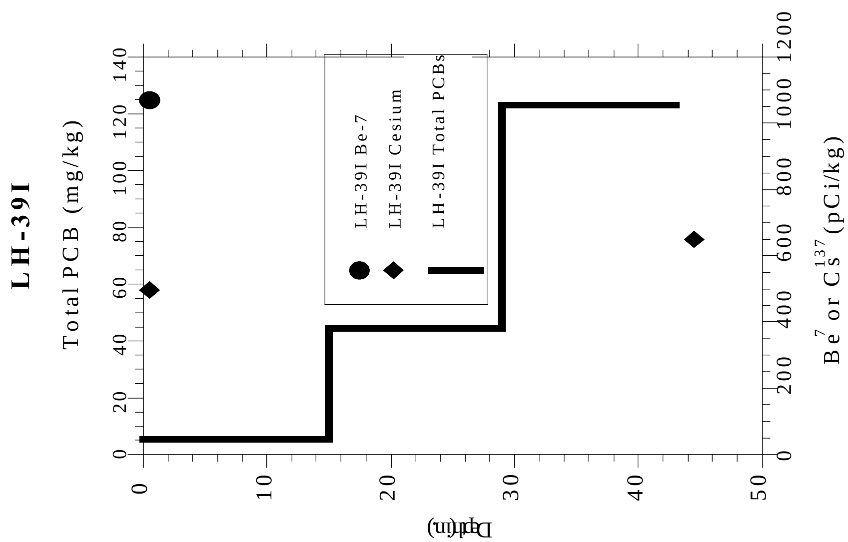

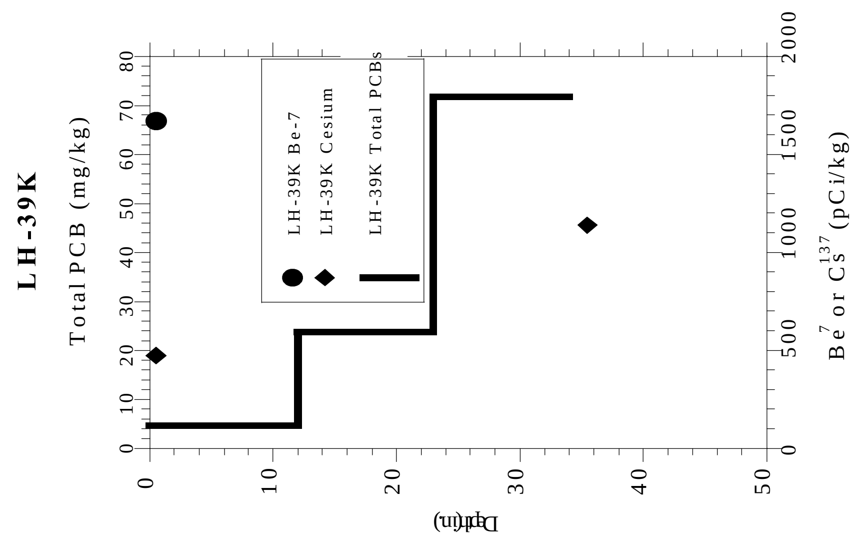

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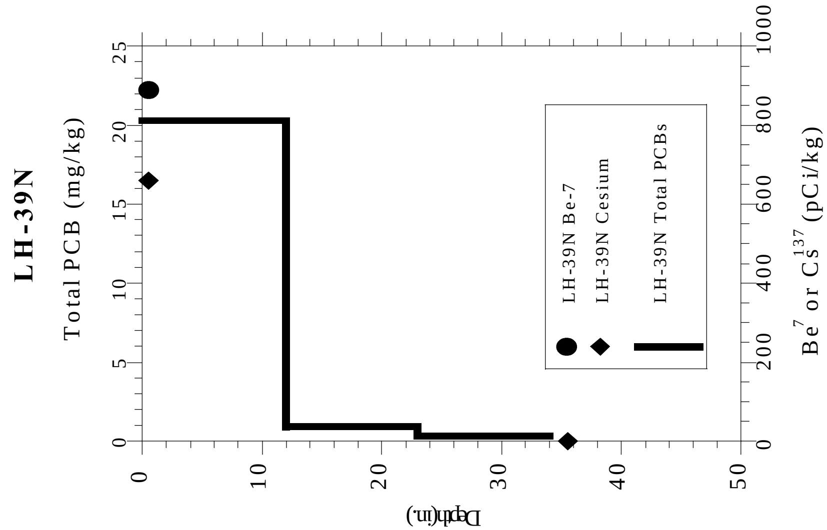

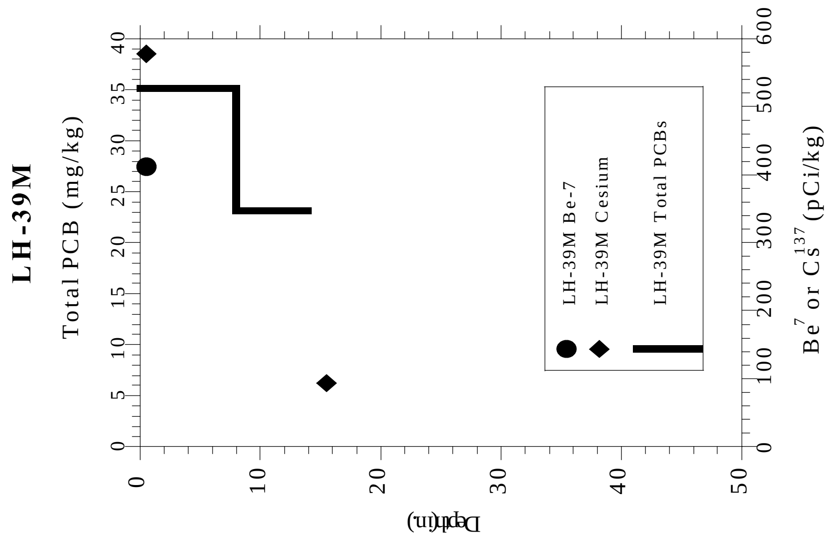

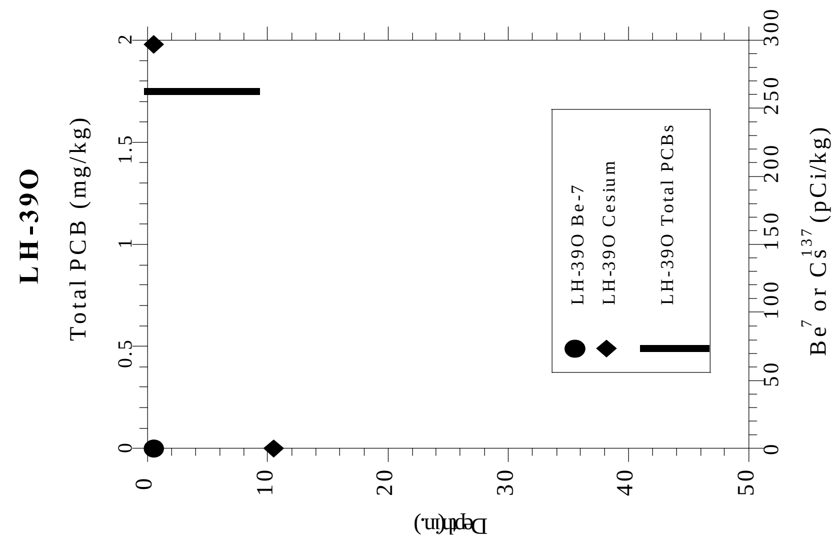

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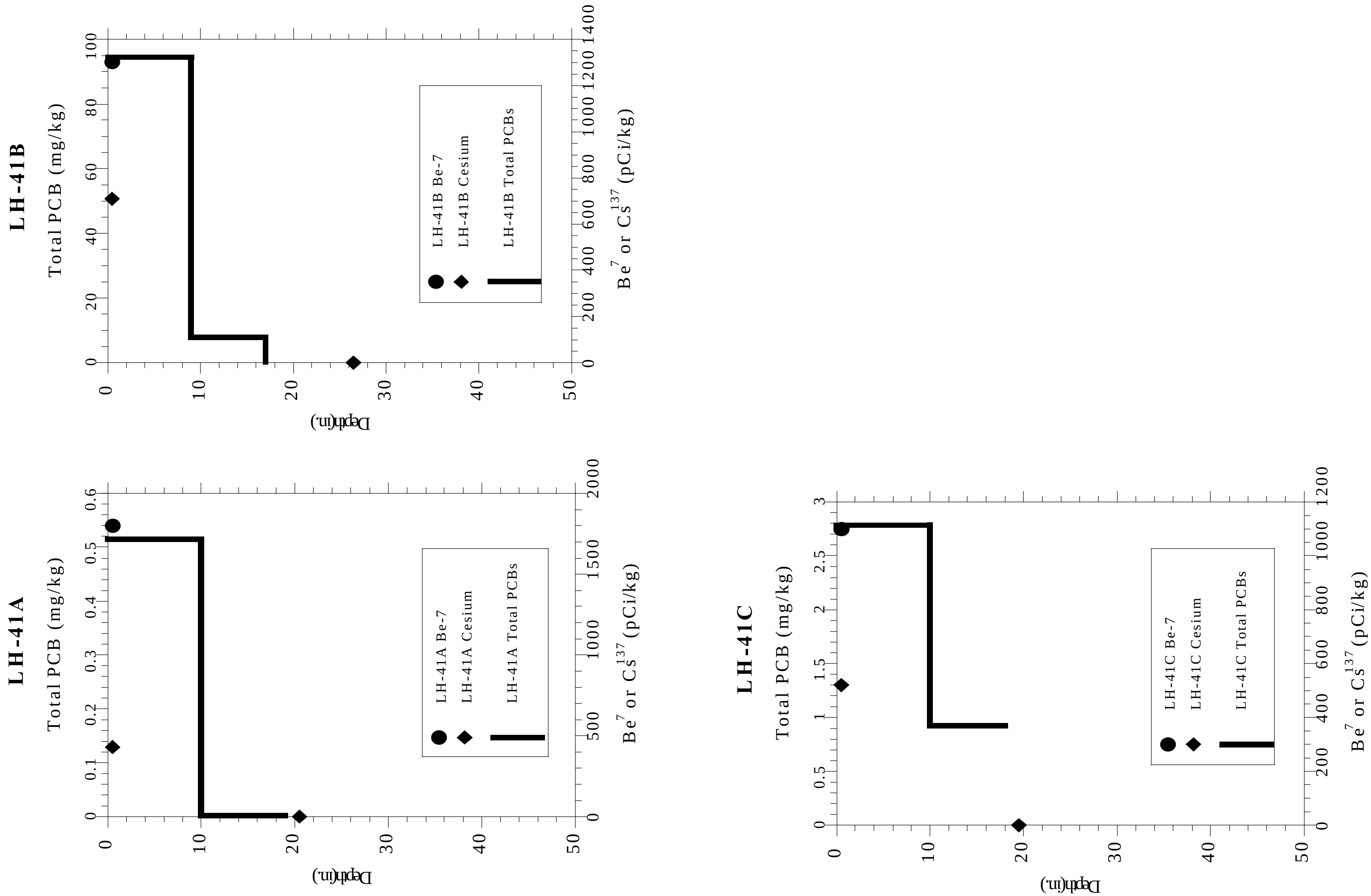

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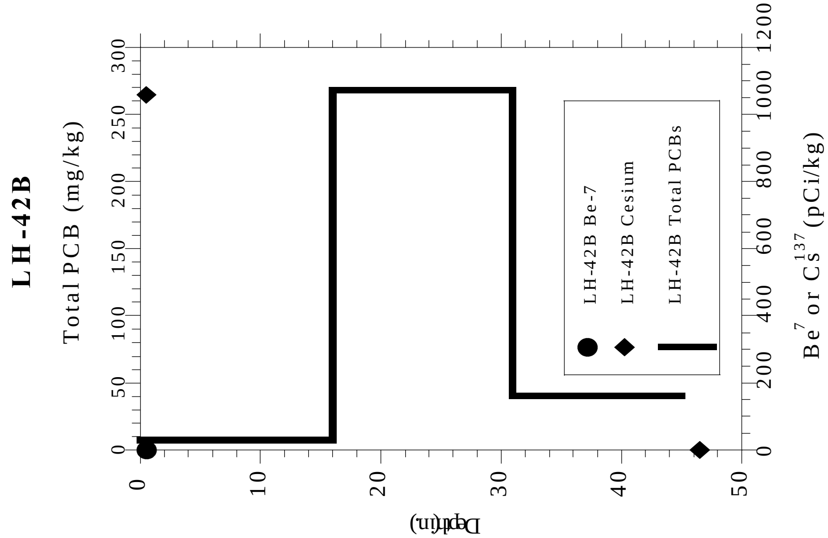

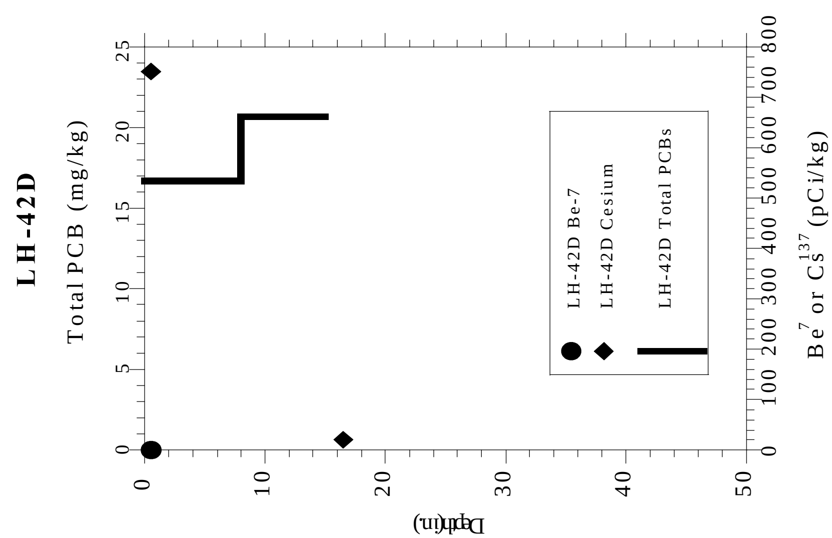

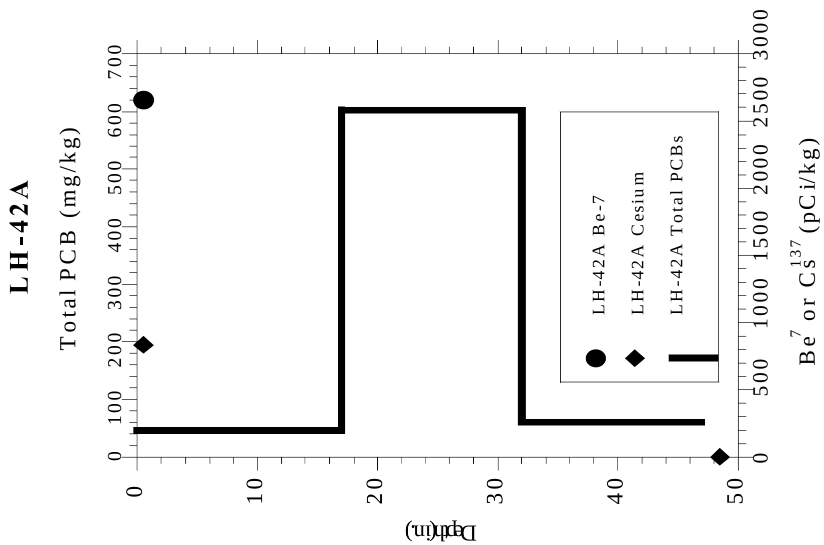

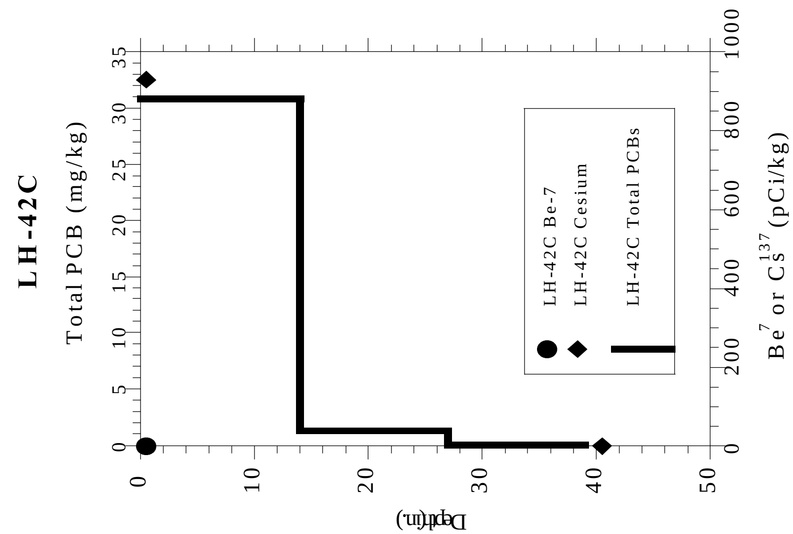

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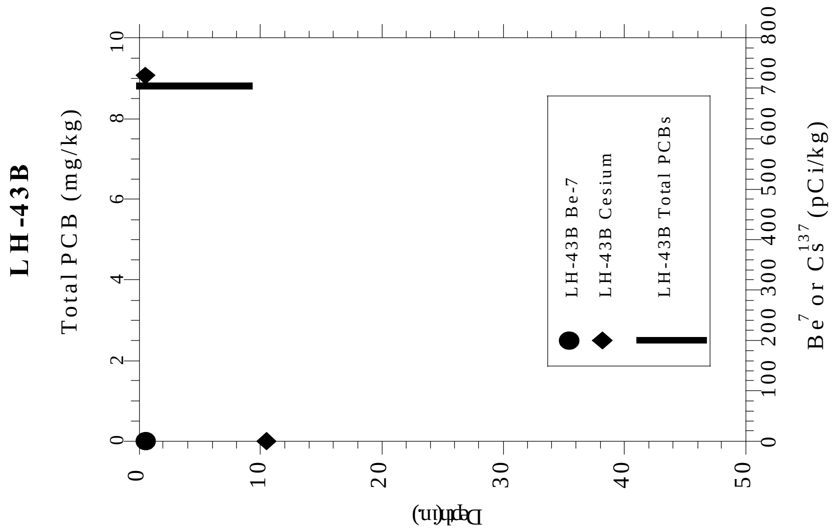

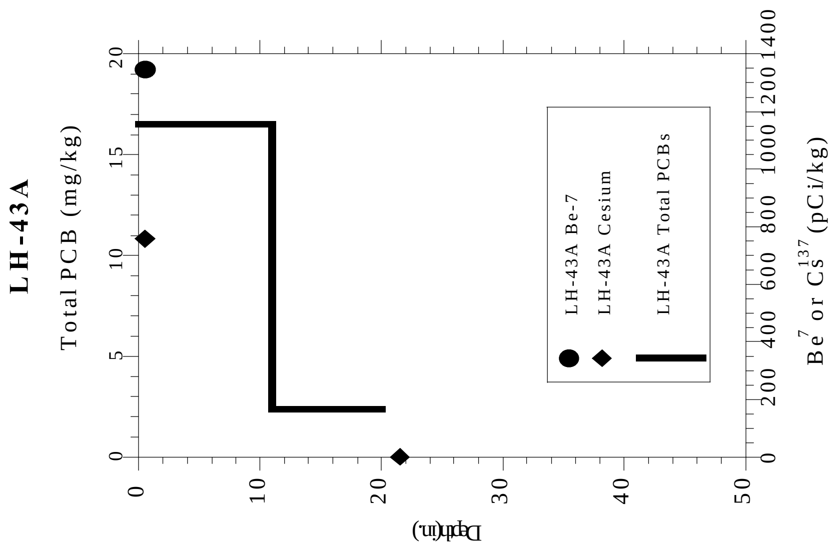

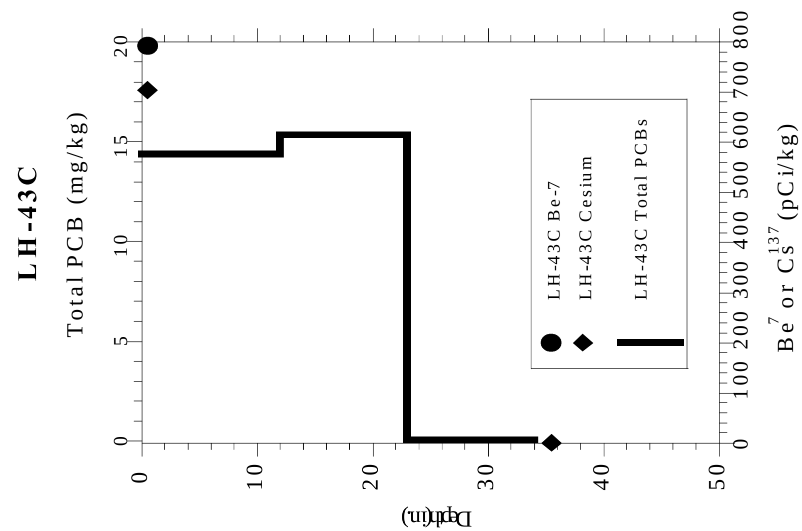

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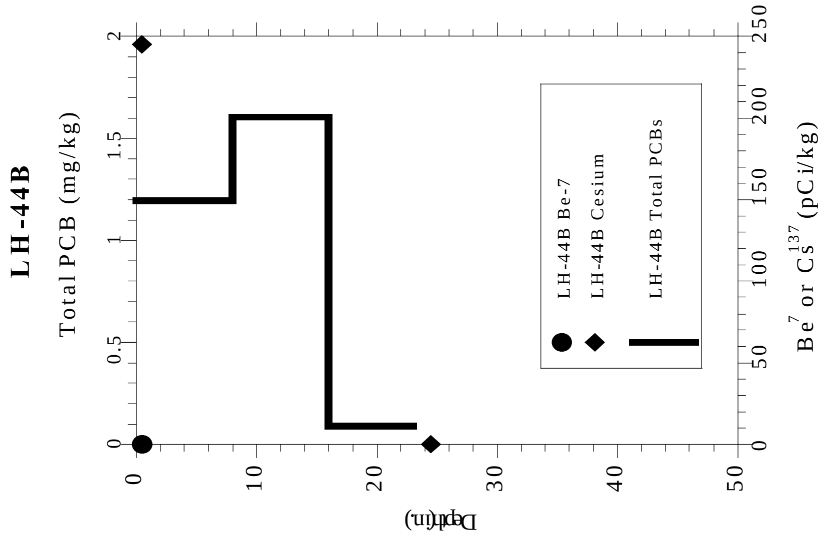

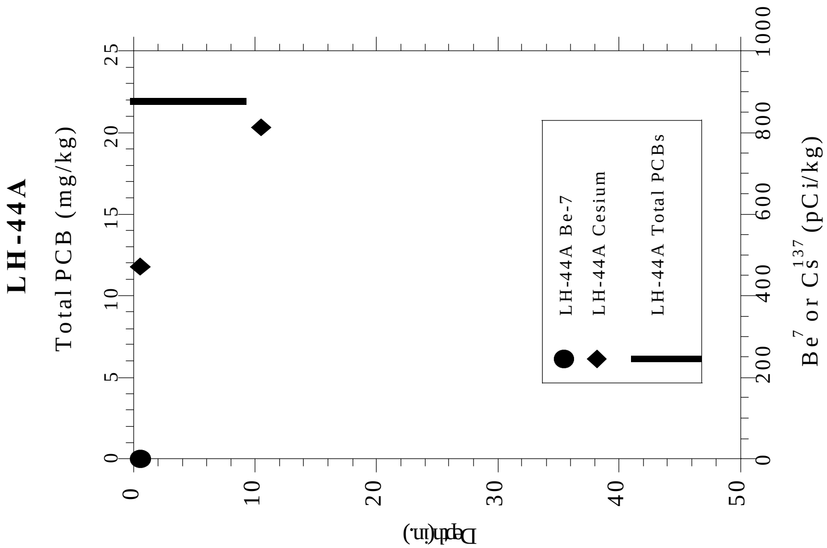

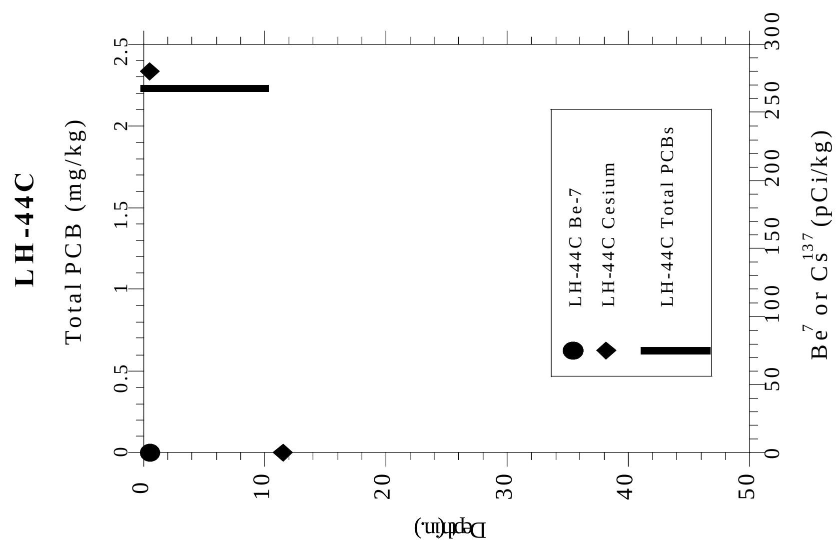

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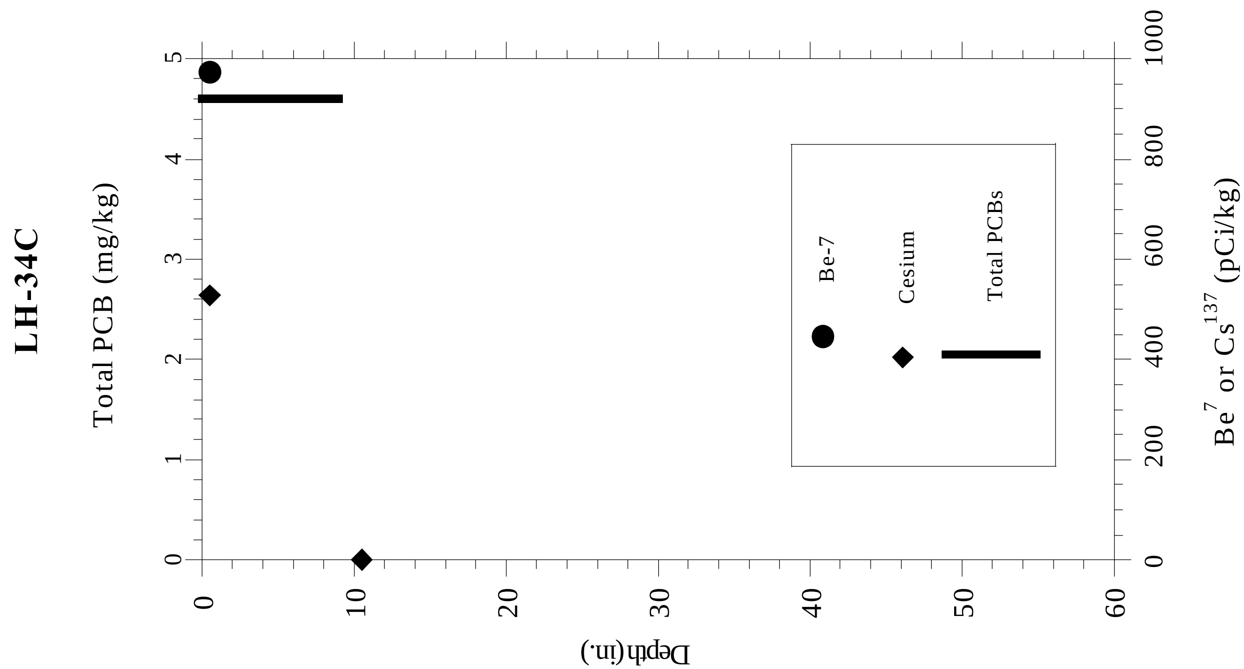

1994 Low Resolution Core Profiles below the Thompson Island Pool

APPENDIX E

ANALYSIS OF 1984 SEDIMENT PCB QUANTITATION

Analysis of 1984 Sediment PCB Quantitation

Jonathan B. Butcher
Tetra Tech, Inc.
June19, 1998

Purpose

PCB concentrations reported by NYSDEC for the 1984 Thompson Island Pool sediment survey are dependent on the Aroclor quantitation methods used and are not equivalent to results which would be obtained using capillary column GC analysis for PCB congeners. A translation scheme is required to make these data consistent with Phase 2 congener-based quantitations.

Summary

"Total PCBs" reported for the 1984 sediment data (calculated by NYSDEC as a sum of Aroclors) provide a good representation of the sum of tri- and higher-chlorinated congeners. They do not accurately reflect total of all congeners. A linear relationship can be used to correct these data to a basis consistent with the sum of tri- and higher-chlorinated congeners (ΣTri+) in the EPA Phase 2 data.

Introduction

Valid interpretation of historical trends in PCB concentrations cannot be made without consideration of the changes in analytical methods which have occurred over time. That is, a comparison is valid only when there is consistency in what is being measured. The most dramatic change in analytical methods is that between the recent data, using state-of-the-art, capillary-column, PCB congener analyses, and older analyses based on packed-column quantitation of Aroclor equivalents. Because an Aroclor is a complex mixture of many individual congeners, interpretation of the older packed-column data raises difficult technical issues. In addition, packed-column Aroclor quantitation methods have changed over time, and these changes have significant implications for the interpretation of historical trends in the data and the development of valid statistical relationships.

Because a commercial PCB mixture consists of many individual congeners, each with its own set of chemical properties, introduction into the environment quickly changes the original mixture and the relative proportions of the congeners. Processes such as weathering, dechlorination and biological accumulation affect the individual congeners to varying degrees. Thus, analytical Aroclor quantitations on environmental samples are not directly comparable to actual concentrations of PCB congeners. Results of capillary column analyses do not have a direct interpretation as "Aroclors"; however, total PCB concentration is readily estimated as the sum of individual congener concentrations.

The 1984 sediment survey (Brown et al., 1988) represents the most comprehensive database on PCB concentrations in Thompson Island Pool sediments. It is thus crucial to understand what is reported in these data and estimate how well the NYSDEC reported total represents actual total PCBs that would have been calculated by summing congener concentrations.

Analytical quantitations for the 1984 sediment survey were performed by Versar using packed-column GC and Aroclor standards. Versar reported concentrations of Aroclors 1242, 1254, and 1260. The chromatogram division flowchart described by Webb and McCall (1973) was used as a guideline to determine which packed column peaks should be included in these calculations. They did not, however, use the complete Webb and McCall method, nor did they report concentrations of lighter Aroclors.

Like the Webb and McCall (1973) approach, the method used by Versar is an *apportionment* method: that is, the packed-column peaks are each assigned to an individual Aroclor, and the concentration of that

Aroclor is then simply the sum of the concentrations represented by those peaks. Versar used "major" peaks only, with the result that some degree of underestimation is inevitable for any peaks not included in the quantitation. Indeed, NYSDEC determined that Versar's Aroclor 1242 estimates were significantly underestimated, which "highlights the problem associated with omitting peaks from calculations using the Webb and McCall analyses without correcting for the mass of PCB associated with ignored peaks" (Brown *et al*., 1988, p. 16). There was also concern that Versar had mis-identified peaks. NYSDEC therefore recalculated Aroclor 1242 using a different method which consisted of an average of the weighted responses of three packed column peaks. This recalculation is a *scaling*, rather than *apportionment*, method, in which a response factor is used to scale up the peak concentration to an Aroclor concentration. These re-calculated Aroclor 1242 estimates were summed with the Aroclor 1254 and Aroclor 1260 Versar quantitations to yield the total PCB estimates reported by NYSDEC and contained in the TAMS/Gradient database. (It should be noted that the database reports the original Versar quantitation for Aroclor 1242, and does not directly give the NYSDEC recalculated quantitation. The recalculated Aroclor 1242 estimate can, however, be retrieved by subtracting the Aroclor 1254 plus 1260 concentrations from the reported Total PCB concentration.)

Because there is overlap between the congener composition of Aroclors 1242 and 1254, use of a response factor scaling method for Aroclor 1242 can result in double-counting of congeners which appear in both Aroclor 1242 and the packed-column quantitation peaks used for Aroclor 1254. The original reapportionment method, which used major peaks only, is likely to underestimate PCB concentrations. Finally, it is known that significant dechlorination has occurred in Thompson Island Pool sediments, resulting in elevated concentrations of monochloro- and dichlorobiphenyls.

Methods

Performance of the 1984 quantitation scheme was investigated by performing "as if" numerical experiments on congener quantitations from the Phase 2 High Resolution Core data. This consists of interpreting the congener data "as if" they had been analyzed by the packed column methods used by NYSDEC and comparing the results to the actual sum of congeners.

As noted above, Versar employed a Webb and McCall-type method for Aroclors 1254 and 1260. In this approach, multiple packed-column peaks are used to estimate an Aroclor concentration. Each packed-column peak is used to estimate the concentration of PCBs associated with that peak. The concentrations of PCBs associated with *m* packed-column peaks are then summed to arrive at an estimate of the total Aroclor concentration:

$$[Aroclor] = \sum_{j=1}^{m} Area_j \bullet RF_{pj}$$

where RF_{pj} is a response factor for the packed column peak. Versar did not use any factors to correct for the fact that an Aroclor may not be completely represented by the selected peaks. In this approach, an Aroclor concentration estimate is equal to the sum of concentrations of the n_j PCB congeners associated with each of the *m* the packed column peaks:

$$[Aroclor] = \sum_{j=1}^{m} \sum_{i=1}^{n_j} [congener\ ]_{ij}$$

The NYSDEC Aroclor 1242 re-quantitations used an average of three quantitations based on responses to single packed column peaks. Each individual estimate is obtained based on a response factor relating the peak concentration to an Aroclor standard:

$$[Aroclor\ ]_j = Area_j \bullet RF_s$$

where $Area_j$ is the area associated with packed-column peak *j* and RF_s is a response factor defined as the concentration of standard Aroclor injected divided by the area of the selected packed-column peak. Area of a packed column peak is equivalent to the concentration of individual congeners in that peak divided by a packed-column response factor, defined as the concentration of standard Aroclor injected multiplied by the weight percent of PCBs in the packed-column peak and divided by the area of the selected packed-column peak. By definition, the ratio of the packed-column response factor to the Aroclor response factor is equal to the weight percent of the PCBs in the packed column peak. An equivalent estimate from congener data obtained from packed column peak *j* is approximately (Butcher, 1997):

$$[Aroclor\ ]_j \approx \frac{\sum_{i=1}^{n_j} [congener\ ]_{ij}}{wt\ \%\ peak_j}$$

Note that this interpretation is not technically exact, as it does not take into account variability in response factors among congeners within a packed-column peak. This does not, however, appear to introduce significant bias (Butcher, 1997). The final estimate for Aroclor 1242 is then obtained as the average over *m* peaks:

$$[Aroclor] \approx \frac{1}{m} \sum_{j=1}^{m} \frac{\sum_{i=1}^{n_j} [congener\ ]_{ij}}{wt\ \%\ peak_j}$$

To equate congener-specific analyses with packed-column data, information on the congeners represented in packed-column peaks is required. Because the absolute retention time of a packed-column peak may vary, many researchers adopted the convention of reporting retention times relative to the retention time of a standard compound. For example, Webb and McCall (1973) reported retention times relative to the retention time of p,p'-DDE. In this discussion, all packed-column peaks are referred to by their retention time relative to p,p'-DDE, and individual PCB congeners are referred to by their BZ numbers defined by Ballschmitter and Zell (1980). The packed-column peaks used for quantitation and congeners associated with these peaks (Brown et al., 1984; Gauthier, 1994) are shown in Table 1. Table 1 also shows the associated weight percents of congeners contained in a given RRT peak in the April 1994 Aquatec analyses of Aroclor standards.

Table 1. Quantitation Peaks and Congeners

Aroclor	RRT Peak	Associated Congeners (BZ #)	Weight Percent
1242	.28	15,17,18	13.9
	.47	47,48,49,52,75	8.7
	.58	41,64,*72*	3.5
1254	.98	85,87,97,119,136	8.6
	1.04	77,110	10.4
	1.25	82,107,118,135,144,149,151	14.3
	1.46	105,*132*,146,153	7.6
	1.60	*130*,137,141,*165*,*176*,*179*	12.7
	1.74	129,138,158,175,178	8.6
1260	2.03	128,167,183,185,187	9.1
	2.32	171,172,*173*,174,177,202	10.0
	2.44	156,157,*200*	0.6
	2.80	180,191,193	11.7
	3.32	170,190	4.8
	3.72	189,196,198,199,201,203	4.7
	4.48	195,208	1.0
	5.28	194,206	2.5

Note: congeners shown in italics do not have useable data in the Phase 2 Database.

Data

The analysis is based on the Phase II High Resolution Core data, using samples indicated as mainstem upper river and lower freshwater in the database (Release 3.7b). Both "P" samples and "A" samples with PCB quantitations were included, yielding 241 sample points. Only the 126 "useable" (target and nontarget) congeners were included. A total of eight congeners included within the packed-column quantitation peaks are not available or not useable in the database; these are not, however, believed to represent significant mass fractions. "Value 2" congener concentrations from the database were used, which contain specific corrections for non-detects. All "R" rejected data were dropped.

Results

Using the congener data, estimates of reported Aroclor methods "as if" calculated by the 1984 packed column methods were estimated. Total PCBs "as if" by the 1984 method were reconstituted as the sum of Aroclors 1242, 1254 and 1260. Total PCBs "as if" calculated by the 1984 NYSDEC method are plotted against actual sums of PCB congeners for the High Resolution Core data in Figure 1. From this plot, it is obvious that the NYSDEC sediment totals represent a consistent and significant underestimate of the total concentration PCBs which would be calculated by summing congener concentrations. For the higher concentration samples, the congener sums exceed the 1984-style Aroclor sums by a factor of about 2.5, representing a serious discrepancy.

The reason for this discrepancy is simple: Most of the sediment samples contain a significant proportion of dechlorination products, particularly BZ#1 (monochlorobiphenyl) and BZ#4 (dichlorobiphenyl). The lowest packed column peak used in the quantitation of NYSDEC totals (with Aroclor 1242 recalculation) is RRT .28, which contains BZ#15, BZ#17 and BZ#18. The latter two are trichlorobiphenyls, while BZ#15 is a dichlorobiphenyl. Thus, the NYSDEC sediment quantitations include only one of the dichlorobiphenyls and none of the monochlorobiphenyls, and will not reflect any enhancement of concentrations in this range.

This suggests that the 1984 data should provide a better approximation to the sum of tri- through deca-chlorobiphenyls, designated ΣTri+ (although a discrepancy may be present because Aroclor 1242 does contain a small fraction of mono- and dichlorobiphenyls). In Figure 2, the sum of Aroclors estimated from the High Resolution Core data "as if" by the 1984 quantitation methods are plotted against ΣTri+. It is obvious that the resulting numbers are in much closer agreement; further, the scatter in the 1984-method results is substantially reduced, resulting in a nearly linear plot.

Because a linear relationship holds, a regression-based correction is attractive. This yields the following relationship:

$$\sum Tri + (mg/kg) = -376.38\,(mg/kg) + 0.945 \bullet 1984\ Aroclor\ Sum\,(mg/kg)$$

with an R of 98.3 % and a standard error of 13,569 (ìg/kg). The intercept term is not significantly different from zero, and a regression forced through zero yields the relationship

$$\sum Tri + (mg/kg) = 0.944 \bullet 1984\ Aroclor\ Sum\,(mg/kg)$$

The correction factor is expected to be less than 1 because Aroclor 1242 does contain about 14.6% mono- and dichlorobiphenyls, which are not included in ΣTri+. The mono- and di-chlorobiphenyls which do contribute to Aroclor 1242, but are not included in the NYSDEC quantitation scheme (*i.e.*, all but BZ #15) have a total weight percent contribution of 12.98 % in the April 1994 Aquatec analysis. The correction factor to a tri- through deca-chlorinated homologue sum that would be *expected* based on an accurate quantitation of Aroclor 1242 (but not dechlorination products) is 1/1.1298 = 0.885. The actual correction factor is slightly higher, and likely reflects a small buildup of trichlorobiphenyl intermediate degradation products.

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Figure 1. PCBs in Sediment
Analysis of High Resolution Core Data

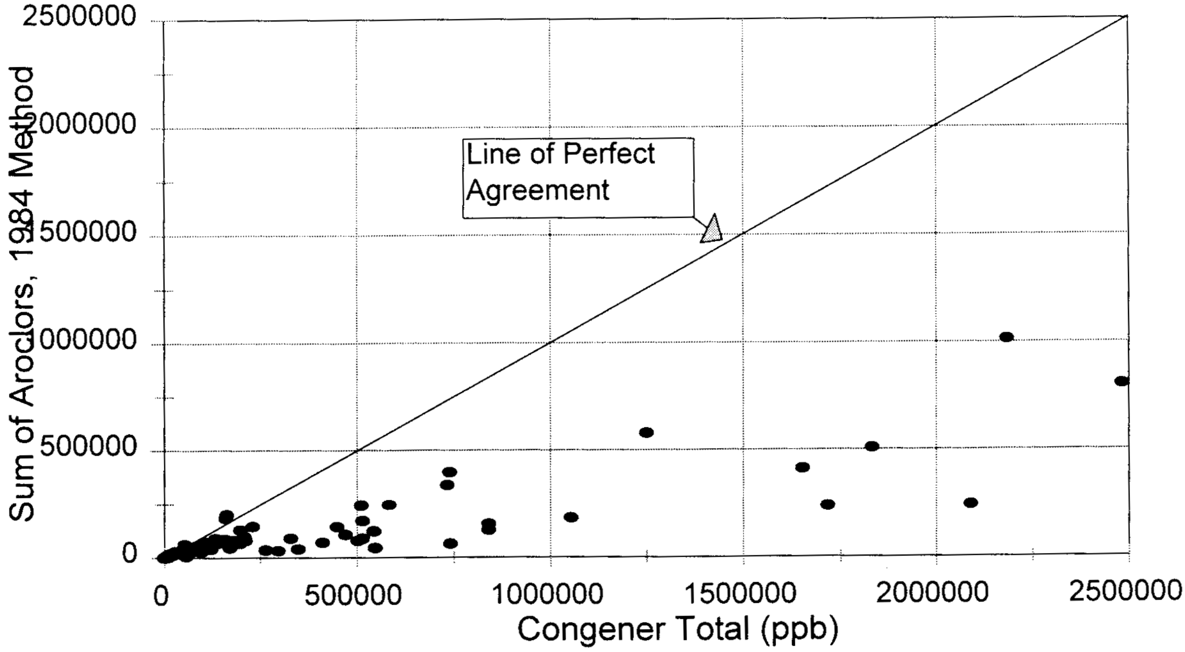
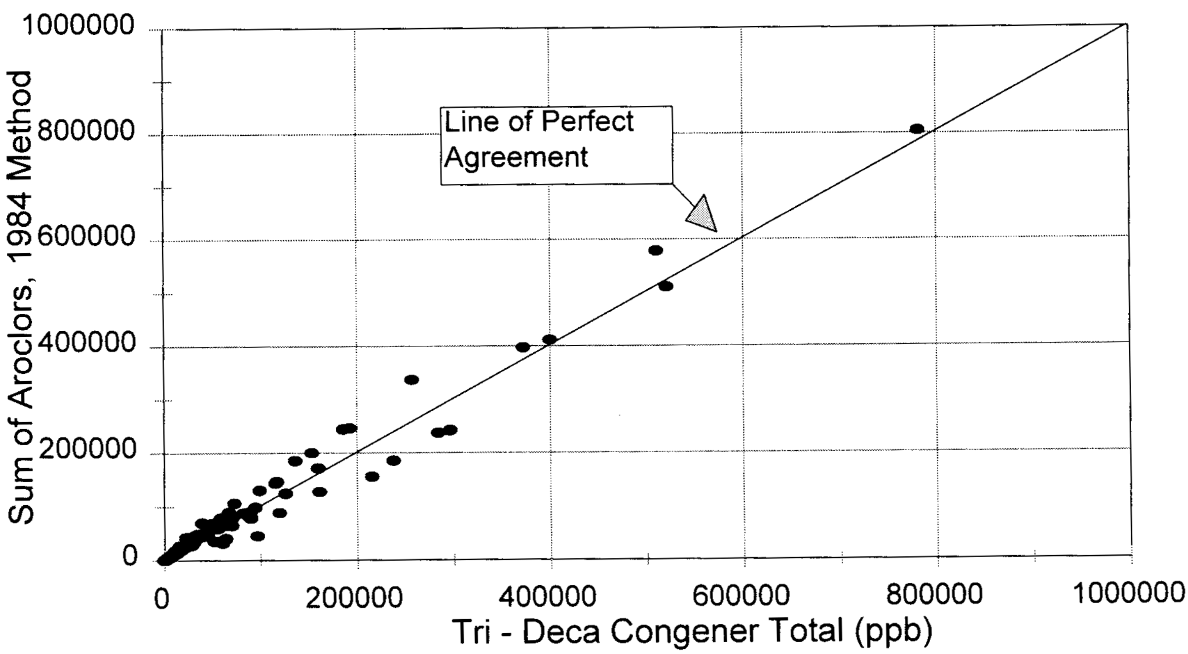


Figure 2. PCBs in Sediment
Analysis of Tri+ Congeners

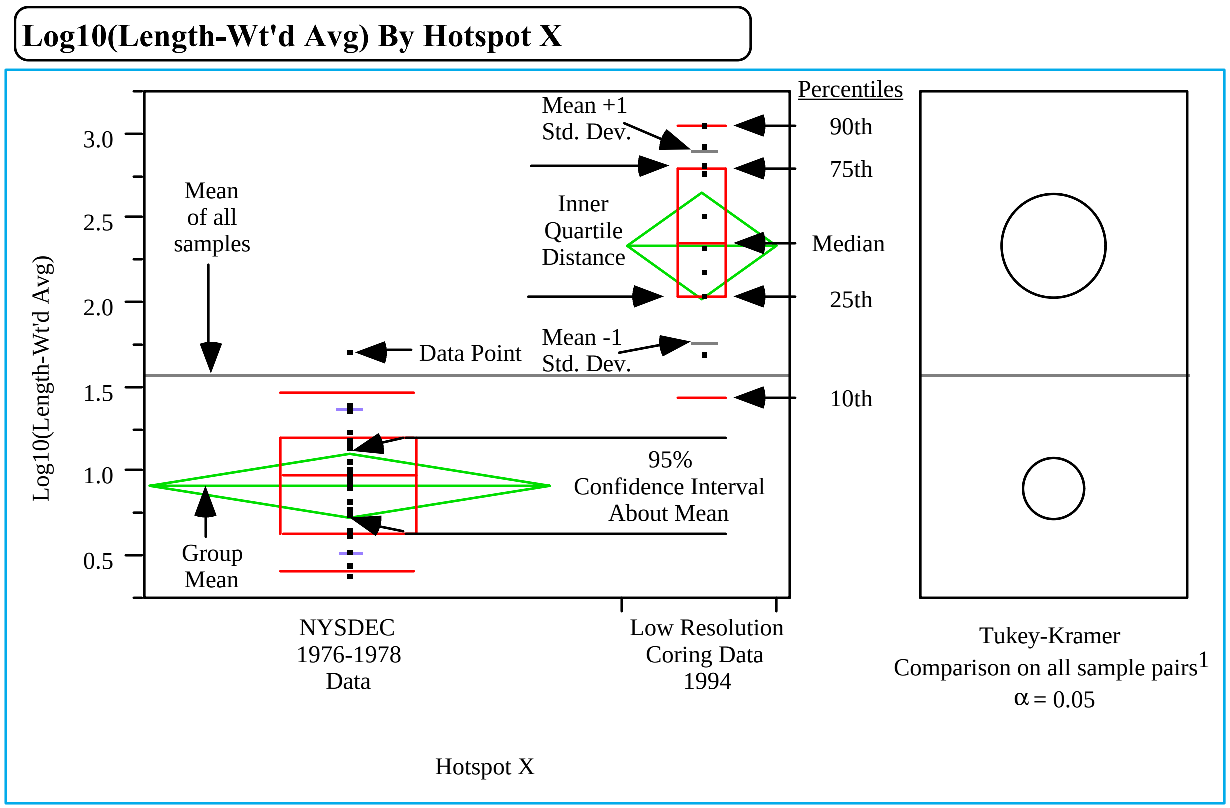


APPENDIX F

STATISTICAL SUMMARY SHEETS

FOR

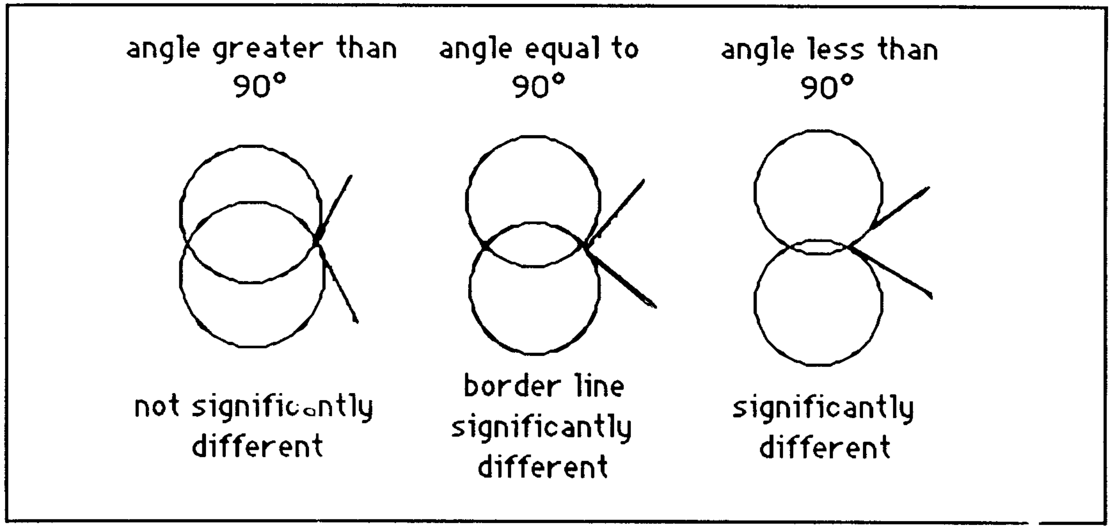
CHAPTER 4



Note:
1. See Key Diagram 2 for an explanation of the Tukey-Kramer comparison.

Appendix F - Key Diagram 1
Statistical Summary for *Hot Spots* Below the TI Dam

Tukey-Kramer Comparison [1]



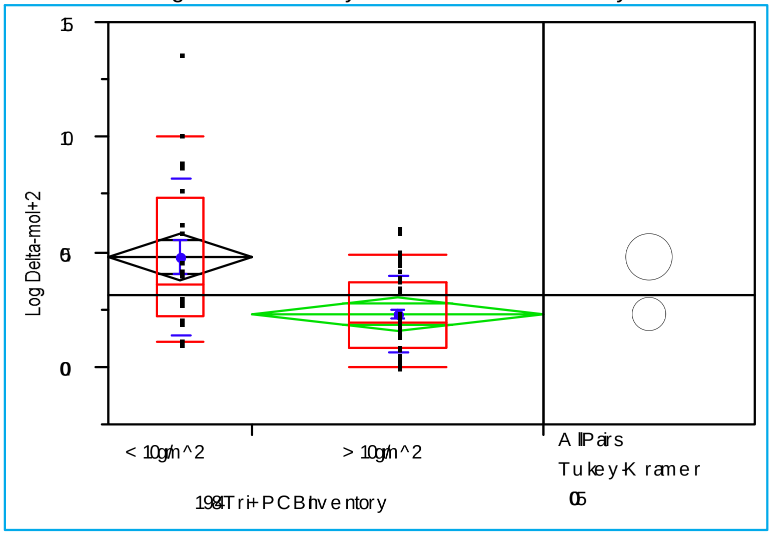
Note:

1. In the Tukey-Kramer comparison, the center of each circle is alligned with the mean of the group it represents. The circle diameter represents the 95% confidence interval about the mean. The outside angle of intersection tells you whether group means are significantly different. Circles for means that are significantly different either do not intersect or intersect slightly so that the outside angle of intersection is less than 90 degrees. If the circles intersect by an angle of more than 90 degrees or if they are nested, the means are not significantly different.

Appendix F - Key Diagram 2
Statistical Summary of Hot Spots Below the TI Dam

Statistical Analysis of Delta-M as a Function of 1984 Sediment Tri+ Inventory

Log Delta-mol+2 By 1984 Tri+ PCB Inventory



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
<10 g/m^2	0.105405	0.109909	0.228273	0.361064	0.738953	1.003681	1.367977
>10 g/m^2	0.002281	0.00555	0.090076	0.197488	0.372704	0.492914	0.614151

Oneway Anova

Summary of Fit

RSquare	0.191714
RSquare Adj	0.177778
Root Mean Square Error	0.243499
Mean of Response	0.317782
Observations (or Sum Wgts)	60

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.247335	3.709	58	0.0005
Std Error	0.066685			
Lower 95%	0.113851			
Upper 95%	0.380819			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8156611	0.815661	13.7568
Error	58	3.4389167	0.059292	Prob>F
C Total	59	4.2545778	0.072111	0.0005

Means for Oneway Anova

Level	Number	Mean	Std Error
<10 g/m^2	20	0.482672	0.05445
>10 g/m^2	40	0.235337	0.03850

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
<10 g/m^2	20	0.482672	0.346325	0.07744
>10 g/m^2	40	0.235337	0.172466	0.02727

Means Comparisons

Dif=Mean[i]-Mean[j]	<10 g/m^2	>10 g/m^2
<10 g/m^2	0.000000	0.247335
>10 g/m^2	-0.24733	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.00177

Abs(Dif)-LSD	<10 g/m^2	>10 g/m^2
<10 g/m^2	-0.15414	0.113847
>10 g/m^2	0.113847	-0.10899

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
<10 g/m^2	20	794	39.7000	2.878
>10 g/m^2	40	1036	25.9000	-2.878

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
794	2.87751	0.0040

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
8.3252	1	0.0039

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
<10 g/m^2	20	15	0.750000	2.716
>10 g/m^2	40	15	0.375000	-2.716

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
15	2.71570	0.0066

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
7.3750	1	0.0066

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
<10 g/m^2	20	10.83155	0.541578	3.124
>10 g/m^2	40	-10.83155	-0.27079	-3.124

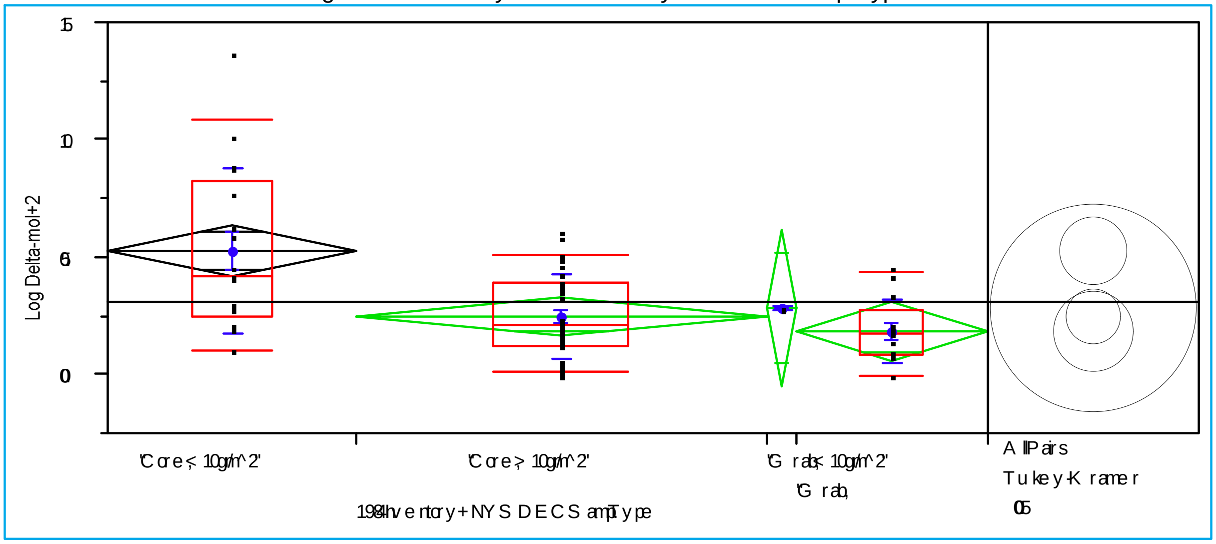
2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
10.831554	3.12414	0.0018

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
9.7603	1	0.0018

Log Delta-mol+2 By 1984 Inventory+NYSDECSamp.Type



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
Core, <10g/m^2	0.105405	0.10803	0.246473	0.423296	0.827968	1.086288	1.367977
Core, >10g/m^2	0.002771	0.01285	0.126361	0.210579	0.393918	0.516151	0.614151
Grab, <10g/m^2	0.278202	0.278202	0.278202	0.284705	0.291207	0.291207	0.291207
Grab, >10 g/m^2"	0.002281	0.002511	0.085531	0.179616	0.278069	0.442029	0.454789

Oneway Anova

Summary of Fit

RSquare	0.255173
RSquare Adj	0.215272
Root Mean Square Error	0.237882
Mean of Response	0.317782
Observations (or Sum Wgts)	60

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	1.0856546	0.361885	6.3951
Error	56	3.1689231	0.056588	Prob>F
C Total	59	4.2545778	0.072111	0.0008

Means for Oneway Anova

Level	Number	Mean	Std Error
Core, <10g/m^2	17	0.527242	0.05769
Core, >10g/m^2	28	0.253761	0.04496
Grab, <10g/m^2	2	0.284705	0.16821
Grab, >10 g/m^2	13	0.186853	0.06598

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
Core, <10g/m^2	17	0.527242	0.356701	0.08651
Core, >10g/m^2	28	0.253761	0.180885	0.03418
Grab, <10g/m^2	2	0.284705	0.009196	0.00650
Grab, >10 g/m^2	13	0.186853	0.144236	0.04000

Means Comparisons

Dif=Mean[i]-Mean[j]	Core, <10g/m^2	Grab, <10g/m^2	Core, >10g/m^2	Grab, >10 g/m^2
Core, <10g/m^2	0.000000	0.242537	0.273482	0.340389
Grab, <10g/m^2	-0.24254	0.000000	0.030944	0.097852
Core, >10g/m^2	-0.27348	-0.03094	0.000000	0.066907
Grab, >10 g/m^2	-0.34039	-0.09785	-0.06691	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*

2.64794

Abs(Dif)-LSD	Core, <10g/m^2	Grab, <10g/m^2	Core, >10g/m^2	Grab, >10 g/m^2
Core, <10g/m^2	-0.21605	-0.22834	0.079807	0.108311
Grab, <10g/m^2	-0.22834	-0.6299	-0.43009	-0.38059
Core, >10g/m^2	0.079807	-0.43009	-0.16835	-0.1445
Grab, >10 g/m^2	0.108311	-0.38059	-0.1445	-0.24707

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Core, <10g/m^2	17	714	42.0000	3.199
Core, >10g/m^2	28	774	27.6429	-1.178
Grab, <10g/m^2	2	66	33.0000	0.185
Grab, >10 g/m^2	13	276	21.2308	-2.153

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
11.8238	3	0.0080

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Core, <10g/m^2	17	13	0.76471	2.557
Core, >10g/m^2	28	12	0.42857	-1.026
Grab, <10g/m^2	2	2	1.00000	1.426
Grab, >10 g/m^2	13	3	0.23077	-2.175

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
10.9203	3	0.0122

Van der Waerden Test (Normal Quantiles)

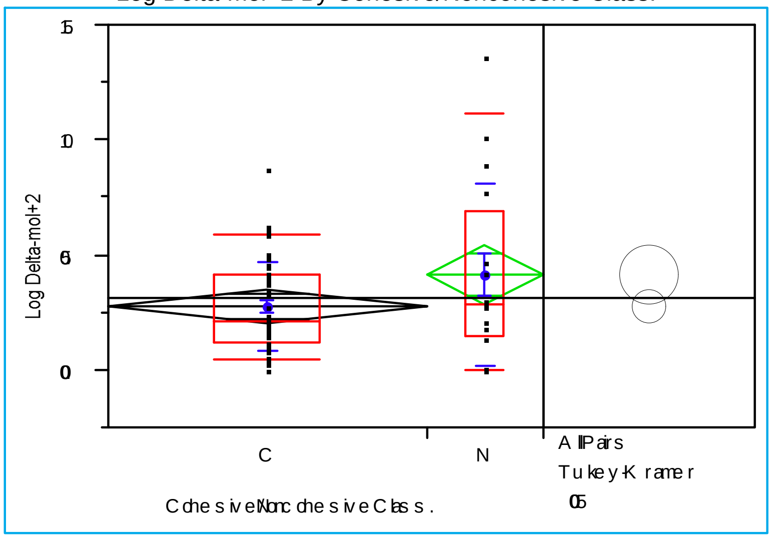
Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Core, <10g/m^2	17	11.36602	0.668590	3.430
Core, >10g/m^2	28	-4.79822	-0.17137	-1.308
Grab, <10g/m^2	2	0.20600	0.103000	0.156
Grab, >10 g/m^2	13	-6.77380	-0.52106	-2.236

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
13.2799	3	0.0041

Analysis of Fractional Change in Mole/m^2 as Log(Delta-M) vs. Cohesive/Noncohesive Sediment Classification for TI Pool Cores (Alpha=0.05) Low Resolution Cores

Log Delta-mol+2 By Cohesive/Noncohesive Class.



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
C	0.002771	0.04982	0.127276	0.218508	0.420494	0.592224	0.881222
N	0.002281	0.002682	0.153385	0.292994	0.698694	1.1215	1.367977

Oneway Anova

Summary of Fit

RSquare	0.050875
RSquare Adj	0.034511
Root Mean Square Error	0.263861
Mean of Response	0.317782
Observations (or Sum Wgts)	60

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.13582	-1.763	58	0.0831
Std Error	0.077031			
Lower 95%	-0.29002			
Upper 95%	0.018372			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.2164511	0.216451	3.1089
Error	58	4.0381267	0.069623	Prob>F
C Total	59	4.2545778	0.072111	0.0831

Means for Oneway Anova

Level	Number	Mean	Std Error
C	44	0.281563	0.03978
N	16	0.417385	0.06597

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
C	44	0.281563	0.197533	0.02978
N	16	0.417385	0.396678	0.09917

Means Comparisons

Dif=Mean[i]-Mean[j]	N	C
N	0.000000	0.135822
C	-0.13582	0.000000

Alpha=	0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.00177

Abs(Dif)-LSD	N	C
N	-0.18674	-0.01838
C	-0.01838	-0.11261

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
C	44	1294	29.4091	-0.794
N	16	536	33.5000	0.794

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
536	0.79402	0.4272

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.6438	1	0.4223

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
C	44	20	0.454545	-1.158
N	16	10	0.625000	1.158

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
10	1.15798	0.2469

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.3409	1	0.2469

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
C	44	-2.718327	-0.06178	-0.836
N	16	2.718327	0.169895	0.836

2-Sample Test, Normal Approximation

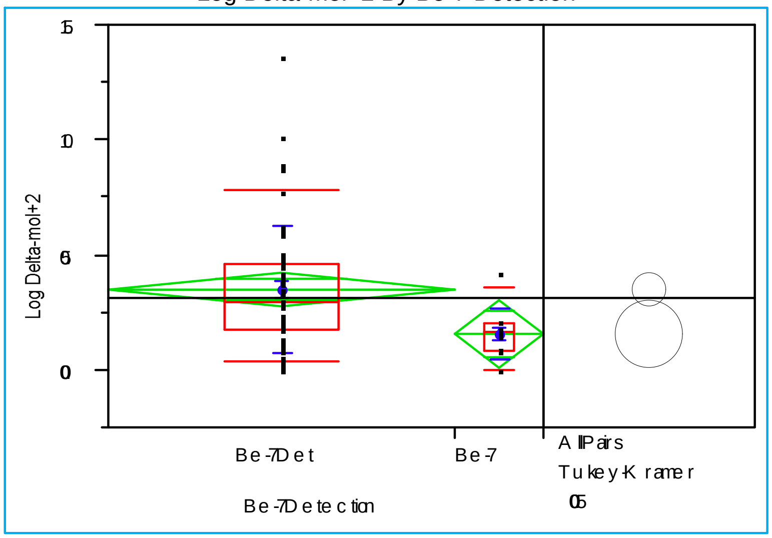
S	Z	Prob>|Z|
2.7183272	0.83580	0.4033

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.6986	1	0.4033

Analysis of Fractional Change in Mole/m^2 as Log (Delta-M) vs. Be-7 Detection in TI Pool Low Resolution Cores

Log Delta-mol+2 By Be-7 Detection



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
Be-7 Det	0.002281	0.039899	0.177117	0.301799	0.467951	0.785365	1.367977
Be-7 Non	0.002771	0.002796	0.090076	0.166507	0.205651	0.365193	0.428032

Oneway Anova

Summary of Fit

RSquare	0.089425
RSquare Adj	0.073726
Root Mean Square Error	0.258447
Mean of Response	0.317782
Observations (or Sum Wgts)	60

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.199078	2.387	58	0.0203
Std Error	0.083414			
Lower 95%	0.032108			
Upper 95%	0.366048			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.3804676	0.380468	5.6960
Error	58	3.8741102	0.066795	Prob>F
C Total	59	4.2545778	0.072111	0.0203

Means for Oneway Anova

Level	Number	Mean	Std Error
Be-7 Det	48	0.357598	0.03730
Be-7 Non	12	0.158520	0.07461

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
Be-7 Det	48	0.357598	0.281936	0.04069
Be-7 Non	12	0.158520	0.112076	0.03235

Means Comparisons

Dif=Mean[i]-Mean[j]	Be-7 Det	Be-7 Non
Be-7 Det	0.000000	0.199078
Be-7 Non	-0.19908	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.00177

Abs(Dif)-LSD	Be-7 Det	Be-7 Non
Be-7 Det	-0.1056	0.032103
Be-7 Non	0.032103	-0.21121

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Be-7 Det	48	1608	33.5000	2.652
Be-7 Non	12	222	18.5000	-2.652

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
222	-2.65196	0.0080

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
7.0820	1	0.0078

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Be-7 Det	48	29	0.604167	3.200
Be-7 Non	12	1	0.083333	-3.200

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1	-3.20048	0.0014

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
10.2431	1	0.0014

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Be-7 Det	48	7.424459	0.154676	2.524
Be-7 Non	12	-7.424459	-0.6187	-2.524

2-Sample Test, Normal Approximation

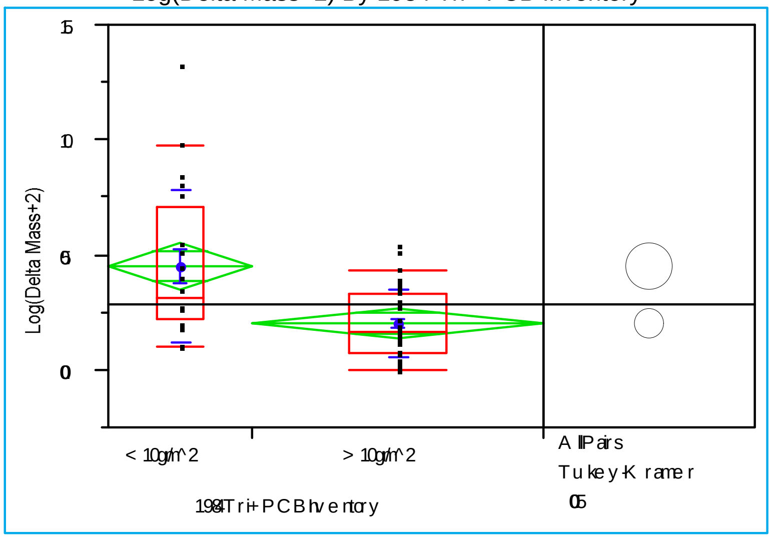
S	Z	Prob>|Z|
-7.424459	-2.52370	0.0116

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
6.3691	1	0.0116

Analysis of Relative Change in Sediment Inventory as Mass/Area (MPA) as a Function of the 1984 Tri+ Inventory

Log(Delta Mass+2) By 1984 Tri+ PCB Inventory



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
<10 g/m^2	0.10305	0.108832	0.221767	0.317801	0.713091	0.978971	1.333799
>10 g/m^2	0.002317	0.005341	0.081851	0.167332	0.336886	0.438039	0.548945

Oneway Anova
Summary of Fit

RSquare	0.217576
RSquare Adj	0.204085
Root Mean Square Error	0.228549
Mean of Response	0.289599
Observations (or Sum Wgts)	60

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.251367	4.016	58	0.0002
Std Error	0.062591			
Lower 95%	0.126078			
Upper 95%	0.376656			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8424728	0.842473	16.1286
Error	58	3.0296203	0.052235	Prob>F
C Total	59	3.8720931	0.065629	0.0002

Means for Oneway Anova

Level	Number	Mean	Std Error
<10 g/m^2	20	0.457177	0.05111
>10 g/m^2	40	0.205810	0.03614

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
<10 g/m^2	20	0.457177	0.334528	0.07480
>10 g/m^2	40	0.205810	0.152193	0.02406

Means Comparisons

Dif=Mean[i]-Mean[j]	<10 g/m^2	>10 g/m^2
<10 g/m^2	0.000000	0.251367
>10 g/m^2	-0.25137	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.00177

Abs(Dif)-LSD	<10 g/m^2	>10 g/m^2
<10 g/m^2	-0.14468	0.126075
>10 g/m^2	0.126075	-0.1023

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
<10 g/m^2	20	806	40.3000	3.066
>10 g/m^2	40	1024	25.6000	-3.066

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
806	3.06568	0.0022

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
9.4466	1	0.0021

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
<10 g/m^2	20	15	0.750000	2.716
>10 g/m^2	40	15	0.375000	-2.716

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
15	2.71570	0.0066

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
7.3750	1	0.0066

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
<10 g/m^2	20	11.41896	0.570948	3.294
>10 g/m^2	40	-11.41896	-0.28547	-3.294

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
11.418959	3.29357	0.0010

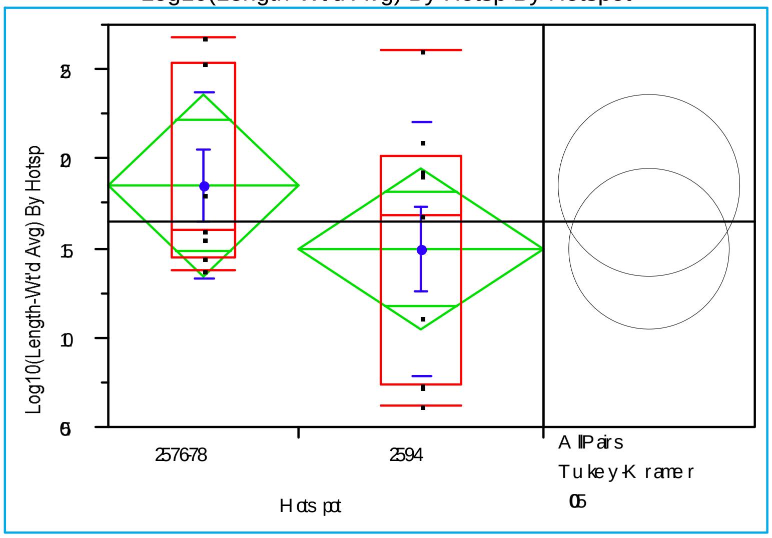
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
10.8476	1	0.0010

Length Weighted Average Comparision **Hot Spot 25**

log_{10}(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
25 76-78	1.380211	1.380211	1.450403	1.602819	2.538637	2.687529	2.687529
25 94	0.630713	0.630713	0.738119	1.692758	2.022499	2.611163	2.611163

Oneway Anova

Summary of Fit

RSquare	0.082278
RSquare Adj	0.016726
Root Mean Square Error	0.641831
Mean of Response	1.657556
Observations (or Sum Wgts)	16

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.36238	1.120	14	0.2814
Std Error	0.32345			
Lower 95%	-0.33136			
Upper 95%	1.05611			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.5170608	0.517061	1.2552
Error	14	5.7672556	0.411947	Prob>F
C Total	15	6.2843164	0.418954	0.2814

Means for Oneway Anova

Level	Number	Mean	Std Error
25 76-78	7	1.86139	0.24259
25 94	9	1.49902	0.21394

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
25 76-78	7	1.86139	0.532695	0.20134
25 94	9	1.49902	0.712800	0.23760

Means Comparisons

Dif=Mean[i]-Mean[j]	25 76-78	25 94
25 76-78	0.000000	0.362377
25 94	-0.36238	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.14478

Abs(Dif)-LSD	25 76-78	25 94
25 76-78	-0.73582	-0.33136
25 94	-0.33136	-0.64893

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
25 76-78	7	66	9.42857	0.635
25 94	9	70	7.77778	-0.635

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
66	0.63511	0.5254

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.4734	1	0.4914

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
25 76-78	7	3	0.428571	-0.488
25 94	9	5	0.555556	0.488

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
3	-0.48795	0.6256

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.2381	1	0.6256

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
25 76-78	7	1.501048	0.214435	0.865
25 94	9	-1.501048	-0.16678	-0.865

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1.5010477	0.86536	0.3868

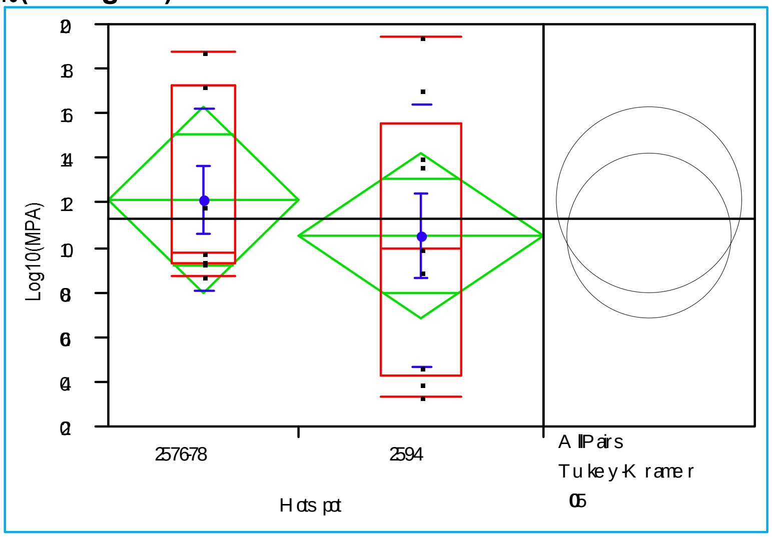
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.7488	1	0.3868

Log10(MPA) By Hotspot

Mass per Unit Area Comparision **Hot Spot 25**

$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
25 76-78	0.8777	0.8777	0.9381	0.9822	1.7302	1.8791	1.8791
25 94	0.3374	0.3374	0.4305	0.9997	1.55875	1.9457	1.9457

Oneway Anova

Summary of Fit

RSquare	0.026647
RSquare Adj	-0.04288
Root Mean Square Error	0.520609
Mean of Response	1.129506
Observations (or Sum Wgts)	16

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.162427	0.619	14	0.5458
Std Error	0.262362			
Lower 95%	-0.40028			
Upper 95%	0.725137			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1038812	0.103881	0.3833
Error	14	3.7944738	0.271034	Prob>F
C Total	15	3.8983550	0.259890	0.5458

Means for Oneway Anova

Level	Number	Mean	Std Error
25 76-78	7	1.22087	0.19677
25 94	9	1.05844	0.17354

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
25 76-78	7	1.22087	0.412873	0.15605
25 94	9	1.05844	0.588610	0.19620

Means Comparisons

Dif=Mean[i]-Mean[j]	25 76-78	25 94

25 76-78	0.000000	0.162427
25 94	-0.16243	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.14478

Abs(Dif)-LSD	25 76-78	25 94
25 76-78	-0.59684	-0.40028
25 94	-0.40028	-0.52637

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
25 76-78	7	64	9.14286	0.423
25 94	9	72	8.00000	-0.423

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
64	0.42340	0.6720

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.2269	1	0.6338

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
25 76-78	7	3	0.428571	-0.488
25 94	9	5	0.555556	0.488

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
3	-0.48795	0.6256

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.2381	1	0.6256

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
25 76-78	7	0.9430254	0.134718	0.544
25 94	9	-0.943025	-0.10478	-0.544

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
0.9430254	0.54366	0.5867

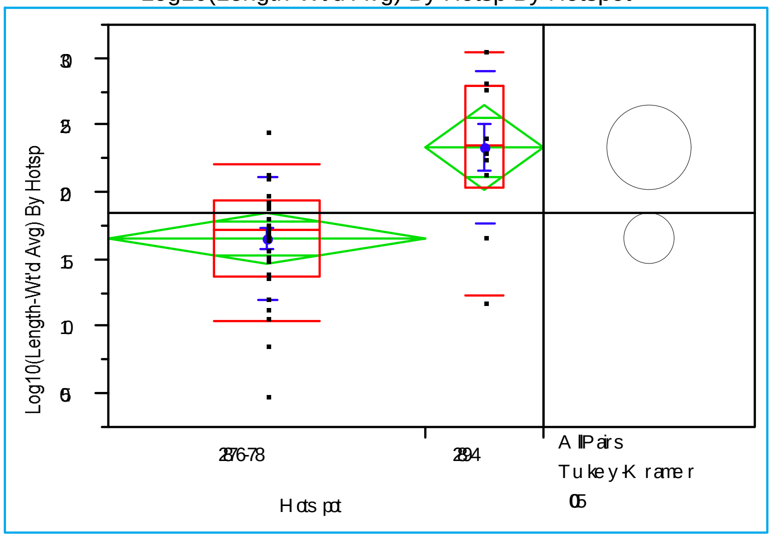
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.2956	1	0.5867

Length Weighted Average Comparision **Hot Spot 28**

$\log_{10}$(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
28 76-78	0.491362	1.042619	1.383277	1.719663	1.948999	2.219556	2.465383
28 94	1.190707	1.240008	2.03907	2.365101	2.799789	3.049263	3.073319

Oneway Anova

Summary of Fit

RSquare	0.286679
RSquare Adj	0.266298
Root Mean Square Error	0.498738
Mean of Response	1.845287
Observations (or Sum Wgts)	37

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.69244	-3.750	35	0.0006
Std Error	0.18463			
Lower 95%	-1.06725			
Upper 95%	-0.31763			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.498839	3.49884	14.0662
Error	35	8.705903	0.24874	Prob>F
C Total	36	12.204742	0.33902	0.0006

Means for Oneway Anova

Level	Number	Mean	Std Error
28 76-78	27	1.65814	0.09598
28 94	10	2.35058	0.15771

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
28 76-78	27	1.65814	0.469277	0.09031
28 94	10	2.35058	0.575438	0.18197

Means Comparisons

Dif=Mean[i]-Mean[j]	28 94	28 76-78
28 94	0.000000	0.692438
28 76-78	-0.69244	0.000000

Alpha=	0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.03012

Abs(Dif)-LSD	28 94	28 76-78
28 94	-0.4528	0.317625
28 76-78	0.317625	-0.27557

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
28 76-78	27	424	15.7037	-3.027
28 94	10	279	27.9000	3.027

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
279	3.02682	0.0025

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
9.2654	1	0.0023

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
28 76-78	27	10	0.370370	-2.290
28 94	10	8	0.800000	2.290

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
8	2.29042	0.0220

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
5.2460	1	0.0220

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
28 76-78	27	-7.858360	-0.29105	-3.133
28 94	10	7.858360	0.785836	3.133

2-Sample Test, Normal Approximation

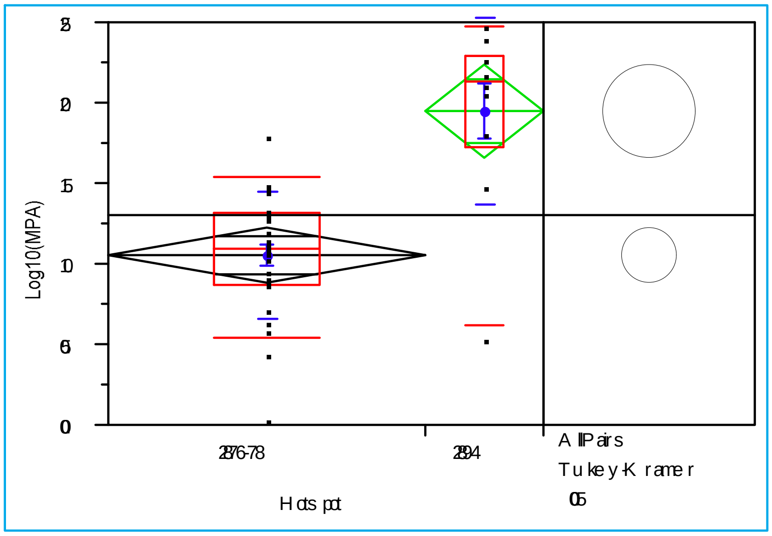
S	Z	Prob>|Z|
7.8583605	3.13349	0.0017

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
9.8187	1	0.0017

Log10(MPA) By Hotspot

Mass per Unit Area Comparision **Hot Spot 28**
$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
28 76-78	0.0364	0.55296	0.8807	1.0991	1.3284	1.54996	1.7958
28 94	0.5279	0.62384	1.727975	2.14065	2.302525	2.47444	2.4828

Oneway Anova
Summary of Fit

RSquare	0.444677
RSquare Adj	0.428811
Root Mean Square Error	0.455715
Mean of Response	1.307165
Observations (or Sum Wgts)	37

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.89309	-5.294	35	<.0001
Std Error	0.16870			
Lower 95%	-1.23557			
Upper 95%	-0.55062			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	5.820410	5.82041	28.0264
Error	35	7.268656	0.20768	Prob>F
C Total	36	13.089065	0.36359	<.0001

Means for Oneway Anova

Level	Number	Mean	Std Error
28 76-78	27	1.06579	0.08770
28 94	10	1.95888	0.14411

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
28 76-78	27	1.06579	0.403642	0.07768
28 94	10	1.95888	0.580475	0.18356

Means Comparisons

Dif=Mean[i]-Mean[j]	28 94	28 76-78
28 94	0.000000	0.893091
28 76-78	-0.89309	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.03012

Abs(Dif)-LSD	28 94	28 76-78
28 94	-0.41374	0.550612
28 76-78	0.550612	-0.2518

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
28 76-78	27	406	15.0370	-3.642
28 94	10	297	29.7000	3.642

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
297	3.64244	0.0003

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
13.3922	1	0.0003

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
28 76-78	27	9	0.333333	-3.021
28 94	10	9	0.900000	3.021

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
9	3.02098	0.0025

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
9.1263	1	0.0025

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
28 76-78	27	-9.115551	-0.33761	-3.635
28 94	10	9.115551	0.911555	3.635

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
9.1155506	3.63455	0.0003

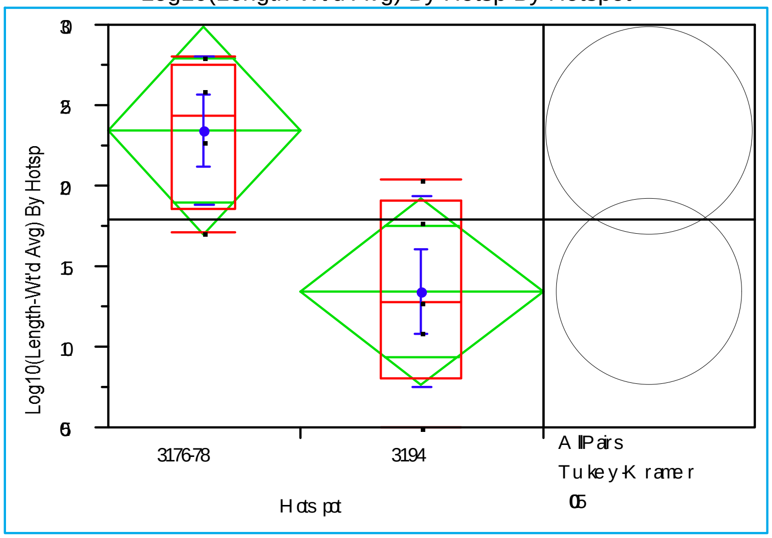
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
13.2100	1	0.0003

Length Weighted Average Comparision **Hot Spot 31**

$\log_{10}$(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
31 76-78	1.722469	1.722469	1.862019	2.438082	2.752984	2.80548	2.80548
31 94	0.508076	0.508076	0.803155	1.28533	1.915143	2.048992	2.048992

Oneway Anova

Summary of Fit

RSquare	0.515412
RSquare Adj	0.446185
Root Mean Square Error	0.549958
Mean of Response	1.791782
Observations (or Sum Wgts)	9

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	1.00664	2.729	7	0.0294
Std Error	0.36892			
Lower 95%	0.13427			
Upper 95%	1.87902			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.2518462	2.25185	7.4452
Error	7	2.1171796	0.30245	Prob>F
C Total	8	4.3690259	0.54613	0.0294

Means for Oneway Anova

Level	Number	Mean	Std Error
31 76-78	4	2.35103	0.27498
31 94	5	1.34439	0.24595

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
31 76-78	4	2.35103	0.471285	0.23564
31 94	5	1.34439	0.602257	0.26934

Means Comparisons

Dif=Mean[i]-Mean[j]	31 76-78	31 94
31 76-78	0.00000	1.00664
31 94	-1.00664	0.00000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.36437

Abs(Dif)-LSD	31 76-78	31 94
31 76-78	-0.91945	0.134373
31 94	0.134373	-0.82238

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
31 76-78	4	28	7.00000	1.837
31 94	5	17	3.40000	-1.837

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
28	1.83712	0.0662

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.8400	1	0.0500

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
31 76-78	4	3	0.750000	1.556
31 94	5	1	0.200000	-1.556

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
3	1.55563	0.1198

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
2.4200	1	0.1198

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
31 76-78	4	2.394226	0.598557	1.959
31 94	5	-2.394226	-0.47885	-1.959

2-Sample Test, Normal Approximation

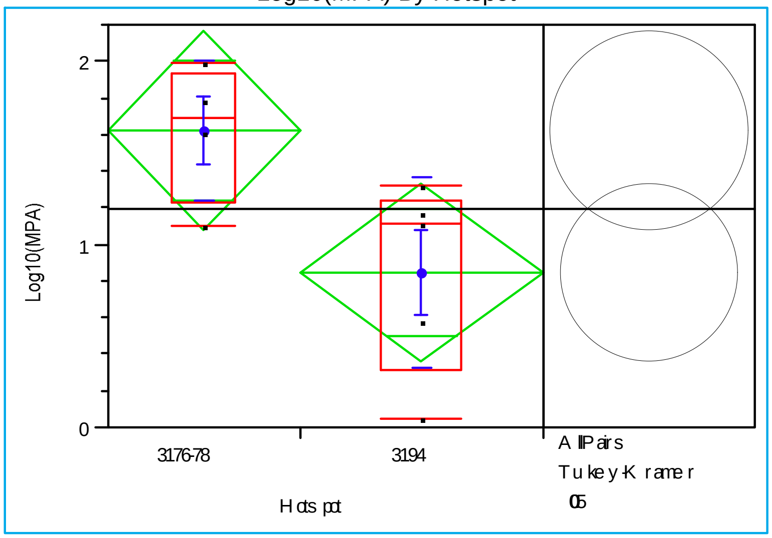
S	Z	Prob>|Z|
2.3942262	1.95855	0.0502

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.8359	1	0.0502

Mass per Unit Area Comparision **Hot Spot 31**
log_{10}(MPA g/m^2) **1976-1978 vs. 1994**

Log10(MPA) By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
31 76-78	1.1019	1.1019	1.2292	1.6991	1.9446	1.9971	1.9971
31 94	0.0538	0.0538	0.3217	1.1127	1.24795	1.3236	1.3236

Oneway Anova
Summary of Fit

RSquare	0.463996
RSquare Adj	0.387424
Root Mean Square Error	0.468659
Mean of Response	1.194356
Observations (or Sum Wgts)	9

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.77390	2.462	7	0.0434
Std Error	0.31439			
Lower 95%	0.03049			
Upper 95%	1.51731			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.3309360	1.33094	6.0596
Error	7	1.5374870	0.21964	Prob>F
C Total	8	2.8684230	0.35855	0.0434

Means for Oneway Anova

Level	Number	Mean	Std Error
31 76-78	4	1.62430	0.23433
31 94	5	0.85040	0.20959

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
31 76-78	4	1.62430	0.382344	0.19117
31 94	5	0.85040	0.524149	0.23441

Means Comparisons

Dif=Mean[i]-Mean[j]	31 76-78	31 94
31 76-78	0.000000	0.773900
31 94	-0.7739	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.36437

Abs(Dif)-LSD	31 76-78	31 94
31 76-78	-0.78353	0.030576
31 94	0.030576	-0.70081

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
31 76-78	4	27	6.75000	1.592
31 94	5	18	3.60000	-1.592

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
27	1.59217	0.1113

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
2.9400	1	0.0864

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
31 76-78	4	3	0.750000	1.556
31 94	5	1	0.200000	-1.556

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
3	1.55563	0.1198

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
2.4200	1	0.1198

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
31 76-78	4	2.123173	0.530793	1.737
31 94	5	-2.123173	-0.42463	-1.737

2-Sample Test, Normal Approximation

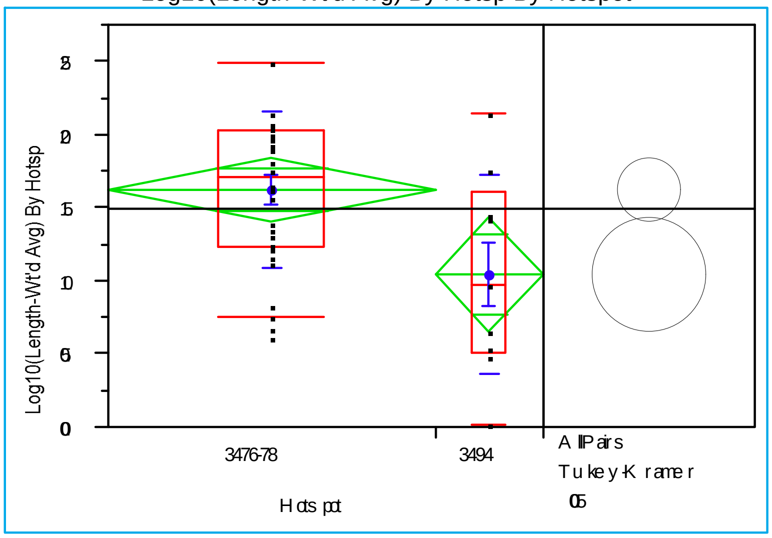
S	Z	Prob>|Z|
2.1231728	1.73682	0.0824

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.0165	1	0.0824

Length Weighted Average Comparision **Hot Spot 34**
$\log_{10}$(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
34 76-78	0.619093	0.755245	1.234071	1.712505	2.030867	2.490832	2.497496
34 94	0.017359	0.017359	0.517217	0.977874	1.607085	2.147043	2.147043

Oneway Anova
Summary of Fit

RSquare	0.162269
RSquare Adj	0.138334
Root Mean Square Error	0.579275
Mean of Response	1.491228
Observations (or Sum Wgts)	37

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.57794	2.604	35	0.0134
Std Error	0.22197			
Lower 95%	0.12733			
Upper 95%	1.02855			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.274936	2.27494	6.7795
Error	35	11.744566	0.33556	Prob>F
C Total	36	14.019503	0.38943	0.0134

Means for Oneway Anova

Level	Number	Mean	Std Error
34 76-78	28	1.63181	0.10947
34 94	9	1.05387	0.19309

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
34 76-78	28	1.63181	0.542327	0.10249
34 94	9	1.05387	0.689507	0.22984

Means Comparisons

Dif=Mean[i]-Mean[j]	34 76-78	34 94
34 76-78	0.000000	0.577943
34 94	-0.57794	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.03012

Abs(Dif)-LSD	34 76-78	34 94
34 76-78	-0.3143	0.127326
34 94	0.127326	-0.55437

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
34 76-78	28	593	21.1786	2.142
34 94	9	110	12.2222	-2.142

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
110	-2.14168	0.0322

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
4.6629	1	0.0308

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
34 76-78	28	16	0.571429	1.799
34 94	9	2	0.222222	-1.799

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
2	-1.79854	0.0721

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.2348	1	0.0721

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
34 76-78	28	5.685596	0.203057	2.346
34 94	9	-5.685596	-0.63173	-2.346

2-Sample Test, Normal Approximation

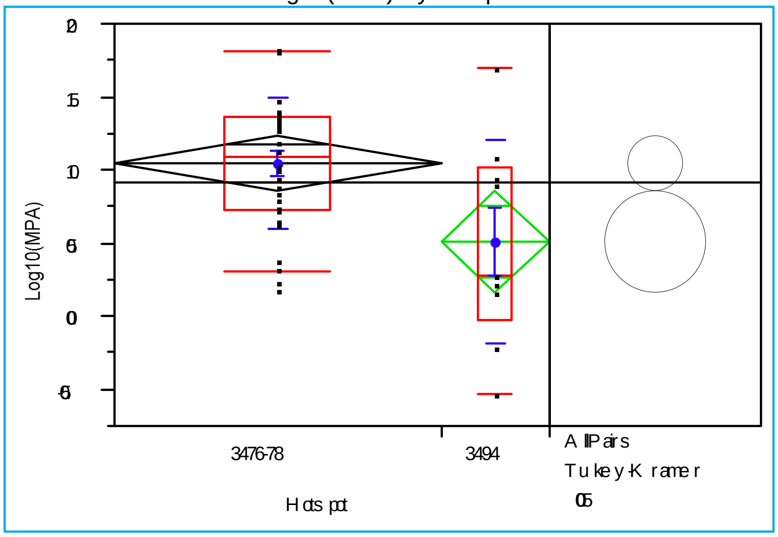
S	Z	Prob>|Z|
-5.685596	-2.34619	0.0190

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
5.5046	1	0.0190

Mass per Unit Area Comparision **Hot Spot 34**
$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**

Log10(MPA) By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
34 76-78	0.1809	0.31707	0.731575	1.09195	1.373075	1.82125	1.8279
34 94	-0.52	-0.52	-0.0216	0.2849	1.02295	1.7019	1.7019

Oneway Anova
Summary of Fit

RSquare	0.171247
RSquare Adj	0.147569
Root Mean Square Error	0.526754
Mean of Response	0.922503
Observations (or Sum Wgts)	37

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.542802	2.689	35	0.0109
Std Error	0.201840			
Lower 95%	0.133047			
Upper 95%	0.952558			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.006699	2.00670	7.2321
Error	35	9.711435	0.27747	Prob>F
C Total	36	11.718134	0.32550	0.0109

Means for Oneway Anova

Level	Number	Mean	Std Error
34 76-78	28	1.05454	0.09955
34 94	9	0.51173	0.17558

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
34 76-78	28	1.05454	0.462196	0.08735
34 94	9	0.51173	0.702101	0.23403

Means Comparisons

Dif=Mean[i]-Mean[j]	34 76-78	34 94
34 76-78	0.000000	0.542802
34 94	-0.5428	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.03012

Abs(Dif)-LSD	34 76-78	34 94
34 76-78	-0.2858	0.133041
34 94	0.133041	-0.50411

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
34 76-78	28	593	21.1786	2.142
34 94	9	110	12.2222	-2.142

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
110	-2.14168	0.0322

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
4.6629	1	0.0308

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
34 76-78	28	16	0.571429	1.799
34 94	9	2	0.222222	-1.799

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
2	-1.79854	0.0721

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.2348	1	0.0721

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
34 76-78	28	5.669361	0.202477	2.339
34 94	9	-5.669361	-0.62993	-2.339

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
-5.669361	-2.33949	0.0193

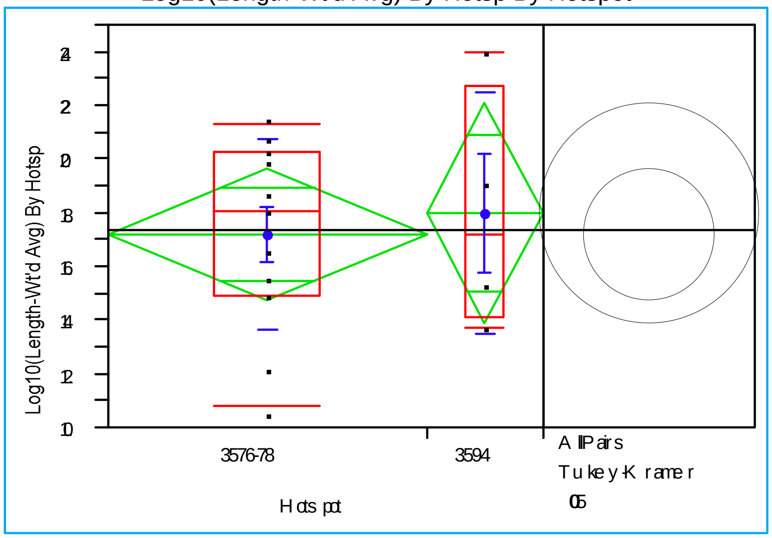
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
5.4732	1	0.0193

Length Weighted Average Comparision **Hot Spot 35**

$\log_{10}$(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
35 76-78	1.048053	1.082673	1.489818	1.812913	2.032337	2.132421	2.146066
35 94	1.376084	1.376084	1.414618	1.721362	2.278457	2.400441	2.400441

Oneway Anova

Summary of Fit

RSquare	0.011076
RSquare Adj	-0.06499
Root Mean Square Error	0.38444
Mean of Response	1.742001
Observations (or Sum Wgts)	15

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.08565	-0.382	13	0.7089
Std Error	0.224464			
Lower 95%	-0.57058			
Upper 95%	0.399274			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0215193	0.021519	0.1456
Error	13	1.9213208	0.147794	Prob>F
C Total	14	1.9428401	0.138774	0.7089

Means for Oneway Anova

Level	Number	Mean	Std Error
35 76-78	11	1.71916	0.11591
35 94	4	1.80481	0.19222

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
35 76-78	11	1.71916	0.359964	0.10853
35 94	4	1.80481	0.456647	0.22832

Means Comparisons

Dif=Mean[i]-Mean[j]	35 94	35 76-78
35 94	0.000000	0.085651
35 76-78	-0.08565	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.16040

Abs(Dif)-LSD	35 94	35 76-78
35 94	-0.58728	-0.39928
35 76-78	-0.39928	-0.35415

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
35 76-78	11	87	7.90909	-0.065
35 94	4	33	8.25000	0.065

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
33	0.06528	0.9480

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0170	1	0.8961

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
35 76-78	11	5	0.454545	-0.151
35 94	4	2	0.500000	0.151

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
2	0.15076	0.8802

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0227	1	0.8802

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
35 76-78	11	-0.476837	-0.04335	-0.320
35 94	4	0.4768369	0.119209	0.320

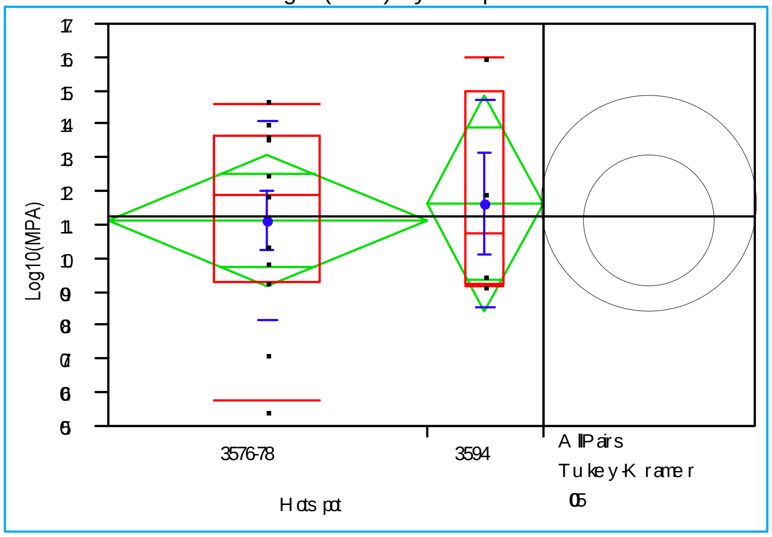
2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
0.4768369	0.32045	0.7486

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.1027	1	0.7486

Mass per Unit Area Comparision **Hot Spot 35**
$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
35 76-78	0.5455	0.58012	0.9357	1.1923	1.3698	1.46276	1.4764
35 94	0.9186	0.9186	0.92745	1.07625	1.502025	1.6032	1.6032

Oneway Anova
Summary of Fit

RSquare	0.006357
RSquare Adj	-0.07008
Root Mean Square Error	0.303979
Mean of Response	1.13104
Observations (or Sum Wgts)	15

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.05118	-0.288	13	0.7776
Std Error	0.177486			
Lower 95%	-0.43462			
Upper 95%	0.332250			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0076848	0.007685	0.0832
Error	13	1.2012439	0.092403	Prob>F
C Total	14	1.2089286	0.086352	0.7776

Means for Oneway Anova

Level	Number	Mean	Std Error
35 76-78	11	1.11739	0.09165
35 94	4	1.16858	0.15199

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
35 76-78	11	1.11739	0.300486	0.09060
35 94	4	1.16858	0.315343	0.15767

Means Comparisons

Dif=Mean[i]-Mean[j]	35 94	35 76-78
35 94	0.000000	0.051184
35 76-78	-0.05118	0.000000

Alpha=	0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.16040

Abs(Dif)-LSD	35 94	35 76-78
35 94	-0.46437	-0.33226
35 76-78	-0.33226	-0.28003

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
35 76-78	11	88	8.00000	0.065
35 94	4	32	8.00000	0.065

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
32	0.06528	0.9480

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0000	1	1.0000

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
35 76-78	11	5	0.454545	-0.151
35 94	4	2	0.500000	0.151

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
2	0.15076	0.8802

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0227	1	0.8802

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
35 76-78	11	-0.315508	-0.02868	-0.212
35 94	4	0.3155083	0.078877	0.212

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
0.3155083	0.21203	0.8321

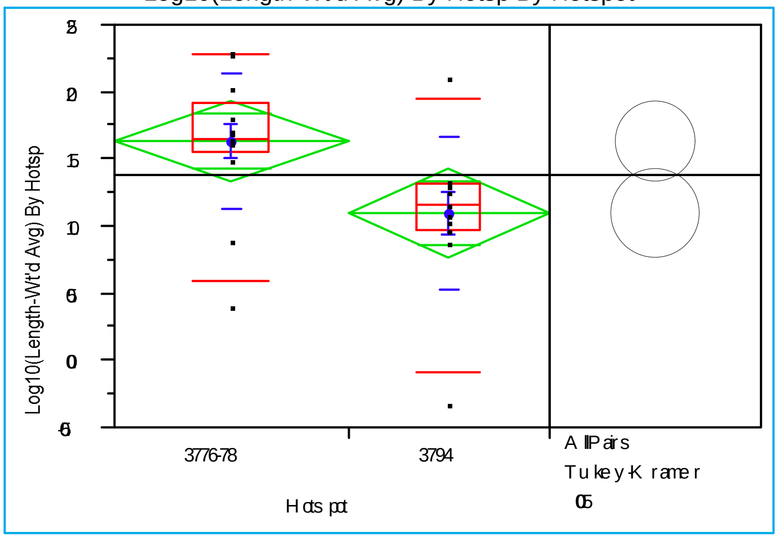
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0450	1	0.8321

Length Weighted Average Comparision **Hot Spot 37**

$\log_{10}$(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
37 76-78	0.40654	0.604725	1.563288	1.661623	1.921761	2.294222	2.303196
37 94	-0.31995	-0.08058	0.975853	1.163684	1.326718	1.961995	2.115728

Oneway Anova

Summary of Fit

RSquare	0.203731
RSquare Adj	0.167537
Root Mean Square Error	0.540768
Mean of Response	1.392613
Observations (or Sum Wgts)	24

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.525604	2.373	22	0.0268
Std Error	0.221538			
Lower 95%	0.066166			
Upper 95%	0.985043			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.6460476	1.64605	5.6289
Error	22	6.4334598	0.29243	Prob>F
C Total	23	8.0795074	0.35128	0.0268

Means for Oneway Anova

Level	Number	Mean	Std Error
37 76-78	13	1.63351	0.14998
37 94	11	1.10791	0.16305

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
37 76-78	13	1.63351	0.510717	0.14165
37 94	11	1.10791	0.574759	0.17330

Means Comparisons

Dif=Mean[i]-Mean[j]	37 76-78	37 94
37 76-78	0.000000	0.525604
37 94	-0.5256	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.07387

Abs(Dif)-LSD	37 76-78	37 94
37 76-78	-0.43988	0.066162
37 94	0.066162	-0.4782

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
37 76-78	13	206	15.8462	2.491
37 94	11	94	8.5455	-2.491

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
94	-2.49127	0.0127

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
6.3516	1	0.0117

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
37 76-78	13	11	0.846154	3.609
37 94	11	1	0.090909	-3.609

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1	-3.60943	0.0003

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
13.0280	1	0.0003

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
37 76-78	13	5.162079	0.397083	2.340
37 94	11	-5.162079	-0.46928	-2.340

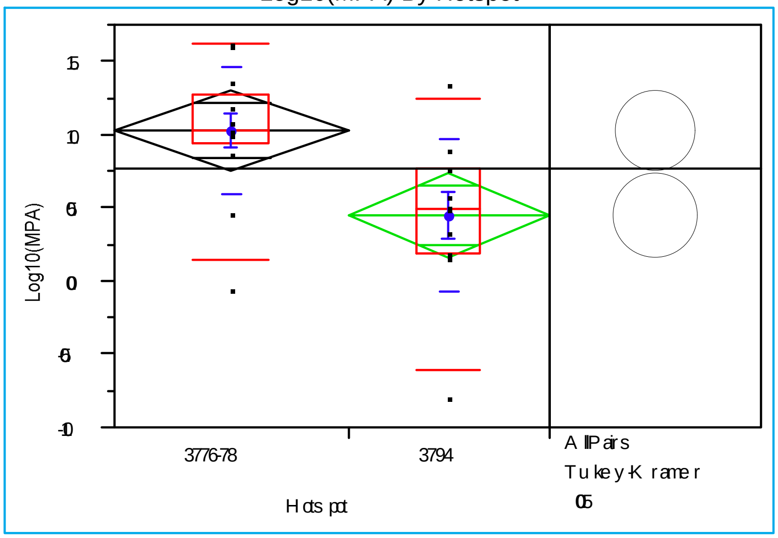
2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
-5.162079	-2.34005	0.0193

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
5.4758	1	0.0193

Mass per Unit Area Comparision **Hot Spot 37**
$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
37 76-78	-0.0484	0.15648	0.94275	1.041	1.27665	1.6246	1.6336
37 94	-0.7894	-0.5998	0.2005	0.5057	0.7705	1.2574	1.3456

Oneway Anova
Summary of Fit

RSquare	0.271216
RSquare Adj	0.23809
Root Mean Square Error	0.485648
Mean of Response	0.767463
Observations (or Sum Wgts)	24

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.569285	2.861	22	0.0091
Std Error	0.198957			
Lower 95%	0.156676			
Upper 95%	0.981893			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.9310063	1.93101	8.1873
Error	22	5.1887958	0.23585	Prob>F
C Total	23	7.1198021	0.30956	0.0091

Means for Oneway Anova

Level	Number	Mean	Std Error
37 76-78	13	1.02838	0.13469
37 94	11	0.45910	0.14643

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
37 76-78	13	1.02838	0.442819	0.12282
37 94	11	0.45910	0.532516	0.16056

Means Comparisons

Dif=Mean[i]-Mean[j]	37 76-78	37 94
37 76-78	0.000000	0.569285
37 94	-0.56928	0.000000

Alpha=	0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.07387

Abs(Dif)-LSD	37 76-78	37 94
37 76-78	-0.39505	0.156672
37 94	0.156672	-0.42946

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
37 76-78	13	208	16.0000	2.607
37 94	11	92	8.3636	-2.607

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
92	-2.60714	0.0091

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
6.9491	1	0.0084

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
37 76-78	13	10	0.769231	2.807
37 94	11	2	0.181818	-2.807

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
2	-2.80733	0.0050

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
7.8811	1	0.0050

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
37 76-78	13	5.530456	0.425420	2.507
37 94	11	-5.530456	-0.50277	-2.507

2-Sample Test, Normal Approximation

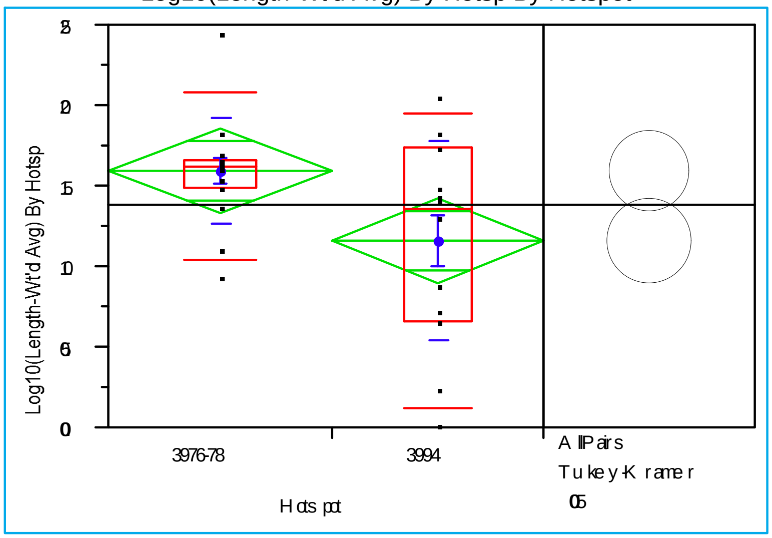
S	Z	Prob>|Z|
-5.530456	-2.50704	0.0122

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
6.2853	1	0.0122

Length Weighted Average Comparision **Hot Spot 39**
log_{10}(LWA mg/kg) **1976-1978 vs. 1994**

Log10(Length-Wt'd Avg) By Hotsp By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
39 76-78	0.946943	1.04914	1.498586	1.631748	1.668293	2.084753	2.459392
39 94	0.019359	0.131136	0.663247	1.360283	1.745127	1.948979	2.066031

Oneway Anova
Summary of Fit

RSquare	0.172447
RSquare Adj	0.141797
Root Mean Square Error	0.497255
Mean of Response	1.387002
Observations (or Sum Wgts)	29

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.438309	2.372	27	0.0251
Std Error	0.184786			
Lower 95%	0.059162			
Upper 95%	0.817455			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.3911736	1.39117	5.6263
Error	27	6.6760908	0.24726	Prob>F
C Total	28	8.0672644	0.28812	0.0251

Means for Oneway Anova

Level	Number	Mean	Std Error
39 76-78	15	1.59860	0.12839
39 94	14	1.16029	0.13290

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
39 76-78	15	1.59860	0.332032	0.08573
39 94	14	1.16029	0.628347	0.16793

Means Comparisons

Dif=Mean[i]-Mean[j]	39 76-78	39 94
39 76-78	0.000000	0.438309
39 94	-0.43831	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.05184

Abs(Dif)-LSD	39 76-78	39 94
39 76-78	-0.37256	0.059158
39 94	0.059158	-0.38563

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
39 76-78	15	266	17.7333	1.768
39 94	14	169	12.0714	-1.768

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
169	-1.76756	0.0771

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.2019	1	0.0736

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
39 76-78	15	10	0.666667	2.016
39 94	14	4	0.285714	-2.016

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
4	-2.01581	0.0438

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
4.0635	1	0.0438

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
39 76-78	15	4.401803	0.293454	1.787
39 94	14	-4.401803	-0.31441	-1.787

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
-4.401803	-1.78698	0.0739

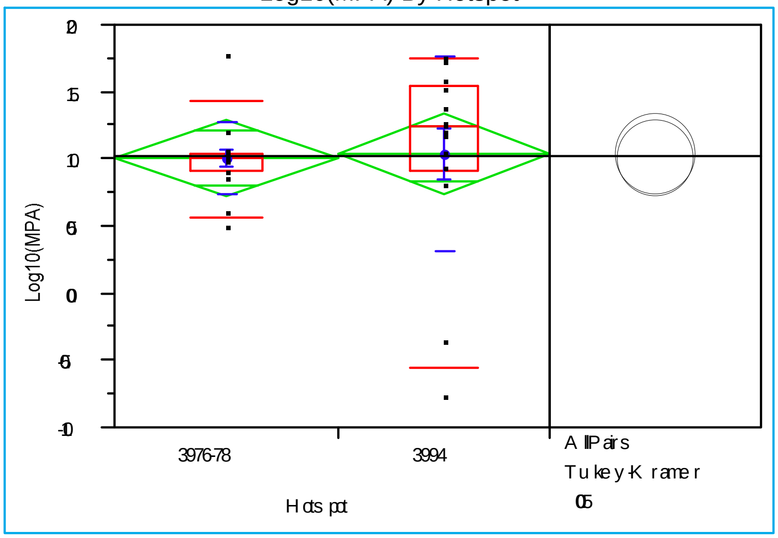
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
3.1933	1	0.0739

Mass per Unit Area Comparision **Hot Spot 39**

$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**

Log10(MPA) By Hotspot



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
39 76-78	0.5087	0.5723	0.9253	1.0112	1.0477	1.44456	1.7898
39 94	-0.7617	-0.5559	0.9223	1.2435	1.553325	1.7533	1.7738

Oneway Anova

Summary of Fit

RSquare	0.001446
RSquare Adj	-0.03554
Root Mean Square Error	0.550744
Mean of Response	1.030048
Observations (or Sum Wgts)	29

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.04047	-0.198	27	0.8447
Std Error	0.204663			
Lower 95%	-0.4604			
Upper 95%	0.379465			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.0118573	0.011857	0.0391
Error	27	8.1896165	0.303319	Prob>F
C Total	28	8.2014738	0.292910	0.8447

Means for Oneway Anova

Level	Number	Mean	Std Error
39 76-78	15	1.01051	0.14220
39 94	14	1.05098	0.14719

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
39 76-78	15	1.01051	0.279450	0.07215
39 94	14	1.05098	0.738831	0.19746

Means Comparisons

Dif=Mean[i]-Mean[j]	39 94	39 76-78
39 94	0.000000	0.040465
39 76-78	-0.04047	0.000000

Alpha=	0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.05184

Abs(Dif)-LSD	39 94	39 76-78
39 94	-0.42711	-0.37947
39 76-78	-0.37947	-0.41263

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
39 76-78	15	187	12.4667	-1.637
39 94	14	248	17.7143	1.637

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
248	1.63663	0.1017

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
2.7505	1	0.0972

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
39 76-78	15	4	0.266667	-2.369
39 94	14	10	0.714286	2.369

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
10	2.36858	0.0179

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
5.6102	1	0.0179

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
39 76-78	15	-3.160932	-0.21073	-1.283
39 94	14	3.160932	0.225781	1.283

2-Sample Test, Normal Approximation

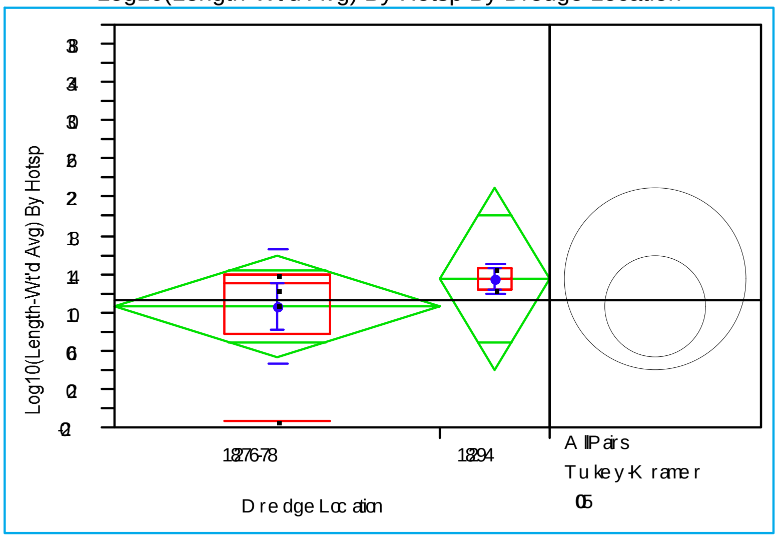
S	Z	Prob>|Z|
3.1609324	1.28323	0.1994

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.6467	1	0.1994

Length Weighted Average Comparision   Dredge Location182
$\log_{10}$(LWA mg/kg)   1976-1978 vs. 1994

Log10(Length-Wt'd Avg) By Hotsp By Dredge Location



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
182 76-78	-0.13077	-0.13077	0.786848	1.326644	1.403721	1.403978	1.403978
182 94	1.255081	1.255081	1.255081	1.372084	1.489086	1.489086	1.489086

Oneway Anova
Summary of Fit

RSquare	0.069208
RSquare Adj	-0.08592
Root Mean Square Error	0.553044
Mean of Response	1.145877
Observations (or Sum Wgts)	8

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.30161	-0.668	6	0.5290
Std Error	0.45156			
Lower 95%	-1.40653			
Upper 95%	0.80332			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1364513	0.136451	0.4461
Error	6	1.8351471	0.305858	Prob>F
C Total	7	1.9715984	0.281657	0.5290

Means for Oneway Anova

Level	Number	Mean	Std Error
182 76-78	6	1.07048	0.22578
182 94	2	1.37208	0.39106

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
182 76-78	6	1.07048	0.601293	0.24548
182 94	2	1.37208	0.165466	0.11700

Means Comparisons

Dif=Mean[i]-Mean[j]	182 94	182 76-78
182 94	0.000000	0.301608
182 76-78	-0.30161	0.000000

Alpha=	0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.44692

Abs(Dif)-LSD	182 94	182 76-78
182 94	-1.35325	-0.80332
182 76-78	-0.80332	-0.78130

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
182 76-78	6	24	4.00000	-0.833
182 94	2	12	6.00000	0.833

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
12	0.83333	0.4047

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.0000	1	0.3173

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
182 76-78	6	3	0.500000	0.000
182 94	2	1	0.500000	0.000

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1	0.00000	1.0000

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0000	1	1.0000

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
182 76-78	6	-1.080930	-0.18016	-1.094
182 94	2	1.080930	0.540465	1.094

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1.08093	1.09355	0.2742

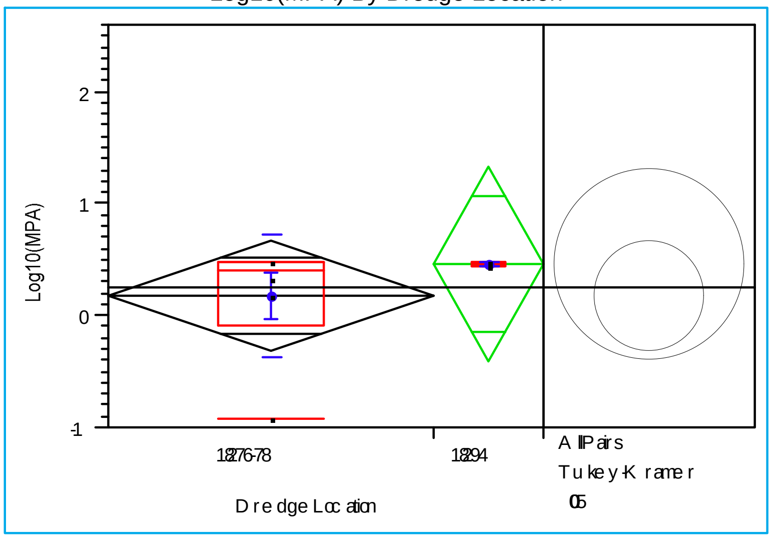
1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.1959	1	0.2742

Mass per Unit Area Comparision **Dredge Location 182**

$\log_{10}$(MPA g/m^2) **1976-1978 vs. 1994**

Log10(MPA) By Dredge Location



Quantiles

Level	minimum	10.0%	25.0%	median	75.0%	90.0%	maximum
182 76-78	-0.5113	-0.5113	0.314825	0.82415	0.901175	0.9014	0.9014
182 94	0.8592	0.8592	0.8592	0.8819	0.9046	0.9046	0.9046

Oneway Anova

Summary of Fit

RSquare	0.078023
RSquare Adj	-0.07564
Root Mean Square Error	0.504662
Mean of Response	0.661687
Observations (or Sum Wgts)	8

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	-0.29362	-0.713	6	0.5029
Std Error	0.41205			
Lower 95%	-1.30188			
Upper 95%	0.71464			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1293161	0.129316	0.5078
Error	6	1.5280994	0.254683	Prob>F
C Total	7	1.6574156	0.236774	0.5029

Means for Oneway Anova

Level	Number	Mean	Std Error
182 76-78	6	0.588283	0.20603
182 94	2	0.881900	0.35685

Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
182 76-78	6	0.588283	0.552643	0.22562
182 94	2	0.881900	0.032103	0.02270

Means Comparisons

Dif=Mean[i]-Mean[j]	182 94	182 76-78
182 94	0.000000	0.293617
182 76-78	-0.29362	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*
2.44692

Abs(Dif)-LSD	182 94	182 76-78
182 94	-1.23487	-0.71465
182 76-78	-0.71465	-0.71295

Positive values show pairs of means that are significantly different.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
182 76-78	6	24	4.00000	-0.833
182 94	2	12	6.00000	0.833

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
12	0.83333	0.4047

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.0000	1	0.3173

Median Test (Number of Points Above Median)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
182 76-78	6	3	0.500000	0.000
182 94	2	1	0.500000	0.000

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1	0.00000	1.0000

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
0.0000	1	1.0000

Van der Waerden Test (Normal Quantiles)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
182 76-78	6	-1.080930	-0.18016	-1.094
182 94	2	1.080930	0.540465	1.094

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1.08093	1.09355	0.2742

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.1959	1	0.2742