United States Army Corps of Engineers
New York District

Environmental Protection Agency
Region II

GUIDANCE FOR PERFORMING TESTS ON DREDGED MATERIAL PROPOSED FOR OCEAN DISPOSAL

18 December 1992

DRAFT

EFFECTIVE DATE:

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TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

ADDAMS	Automated Dredging and Disposal Alternatives Management System
AVS	Acid Volatile sulfides
CS	Congener Specific
CLP	Contract Laboratory Program
DA	Department of the Army
DDD	Dichloro-Diphenyl-Dichloro-ethane
DDE	Dichloro-Diphenyl-Dichloroethylene
DDT	Dichloro-Diphenyl-Trichloro-ethane
DIFC	Disposal form a Continuous Discharge (Model)
DIFH	Disposal from a Hopper Dredge (Model)
DIFID	Disposal from an Instantaneous Dump (Model)
EC50	Median Effective Concentration
EPA	Environmental Protection Agency
LC50	Median Lethal Concentration
LPC	Limiting Permissible Concentration
MDL	Method Detection Limit
MPRSA	Marine Protection, Research, and Sanctuaries Act of 1972
NYD	New York District
NYD/COE	New York District/Corps of Engineers
OMB	Office of Management and Budget
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
QA	Quality Assurance
QC	Quality Control
SEM	Simultaneously Extractable Metals
SOP	Standard Operating Procedure
SRM	Standard Reference Material
TBP	Theoretical Bioaccumulation Potential
TOC	Total Organic Carbon
USACE	United States Army Corps of Engineers
WQC	Water Quality Criteria

1.0 INTRODUCTION

1.1 PURPOSE

This guidance document presents the sediment testing guidelines and requirements to be used by applicants who wish to obtain a Department of the Army (DA) permit from the New York District of the United States Army Corps of Engineers (USACE) for dredging and disposal of the dredged material at an ocean disposal site. The USACE and Environmental Protection Agency (EPA) are responsible for reviewing test results for compliance with the Ocean Dumping Criteria as described below.

This guidance supports the tiered-testing procedure for evaluating compliance with the limiting permissible concentration (LPC) as defined by the ocean-dumping regulations. The procedure comprises levels (tiers) of increasing investigative intensity that provide information to make ocean-disposal decisions. The procedure is comprehensive enough to enable sound decision making without unnecessary expenditure of time and resources.

1.2 BACKGROUND

Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Public Law 92-532, requires that all proposed operations involving the transportation and discharge of dredged material into ocean waters are to be evaluated to determine the potential environmental impact of such activities. The proposed dumping must be evaluated through the use of criteria published by the Environmental Protection Agency (EPA) in Title 40 of the Code of Federal Regulations, Parts 220-228 (40 CFR 220-228) (hereafter: the regulations). In accordance with Subsection 227.27(b) of the regulations, EPA and the USACE developed a testing manual to define procedures for evaluating the suitability of dredged material for ocean disposal that are based upon the biological-testing requirements of the regulations. The first testing manual, Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters, commonly referred to as the "Green Book", was published by EPA and the USACE in 1977. The 1977 Green Book has been updated and retitled, Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual) (EPA/USACE, 1991). The 1991 Testing Manual (hereafter referred to as the Green Book) presents new testing methods and contains revised guidance that reflects regulatory experience gained since the release of the 1977 Green Book.

This regional manual implements the technical guidance contained in the Green Book providing regional specifications such as the use of local or appropriate species in biological tests and identification of contaminants of concern.

1.3 CHANGES FROM THE PREVIOUS EDITION

This manual updates and replaces the Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters (USACE New York District/EPA Region II, 1984). Changes from the previous edition are substantive and include the following:

- Tiered-testing procedure
- Acute toxicity testing using amphipods
- 28-day bioaccumulation testing
- A more comprehensive list of contaminants of concern

To keep up with technical advances and new procedures in the assessment of sediment contamination and potential impacts due to dredging and disposal activity, sections of this document will be revised or updated. When major revisions or new tests are instituted, the availability of the revised or new sections will be announced. A set of revisions will be mailed to everyone on the current distribution list for this document. Contact the Water Quality Compliance Branch of the New York District Corp of Engineers to add your name to the mailing list.

United States Army Corps of Engineers
New York District, CENAN-OP-W
Water Quality Compliance Branch
26 Federal Plaza, Rm. 1937
New York, NY 10278-0090
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(212) 264-5620
(212) 264-4260 (FAX)

1.4 ORGANIZATION OF THE MANUAL

The organization of this manual parallels the organization of the Green Book. This introductory Section provides an overview of the manual and presents general information regarding the testing of dredged material. Section 2.0 is an overview of the tiered-testing approach. It identifies data that the applicant must submit in each of the tiers. Section 3.0 outlines requirements for Laboratory Work/Quality Assurance Plans (Work/QA Plans). Specific technical procedures that must be followed by the applicants are given in Section 4.0.

1.5 ADMINISTRATIVE REQUIREMENTS

Applicants for DA permits must provide the information necessary to process the permit and the information required to evaluate the impact of the proposed activity. The applicant must also demonstrate that the proposed disposal of dredged material will satisfy the environmental impact prohibitions, limits, and conditions set forth in the ocean-dumping regulations. The sediment testing requirements set forth in this guidance document and in the Green Book provide sufficient information to determine if the proposed discharge of dredged materials will meet or exceed the LPC (40 CFR 227.27).

1.5.1 Requirements for Permit Applications

Applicants for DA permits for dredging and ocean discharge of dredged material must use the standard form (ENG Form 4345, OMB Approval No. OMB 49-R0420) and must also submit the additional technical information described in this Section and in Table 1-1. An explanation of the permit process and the proper information to be included on the application are given in the pamphlet, United States Army Corps of Engineers Regulatory Program – Applicant Information (EP 1145-2-1, May 1985). Both the application and the pamphlet may be obtained from the USACE New York District. New York District personnel are also available for preapplication consultation.

For permits pertaining to dredging in navigable waters and disposal at the Mud Dump Site, the application must include a description of the area to be dredged; type, composition, and quantity of the material to be dredged; the need for the dredging and analysis of non-ocean disposal alternatives; the method of dredging; the method of transportation and disposal; and a summary of past dredging and spills at the site. A summary of the technical information that must be submitted with an application for permits authorizing dredging and ocean disposal of dredged material is provided in Table 1-1.

Table 1-1. Technical information (with Supporting Documentation) To Be Submitted with Applications for DA Permits for Dredging and Ocean Discharge of Dredged Material.

Site Plans of Area to be Dredged

- Two recent (no more than 1-year old) bathymetric surveys with the area to be dredged clearly marked. Indicate location of any wetlands, shellfish areas, or other special habitats. Include lat/long on survey map.
- 8½" x 11" location and site-plan map with area to be dredged clearly marked
- History of previous dredging (i.e., permits, volumes, disposal dates)
- History of previous sediment sampling and testing and a summary of test results
- Location of outfalls and other discharges into the area to be dredged as well as into surrounding areas that would influence the area to be dredged
- History of spills (type, volume, date) since last sampling date
- Additional information or modifications to the forementioned site plans may be required for specific projects

Analysis of the Need for the Proposed Dredging

- Area to be dredged
- Depth of the channel to be dredged
- Inability to utilize alternative disposal options
- Reason for the proposed dredging
- Benefits to be gained (or retained) by the proposed dredging

Method of Dredging, Transportation, and Disposal

- Type of dredging equipment (i.e. clamshell, hopper dredge)
- Type of transportation equipment (i.e. split hull, pocket barge)
- Capacity of the transport vessels

Type, Composition, and Quantity of the Dredged Material

- Volume of material to be dredged
- Types of dredging (i.e., maintenance, channel widening/deepening)
- Composition of the dredged material (i.e. % sand, silt, and clay)

Site and Plans for Disposal of the Dredged Material

- 8½ x 11 location and site-plan map for each disposal alternative

1.5.2 Requirements for Permit Evaluation

The decision to grant or to deny a permit for disposal is based on a Public Interest Review of the probable impact of the proposed activity and its intended use. General criteria for evaluating permits are discussed in the applicant information pamphlet described above. However, for permits authorizing discharge of dredged material into ocean waters, the proposed activity must also be evaluated in accordance with the criteria set forth in the ocean-dumping regulations. The NYD/COE and EPA Region II will coordinate this process to ensure that there is a minimum of conflict regarding sampling and testing procedures for a given applicant.

The applicant is responsible for providing all information necessary to support the required evaluations. The remaining sections of this guidance document focus on the procedures for testing the proposed dredged material and on the supporting information and data that must be provided by the applicant. The tiered-testing approach of this guidance and the Green Book calls for testing the sediment only to the extent necessary to determine compliance with the LPC requirements of the regulations. Figures 3-1 through 3-3 in the Green Book illustrate the tiered testing approach. Specifically, figure 3-2 shows the approach to evaluating potential water-column impact and Figure 3-3 shows the approach to evaluating potential benthic impacts.

As detailed in the Green Book, there are four tiers for testing and evaluating dredged material that is proposed for ocean disposal.

- **Tier I**
  Assesses existing information on the proposed dredged material and identifies contaminants of concern. Determines if the dredged material meets the exclusionary criteria in 40 CFR 227.13(b), or if existing information is sufficient to make a decision.

- **Tier II**
  Uses calculations and numerical models to screen the chemical and physical characteristics of the dredged material. Determines if water quality criteria (WQC) are met.

- **Tier III**
  Consists of standardized acute toxicity and bioaccumulation tests with appropriate sensitive marine organisms.

- **Tier IV**
  Provides specifically designed case studies to evaluate proposed dredged material with unusual contamination problems for which information from the previous tiers is inconclusive. The Green Book emphasizes that this tier is not intended for routine application. Accordingly, no generic guidance on conducting Tier IV tests is provided in this manual.

A complete discussion of each tier is presented in the Green Book Section 3.2, Tiered Testing and Evaluation. A brief overview of the tiers and an itemization of the data to be submitted by the applicant upon completion of the tiers are presented in Section 2 of this regional guidance manual.

1.6 PRETESTING CONSULTATION

Prior to submitting the permit application and information required to process the permit, the applicant may call New York District personnel to discuss the testing program.

The information listed in Table 1-1 must be sent to the New York District for a determination regarding LPC compliance using existing Tier I data. If further testing is required, the New York District will provide the applicant with a sampling scheme and a list of testing requirements.

The names of all laboratories performing sampling and testing must be provided to the New York District prior to commencement of sampling episodes in order to update their Work/QA Plans (See Section 3.0: Work/Quality Assurance Plan). This will ensure that the number and distribution of samples is appropriate, that the necessary tests are scheduled, and that the tests will provide reliable and useful data for the required evaluations.

Inquiries on testing and laboratories should be directed to:

United States Army Corps of Engineers
New York District, CENAN-OP-W
Water Quality Compliance Branch
26 Federal Plaza, Rm. 1937
New York, NY 10278-0090
(212) 264-5620

Application submissions and all other inquiries should be directed to:

United States Army Corps of Engineers
New York District, CENAN-OP-R
Regulatory Branch
26 Federal Plaza, Rm. 1937
New York, NY 10278-0090
(212) 264-0183

Copies of the national guidance, Evaluation of Dredged Material Proposed for Ocean Disposal (EPA/USACE, 1991), also known as the "Green Book" may be obtained by writing to:

Green Book Mailing List
Attn: Ms. Billie Skinner
USACE Waterways Experiment Station
EP-D
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

2.0 TIERED TESTING

The tiered-testing protocol in the Green Book provides tiers of increasing investigative intensity to generate the information necessary to evaluate the proposed discharge of dredged material at an ocean site. When sufficient information has been collected to allow the USACE and EPA to determine if the proposed discharge of dredged material will comply with the limiting permissible concentration (LPC) requirements of the ocean dumping regulations, further testing becomes unnecessary.

LPC is defined by the regulations in 40 CFR 227.27 and discussed at length in Green Book Section 2.7: Part 227, Subpart G; Definitions. In general, the water-column LPC is the concentration that, after allowance for initial mixing, does not exceed applicable marine water-quality criteria (WQC) and/or a toxicity threshold of 0.01 of the acutely toxic concentration. The benthic LPC is the concentration that will not cause unreasonable toxicity or bioaccumulation of contaminants of concern.

The guidance in the Green Book and the testing required by this manual are oriented toward making LPC compliance determinations. If testing shows that either the water-column or benthic LPC cannot be met for a proposed dredged material, dredging and unrestricted disposal of dredged material will not be approved. In such cases, the applicant must either

- Abandon the proposed project or
- Modify the proposed dredging and disposal activity (e.g., move the proposed work, realign proposed channels, alter project depths, take sediment to a non-ocean disposal site, control dump releases, apply predisposal treatment) and submit additional data for review under the existing permit request.

If bioaccumulation exceeds acceptable criteria, the applicant must either

- Follow management scenario to lessen the environmental impact (e.g., disposal-site capping, submarine burial) provided by NYD/COE for the proposed discharge of dredged material, or
- Abandon the proposed project.

These actions are both project- and site-specific and may require additional testing and analysis. These alternatives will be considered by the New York District on a case by case basis. A discussion of management actions for dredged material disposal is beyond the scope of this technical manual.

As shown in Figures 3-1 through 3-3 of the Green Book, the tiered-testing approach involves separate paths for evaluating potential water-column and benthic impacts of the proposed dredged material. Testing continues along each path until the data support a determination.

2.1 TIER I

The purpose of Tier I is to determine if the proposed dredged material complies with the LPC requirements through analysis of existing chemical, physical, and biological information and identifies contaminants of concern. If the information on the proposed dredged material is insufficient to reach an LPC determination, the existing information may still define and augment the information required to determine LPC compliance in subsequent tiers and, thereby, reduce costs to the applicant.

Section 4.1 of the Green Book, Compilation of Existing Information, lists sources of potential information on the proposed dredged material. The list is not intended to be comprehensive, and other sources may be considered for additional information. Whatever the source of the information collected for Tier I, the quality of the data must be evaluated and weighed accordingly.

Tier I provides for determining if the proposed dredged material satisfies either of the exclusionary criteria [given in 40 CFR 227.13 (b)] applicable to ocean disposal of dredged material:

- The proposed dredged material is composed predominantly of sand, gravel, rock, or any other naturally occurring bottom material with particle size larger than silt, and the material is found in areas of high current or wave energy such as streams with large bed loads or coastal areas with shifting bars and channels.
- The proposed dredged material is to be utilized for beach nourishment or restoration and is composed predominantly of sand, gravel or shell with particle sizes compatible with material on the receiving beaches.
- The material proposed for dumping is substantially the same as the substrate at the proposed disposal site, and the proposed dredging site is far removed from known existing and historical sources of pollution so as to provide reasonable assurance that the dredged material has not been contaminated by such pollution.

The New York District will evaluate submitted Tier I data case by case. If the Tier I data do not demonstrate that the proposed dredged material satisfies one of the exclusionary criteria, or that the dredged material meets or exceeds the LPC, then further testing is required. The evaluation then moves on to Tier II.

2.2 TIER II

Tier II water-column evaluations consist of physical and chemical data evaluations to determine marine WQC compliance, using a numerical mixing model (DIFID). Tier II benthic evaluations determine the potential for nonpolar organic compounds to bioaccumulate in marine organisms, using a theoretical bioaccumulation potential (TBP) calculation.

Section 5.0 of the Green Book provides an overview of Tier II evaluations and Section 10.0 presents guidance for performing Tier II tests.

2.2.1 Tier II Water-Column Evaluations

The Tier II water-column evaluation for WQC compliance is a two-step process that includes application of a numerical mixing model (ADDAMS). Step 1 (optional) assumes that all contaminants in the dredged material are released into the water column during the disposal process. Step 2 is modification of step 1, incorporating the results from the chemical analysis of the elutriate prepared from the dredged material. The potential for water-column impact is determined by comparing these concentrations with the concentration of contaminants in disposal site water following initial mixing and dilution as calculated by the ADDAMS model. Step 1 serves as a screen, indicating the need for additional testing. Step 2 predicts whether or not the contaminant of concern that requires the greatest dilution will meet or exceed the LPC for WQC. A list of the data that must be provided to the New York District for running the model is given in Appendix B of the Green Book. Appendix B of this guidance manual provides test conditions and acceptability criteria for water-column toxicity testing.

The proposed discharge of dredged material must not exceed applicable marine WQC for all of the dissolved contaminants of concern outside the boundaries of the disposal site at any time nor exceed the WQC anywhere in the marine environment 4 hours after discharge of the dredged material. If the model predicts that one or more dissolved contaminants will exceed the marine WQC either outside the disposal site or within the disposal site after 4 hours of initial mixing, the proposed discharge will not comply with the LPC requirements of the regulations. If no WQC exist for contaminants or synergistic effects are suspected, water-column impact evaluation proceeds to Tier III.

2.2.2 Tier II Benthic Evaluations

Since at this time, only benthic effects attributed to nonpolar organic chemicals in the deposited sediment are addressed through Tier II testing, TBP calculations will not be routinely required by the New York District.

2.3 TIER III

Tier III testing includes (1) determination of water-column toxicity, (2) assessment of benthic toxicity, and (3) evaluation of bioaccumulation potential of the contaminants in the proposed dredged material. Green Book Section 6.0 provides an overview of Tier III evaluations and Sections 11.0 and 12.0 present guidance for performing Tier III tests.

2.3.1 Tier III Water-Column Evaluations

Tier III water-column tests evaluate the acute toxicity of the dissolved and suspended portions of the dredged material that remain in the water column after discharge of the dredged material. The Tier III water-column bioassays are run if the Tier II evaluations are inconclusive: i.e., there are no WQC for all contaminants of concern or there is reason to suspect additive or synergistic effects among the contaminants. The Tier III water-column tests involve exposing fish (Menidia menidia, Menidia beryllina, or Menidia peninsulae), crustaceans (Mysidopsis bahia) and zooplankton (bivalve larvae: Mytilus edulis, Mercenaria mercenaria, Crassostrea virginica, or Mulinia lateralis) to a dilution series containing dissolved and suspended components of the proposed dredged material. An overview of the Tier III water-column evaluations is presented in the Green Book under Section 6.:1 Water-Column Bioassays. Technical guidance for performing the tests is provided in Green Book Section 11.1: Tier III Water-Column Bioassays. The applicant should use the organisms specified in Table 4-5 (page 4-15) of this manual for these tests. Appendix B of this manual provides detailed procedures for water-column toxicity testing.

The results of the toxicity test will be used by the New York district to determine compliance with the LPC. The results of the water-column tests are used to calculate the EC_{50} and/or LC_{50} concentration of the dredged material in the water column. The LPC for the dredged material is 1% of the LC_{50} (EC_{50}). If the numerical mixing model predicts that the concentration of dredged material in the water column will not exceed 1% of the LC_{50} (EC_{50}) concentration either outside the disposal site or within the disposal site 4 hours after discharge of the dredged material, the proposed discharge of dredged material meets the water-column LPC. If either of these criteria are not met, the dredged material does not meet the water-column LPC.

2.3.2 Tier III Benthic Toxicity Test Evaluations

Tier III benthic toxicity tests are designed to determine whether the proposed dredged material is likely to produce unacceptable adverse effects on the benthic marine environment. In the acute toxicity tests, two species of burrowing amphipods (Ampelisca abdita, and either Rhepoxynius abronius or Eohaustorius estuarius) and mysids (Mysidopsis bahia) are exposed to the proposed dredged material, reference sediment, and laboratory control sediment. After 10 days, the number of survivors is recorded. Another measure of amphipod health is the ability to rebury in sediment once the experiment is terminated. Section 4.0 of this manual gives additional requirements for Tier III toxicity tests.

The results of the toxicity test will be used by the New York District to determine compliance with the LPC. Dredged material does not meet the LPC for benthic toxicity when 1) the mortality of any

one species exposed to proposed dredged sediment exceeds the mortality observed with reference sediments by at least 10% (20% for amphipods) and 2) this difference is statistically significant (p=0.05). Excessive mortality in the reference sediment may indicate a problem with conditions which will be further evaluated with the Corps and EPA.

2.3.3 Tier III Bioaccumulation Test Evaluations

The regulations require that bioaccumulation potential also be evaluated. The bioaccumulation tests (usually synchronized with the toxicity tests) evaluate the potential of benthic organisms to accumulate contaminants from the dredged material into their tissues. A 28-day exposure period, approaching 80% steady state for some of the contaminants (Lee pers. comm.), is required for evaluating tissue residues of metals and organic contaminants. For these bioaccumulation tests, the applicant must use the polychaete Nereis virens and the mollusc Macoma sp.

The New York District will use the results of the bioaccumulation tests to determine LPC compliance. If tissue concentrations for any contaminant of concern in organisms exposed to the dredged material is at least two times higher than concentrations in organisms exposed to the reference sediment and statistically significant at alpha=0.05, then a review should be undertaken to determine biological significance. Case-specific evaluative criteria will be used for determining compliance with the bioaccumulation LPC. Factors considered in this compliance determination are given in Section 6.3 of the Green Book.

Dioxin is a special case (see page 4-5, par 4).

If excessive mortality is observed for either test species, it will be factored into the Corps/EPA compliance evaluation.

3.0 WORK/QUALITY ASSURANCE PLAN

The New York District must approve the Work/Quality Assurance Plan (Work/QA Plan) for all laboratories performing the dredged material testing as described in this manual. A Work/QA Plan must clearly define the tests that the laboratory will conduct, who will conduct the work, and the product of the work. The Work/QA Plan must be detailed enough to fully identify all roles and responsibilities, quality-assurance (QA) objectives, and how the QA objectives are to be achieved.

Each laboratory that wishes to submit data to the New York District must first submit a written Work/QA Plan to the New York District for approval. An inspection of the laboratory facilities will be performed by New York District and/or Region II personnel. Laboratories conducting 2,3,7,8-TCDD work must meet occupational health and safety standards, dispose of all wastes appropriately, demonstrate competence by analyzing performance evaluation samples and be inspected specifically for dioxin testing. Subsequent reinspections will be made whenever it is deemed necessary by either New York District or Region II.

Once approved, Work/QA Plans will be kept on file in the New York District and will be updated by the laboratory as required. If the applicant plans to do any part of the testing (e.g., sampling), a Work/QA Plan for that portion of the work must be submitted for approval prior to commencement of sampling.

Quality assurance is an integral component of dredged material sampling and analysis. An effective QA program ensures that the laboratory's test data are defensible and of sufficiently high quality to support the final LPC evaluations. General QA guidance is given in Green Book Section 14.0: Quality-Assurance Considerations, and throughout Part III: Data Generation.

3.1 LABORATORY WORK/QA PLAN DEVELOPMENT

The laboratory Work/QA Plan must be developed according to EPA (1983, 1984, 1987) or other guidance and must be signed by an authorized representative of the laboratory. The plan must be written in sufficient detail so that a technical person unfamiliar with dredged-material evaluations can understand the objectives of the work and how the objectives will be met. The Work/QA Plan assigns responsibility and ensures that all participants possess a thorough understanding of the work. Therefore, the laboratory's Work/QA Plan must include:

- Descriptions of all technical procedures for field sampling, laboratory analysis, data reduction and validation, and reporting
- All field and analytical procedures in clearly written standard operating procedures (SOP) [Appendix B SOPs or other EPA and USACE SOPs may be used]
- Clearly defined QA objectives that are consistent with the regulations, the Green Book, and the permit application
- Mechanisms for conducting performance and systems audits during the course of the field and laboratory work
- Procedures for detecting problems with the sampling and analytical work, and implementing corrective actions in a timely manner.

The applicant is responsible for confirming that his/her contract laboratories adhere to all applicable sections of the Work/QA Plan. The laboratory is responsible for adhering to the approved Work/QA Plan and also for budgeting the necessary time and resources for New York District inspections of field-sampling and laboratory activities. The New York District conducts its own QA evaluations and data audits during the sampling and testing activities, as it deems necessary. As part of its QA evaluations, the District may require the applicant's laboratories to analyze quality control (QC) samples.

The following subsections describe the necessary components of a laboratory's Work/QA Plan for dredged-material testing within the New York District. The laboratory is responsible for updating the Work/QA Plan as components become outdated. Any deviation from the Work/QA Plan on file with the district must be coordinated with New York District prior to initiation of sampling.

3.1.1 QA Objectives

The following QA objectives must be clearly defined in the Work/QA Plan. Refer to EPA (1983, 1984) for definitions of these parameters.

- **Quantitative objectives**
  - Method detection limits (MDL)
  - Precision
  - Accuracy
  - Completeness

- **Qualitative objectives**
  - Representativeness
  - Comparability

- **Corrective procedures if QA objectives are not met**

The New York District will verify that the QA objectives are consistent with the regulations and guidelines governing dredged-material testing.

3.1.2 Organization and Responsibilities

This will include the lines of authority and responsibilities for all key technical personnel, including subcontractors. An organizational chart is often included in this portion of the plan to show project management structure and lines of communication.

3.1.3 Internal Quality-Control Checks

Quality-control analyses must be incorporated into all field and laboratory activities. All points in the sampling and analytical procedures where QC checks are required must be defined, and the frequency, types of checks, and acceptance /rejection criteria must be stated in the Work/QA Plan. QC checks for laboratory analyses generally include:

- Sample splits and replicates
- Blanks (field, method, reagent, instrument, etc.)
- Spiked blanks
- Matrix spikes and matrix-spike duplicates
- Surrogates and internal standards
- Standard reference materials (SRM) (sources of SRMs are listed in Green Book Section 9.0: Physical Analysis of Sediment and Chemical Analysis of Sediment, Water, and Tissue Samples, Table 9-4)
- Calibration standards

Chemical QC specifications are the ranges considered acceptable for:

- Instrument calibration
  Established by determining a linear response over the range of data to be collected
- Analyte recovery

Determined by analyzing a sample spiked with a known amount of chemical

- Accuracy
  Established by including a series of spiked and blank samples in each analysis
- Precision
  Established by analyzing replicate samples.

These specifications are discussed in Green Book Section 14.3.2: Chemical Quality Control.

Biological QC entails periodic reference-toxicant tests being conducted with all test organisms to determine the relative health of the organisms. The reference-toxicant test should be run for 96 hours without sediment for all test species except bivalve larvae. For bivalve larvae prodissoconch I stage development, reference-toxicant tests should be run concurrently with the toxicity tests for 48 hours or the duration of the water-column test. The application and benefits of reference-toxicant tests are discussed by Lee (1980). The acceptable LC_{50} range for each species must be determined. EPA Region II and the New York District can provide assistance in establishing biological QC objectives. These specifications are discussed in Green Book Section 14.3.3: Biological Quality Control.

The New York District may require that certain samples be submitted routinely to government laboratories for analysis. These activities provide an independent QA check on activities that are being performed and on data being generated.

Data-quality requirements and assessments are discussed in Green Book Section 14: Quality Assurance Considerations.

3.1.4 Sampling and Analytical Procedures

A sampling scheme must be obtained from the New York district. If sampling is undertaken by the applicant and not the contract laboratory for the NYD, then this component of the Work/QA Plan must be submitted to the New York District for approval prior to commencement of sampling activity.

Sampling and analytical techniques must be outlined step by step, as in a flow chart. All methods and procedures used in the field and laboratory must be described, and written protocols must be referenced detailing the following:

- Use of sampling equipment and facilities
- Sample collection
- Sample compositing
- Sample preparation and manipulation
- Culture methods and acclimation procedures
- Sample analysis
- Data entry and data reduction
- Sampling preparation (equipment cleaning, sample containers, reagents, supplies, etc.)
- Equipment calibration
- Chain-of-custody and sample labeling
- Sample transport, storage and disposal
- Sample preservation methods
- Sample holding times (including before and after extraction)
- Deviations from standard methodologies or prescribed sampling and testing procedures
- Narrative of matrix interferences, confounding results, problems, comments

All methods, whether for critical or noncritical analyses, must be validated to show that the results will meet QA objectives. If an EPA- or USACE-approved method or other standard validated method is used, the complete reference citation for the method must be in the Work/QA Plan.

If a nonstandard or modified procedure is used, the entire procedure and validation methods must be clearly described in a SOP. Such a document describes routine study methods and procedures that affect data quality and integrity. SOPs are guides for the persons who conduct the work, so that individual procedures are not changed over time. These modifications or substitutions must be reviewed by EPA, Edison, New Jersey prior to commencement of the project.

Sampling and analytical requirements are discussed in the following Sections of the Green Book and this manual.

	This Manual	Green Book
• Field sampling	4.2	8.0
• Physical analysis of sediment	4.3.1	9.1 and 9.2
• Chemical analysis of sediment	4.3.2	9.3
• Chemical analysis of water	4.3.3	9.4
• Chemical analysis of tissue	4.3.4	9.5
• Water-column bioassays	4.4.1	11.1
• Whole-sediment bioassays	4.4.2	11.2
• Whole-sediment bioaccumulation analysis	4.4.3	12.1

3.1.5 Equipment Calibration and Maintenance

Calibration and maintenance procedures for all field and laboratory equipment should be specified in writing and all activities related to these procedures should be documented. The Work/QA Plan must include:

- List of standards, including source, traceability, purity checks
- List frequency of checks
- Acceptance/rejection criteria
- Remedial action for rejected measurements

Calibration and maintenance are discussed in Green Book Section 14.2.4: Equipment and Supplies.

3.1.6 Sample Custody and Tracking

Chain-of-custody and sample-tracking procedures must be described for sample collection, analysis, and transfer, and for data reduction and reporting. To monitor the chain of custody and track the samples, the Work/QA Plan must contain:

- Names of all individuals and companies who handle and have responsibility for the samples
- Records of sample acquisition
- Records of sample preservation
- Records of sample disposal
- Examples of sample labels and custody seals
- Forms for field and laboratory sample tracking and chain of custody
- Procedures for transferring samples from the field to the laboratories, within the laboratories, and between laboratories
- Procedures for tracking data to the samples

Archiving protocols should indicate the storage requirements, location, indexing codes, storage time, security, and environmental measures needed to preserve the data and samples.

Sample custody, handling, and tracking are discussed in Section 14.2.6: Sample Handling and Tracking, and Section 14.3.6: Archiving of Data and Samples of the Green Book.

3.1.7 Documentation, Data Reduction, and Reporting

The activities described in Sections 3.1.4 through 3.1.7 of this manual must be documented to ensure that the applicant's data are defensible and verifiable. The District requires that original data records and QC information for dredged-material testing be maintained and archived for at least 3 years from the submission of the laboratory report. These materials must be available to the District at all times.

3.1.8 Data Validation

Data validation involves all procedures used to accept or reject data after collection and prior to use, including editing, screening, checking, auditing, verifying, and reviewing. Data-validation procedures ensure that the standards for data accuracy and precision are met, that data are generated in accordance with the Work/QA Plan and SOPs, and that data are traceable and defensible. All reported data must be properly validated following standardized procedures to ensure that data are of consistent and documented quality. Data validation is discussed in Green Book Section 14.3.1: Data Validation.

3.1.9 Performance and Systems Audits

The applicant, or the applicant's contractors, must conduct performance and system audits of all field and laboratory work. Performance audits comprise independent measurements, taken for comparison with similar, routinely obtained data. These audits are accomplished by using field blanks, trip blanks, blind samples, duplicate samples, spiked samples, and interlaboratory comparison studies.

Systems audits review the entire project to ensure that work is proceeding in accordance with the Work/QA Plan. These audits include on-site reviews of field and laboratory operations to verify that (1) appropriate SOPs are in place, (2) staff training is appropriate and has been documented, (3) all equipment is properly calibrated and maintained, (4) approved analytical procedures are being followed, (5) facilities are adequate and (6) occupational health and safety procedures are followed.

Laboratory audits will be conducted periodically by the New York District and/or Region II and whenever there are major changes in key personnel (e.g., laboratory director) or laboratory location.

Audits are discussed in Green Book Section 14.3.4: Performance and Systems Audits.

3.1.10 Corrective Action

One purpose of QA program is to identify a nonconformance event as quickly as possible. A nonconformance event is defined as any event that does not follow defined methods, procedures, protocols, or any problem that may affect the quality of the data or study. The Work/QA Plan must include mechanisms for identifying problems in both the sampling and analysis phases, and for implementing corrective action. Corrective action is discussed in Green Book Section 14.3.5: Management of Nonconformance Events.

3.1.11 Reports

After testing has been completed, the applicant must submit one hardcopy of the testing report to the New York District. Data presentation must follow the CLP style format. Spreadsheet formats will be suggested by NYD. A copy of the updated components of the Work/QA Plan must accompany each copy of the test results. The testing report must include:

- Raw and reduced data for all tests, a separate page per organism. As described in the 40 CFR 792, raw data are ". . . any laboratory worksheets, records, memoranda notes, or exact copies thereof, that are the result of original observations and activities or a study and are necessary for the reconstruction and evaluation of the report of that study."
- 8.5×11-in. map of the area to be dredged, indicating the sampling sites (including control and reference sites) plus site coordinates (lat/long, Loran readings) for sediment and water
- Names of the laboratories and personnel that performed the tests
- Description and results of Quality Control (QC) checks and data validation
- Analytical methods and observations
- Sampling logs
- Clear mechanisms for correlating sample collection and sample analytical results (sample tracking, sample and project identification)
- Summary of reference-toxicant tests (one page per organism)
- All chain-of custody forms
- Source of water, and its handling, manipulation, storage and disposal
- Source of sediment, and its handling, manipulation, storage and disposal
- Source of test organisms, and their handling, culturing, acclimation and disposal
- A high density disk (3 1/2" or 5 1/4") containing all data in a format to be specified by NYDCOE
- Problems and corrective actions
- Deviations from prescribed field and laboratory protocol

3.2 NEW YORK DISTRICT QC REQUIREMENTS

3.2.1 Physical Analyses

The New York District requires the following physical-assessment QC checks for sediments:

- Triplicate – One with every batch of 1-20 samples, with at least one being test

3.2.2 Chemical Analyses

The New York District requires the following chemistry QC checks for each sample matrix:
MDL verification must be made using matrix of interest, eg. seawater, sediment, tissue.

- Sediment samples (see Green Book Section 9.3: Chemical Analysis of Sediment, for details)
  - Procedural blanks – One with every batch of 1-20 samples
  - Matrix spike – One with every batch of 1-20 samples
  - Triplicate – One with every batch of 1-20 samples, with at least one being test (except TOC, where every sample is processed in triplicate)
  - SRMs – One with every batch of 1-20 samples, if available (see Green Book Table 9-4: Sources of Marine Reference Materials and Standards, for sources of SRMs)
  - Recovery of surrogate spikes – Daily, Organics only
  - MDL verification - Spike sediment samples with analytes of concern at 5 - 7 times the estimated detection limits. Analyze samples 4 times using each step of the analytical procedure. This should be done with each set of 1-20 samples. The values obtained should be reported as the "practical detection limit".

- Water samples (see Green Book Section 9.4: Chemical Analysis of Water, for details)
  - Procedural blanks – One with every batch of 1-20 samples
  - Seawater matrix spike – One with every batch of 1-20 samples
  - Triplicate – One with every batch of 1-20 samples, with at least one being test
  - SRMs – One with every batch of 1-20 samples, if available (see Green Book Table 9-4: Sources of Marine Reference Materials and Standards, for sources of SRMs)
  - Recovery of surrogate spikes – Daily
  - MDL verification - For metal analyses in seawater, spike 2% sodium chloride solutions with analytes of concern at 5-7 times the estimated detection limits. Analyze these samples 4 times using each step of the analytical procedure. The values obtained should be reported as the "practical detection limit". This should be done with each set of 1 - 20 samples.
- Tissue samples (see Green Book Section 9.5: Chemical Analysis of Tissues, for details)
  - Procedural blanks – One with every batch of 1-20 samples
  - Tissue matrix spike – One with every batch of 1-20 samples
  - Triplicate – One with every batch of 1-20 samples, with at least one being test
  - SRMs – One with every batch of 1-20 samples, if available (see Green Book Table 9-4: Sources of Marine Reference Materials and Standards, for sources of SRMs)
  - Recovery of surrogate spikes – Daily
  - MDL verification - Spike tissue samples with analytes of concern at 5 - 7 times the estimated detection limits. Analyze samples 4 times using each step of the analytical procedure. This should be done with each set of 1-20 samples. The values obtained should be reported as the "practical detection limit".

3.2.3 Biological Analyses

The New York District requires the following biology QC checks for each sample matrix

- Water bioassay samples (see Green Book Section 11.1: Tier III: Water-Column Bioassays, for details)
  - Reference toxicant tests – Geometric dilution series of five unreplicated concentrations, one of which must give >50% mortality and one of which must give <50% mortality; conducted once monthly per laboratory-cultured species and on each lot of purchased or field-collected organisms; 10 organisms per exposure chamber; 96 hour exposure (48 hour minimum for bivalve larvae); no sediment; use artificial seawater or clean natural seawater as the diluent depending on which was employed in the bioassays
  - Control mortality $\leq$10% mean ($\leq$30% abnormality for live oyster and mussel larvae, $\leq$40% for clam larvae)
- Sediment bioassay samples (see Green Book Section 11.2: Whole-Sediment Bioassays, for details)
  - Reference toxicant tests – Geometric dilution series of five unreplicated concentrations, one of which must give >50% mortality and one of which must give <50% mortality; conducted once monthly per laboratory-cultured species and on each lot of purchased or field-collected organisms; 10 organisms per exposure chamber; 96 hour exposure; no sediment; use artificial seawater or clean natural seawater as the diluent depending on which was employed in the bioassays
  - Control mortality $\leq$10% mean (amphipods control mortality $\leq$10% mean and no individual chamber $\geq$20% mortality)
- Sediment bioaccumulation samples (see Green Book Section 12.1: Tier III: Determination of Bioavailability, for details)
  - Reference toxicant tests – Geometric dilution series of five unreplicated concentrations, one of which must give >50% mortality and one of which must give <50% mortality; conducted once monthly per laboratory-cultured species and on each lot of purchased or field-collected organisms; 10 organisms per exposure chamber; 96 hour exposure; no sediment; use artificial seawater or clean natural seawater as the diluent depending on which was employed in the bioaccumulation studies
  - Where control mortality >10% determine if have a) adequate replicates to obtain statistical power, b) stressed organisms c) contaminated control sediment d) contamination of test system e) quality control problems

4.0 TECHNICAL GUIDANCE

4.1 REFERENCE AND CONTROL SAMPLES

The following information supplements the national guidance in Green Book Section 3.1: Reference and Control Sediments.

4.1.1 Reference Sediment

A reference sediment is a natural sediment that is:

- Substantially free of contaminants
- As similar in grain-size distribution, organic content, and % moisture to the proposed dredged material as possible
- Reflective, as possible, of hydrographic conditions characteristic of the disposal site
- Serves as a point of comparison to identify potential effects of contaminants in the dredged material and to determine compliance with the LPC

The reference sediment for all New York District projects must be collected at the Mud Dump Site Reference Site, located at 40°20'13"N, 73°52'11"W (40°20.21'N, 73°52.19'W), Loran C coordinates 9960-x-26910.7/9960-y-43629.2. The reference site is approximately 2.6 mi SW of the center of the Mud Dump Site, in about 70 ft of water.

A new reference site is being considered to better reflect the physical characteristics of sediment typically dredged in this region. As soon as a new site is designated, the site described in the preceding paragraph will no longer be used as the reference site. Coordinates for the reference point will be provided at that date (as soon as possible). Please check with the NYD prior to collecting reference sediment to confirm current site coordinates. Using inappropriate reference sediment invalidates testing.

Excessive mortality in the reference-sediment tests indicates a problem with the test conditions or the experimental design (contaminated sediment, grain size effect on the organisms, quality control, etc.) and requires a joint evaluation by NYD and EPA Region II concerning the acceptability of the data.

4.1.2 Control Sediment

A control sediment is a natural sediment that is essentially free of contaminants and is compatible with the biological needs of the test organisms. The control sediment should have no discernible negative influence on the test organism. The purpose of the control sediment is to confirm the biological acceptability of the test conditions and to help verify the health of the organisms during the test.

Excessive mortality (see Section 3.2.3: Biological Analyses) in the control-sediment tests indicates a problem with the test conditions or with the organisms, and invalidates the results of the corresponding dredged material test.

The individual laboratory must provide the control sediments. The sediments must not contain detectable levels of contaminants originating from local point or non-point sources (global origin only) nor can they adversely affect the test organisms in any way. The sediment can be taken from uncontaminated sites where field-collected organisms were obtained. If the organisms are

laboratory reared or purchased from a supplier, then the control can be the sediment that the organisms were shipped or cultured in. The testing laboratories must maintain the control-sediment test results (e.g., amphipod mortality) as a component of their quality-control program. Each laboratory's control-sediment test results must fall within the range of acceptability (e.g., mortality $\leq$10%). They must also be able to show that the sediments are essentially contaminant free.

The New York District strongly advises that applicants review a laboratory's control data files prior to contracting its services. Similarly, the District advises that applicants not designate control-sediment sites or collect control-sediment samples for the contracting laboratories. When an applicant requires that a testing laboratory alter its established QC procedures, he/she usurps the laboratory's accountability for the performance (results) of the control-sediment tests.

4.1.3 Control Water

Control water is analogous to control sediment as it is used for water-column bioassay control treatments. Control water should be the same water in which the test organisms are held prior to testing. If water is collected in the field, it should be taken prior to sediment collection and near the bottom. Specifics regarding collection of water are provided in Section 8.2.5.2. of the Green Book. As with the control sediments, the testing laboratories are responsible for collecting control water from the field or creating control water from artificial sea/salt mixtures. The laboratories also must construct control data files from the results of the control treatments.

4.1.4 Dredging Site Water

Water obtained from the dredging site will be used to prepare an elutriate sample and will be analyzed for contaminants of concern (see Section 4.3.3: Chemical Analysis of Water). At a minimum, one near- (sub)surface water sample must be collected from within the boundaries of the dredging site. If the project is subdivided into different units due to different hydrographic influences, concern over isolated spills, or distances between sampling sites, a minimum of one near-surface water sample per subunit must be collected. As a result, there would be an elutriate analysis conducted which corresponded to each bioassay/bioaccumulation evaluation. The sampling scheme provided by NYD/COE will indicate the specifics. Laboratories should consult with the NYD/COE if there are any questions regarding this matter.

4.2 FIELD SAMPLING

The following information supplements the National guidance in Green Book Section 8.0: Collection and Preservation of Samples.

Proper sampling is essential to the full evaluation of a dredging project. The goal of sampling and testing is to obtain sufficient information to evaluate the environmental impact of the dredging operation within the constraints of the operation. Although such constraints do not justify inadequate environmental evaluation, time and funding constraints are recognized. Sample locations required for a project will be provided to the applicant by the New York District. All subsequent changes in project area must be coordinated with the New York District so as to ensure that the sampling scheme continues to represent the material proposed for ocean disposal.

Table 4-1 summarizes the sample-collection requirements within each tier of the evaluation process. It is very important that sufficient sample material be collected to conduct all of the required tests, and that the collection and handling operations do not contaminate the samples. Refer to Sections 8.2.6.2 and 8.2.6.3 and Table 8-2 of the Green Book and ASTM (1992) for appropriate sample preservation and storage techniques.

Sampling must adequately characterize the heterogeneity and spatial extent of the project. Core sampling to 2 feet below project depth is required for all proposed dredging projects. Grabs are not permitted without written consent of the NYD/COE. Failure to comply with sampling protocol will invalidate test results.

Refer to Green Book Section 8.2: Components of a Sampling Plan, for further guidance on the following:

- Review of historical data
- Subdivision of dredging area
- Selection of sampling sites and number of samples
- Sample-collection methods
- Sample handling, preservation, and storage
- Quality-control issues.

Table 4-1. Sample-Collection Requirements

This table indicates the type of samples that may require field collection. Based on the pre-application permit materials provided by the applicant, the New York District will determine sampling requirements for individual projects.

Tests	Water Samples			Sediment Samples		
	Disposal Site	Dredging Site	Control[a]	Dredging Site	Ref. Site	Control[a]
Tier II						
Water column	●[b]	●		●		
Tier II						
Benthic				●	●	
Tier III						
Water column	●[c]	●	●	●		
Tier III						
Benthic				●	●	●

[a] May or may not be field-collected
[b] Determine WQC compliance; may substitute existing agency data
[c] Dilution water; artificial or clean seawater may be used

4.3 PHYSICAL AND CHEMICAL ANALYSIS

The following information supplements the National guidance in Green Book Section 9.0: Physical Analysis of Sediment and Chemical Analysis of Sediment, Water, and Tissue Samples. For all required constituents, the testing laboratories must report any observations (signal peaks) which fall between MDL and instrument detection limits at the measured level rather than at "less than" detection levels. This information is being requested in order to address the problem of determining statistical significance when some or all values are reported as "less than" detection.

Modifications to any of physical or chemical analyses must be cleared by EPA, Edison, New Jersey before they are incorporated as standard operating procedures.

4.3.1 Physical Analysis of Sediment

All individual core samples of the dredged material must be visually inspected, and any sediment strata present within the core must be recorded. If the sediment appears uniform within a single core sample, the entire core should be homogenized and analyzed. When other information indicates that there might be significant physical or chemical differences within a core sample (e.g., there was a historical discharge or spill in the area or the sample includes maintenance material and new work or there are discernible strata within the core), physical analyses will be done on each stratum of every stratified core. The core sample must be analyzed in sections (homogenization within each stratum but no homogenization between strata). The applicant and/or the contract laboratory must contact the New York District immediately if there is a question regarding the need to test strata separately.

All samples, subsamples, and reference and control sediments must be analyzed for

- Grain size
- Percent moisture
- Total solids
- Specific gravity

The grain-size analysis must be conducted according to the methods described by Folk (1980) and reported as percentages and volumes within these general size classes.

Sand: ≥ 0.0625-mm diameter
Silt: < 0.0625-mm diameter and ≥ 0.0039-mm diameter
Clay: < 0.0039-mm diameter

The other physical analyses should be conducted according to the methods described by Plumb (1981) and APHA (1989).

Note that the results of the above physical analyses may be used to support compliance with one or more of the three exclusionary criteria in 40 CFR 227.13(b). If physical analyses show that the dredged material meets one or more of the three exclusionary criteria, and if other pertinent, historical, and site-specific information can support the criteria, the material will be approved for disposal without further testing. Refer to Section 2.1 of this manual for details.

4.3.2 Chemical Analysis of Sediment

Bulk-sediment chemical analyses must be conducted on the same sediment samples that were used for the physical analyses (i.e., all samples, subsamples, and reference and control samples). At a minimum, sediment analysis must be conducted for total organic carbon (TOC) (Table 4-2A). Sulfide and ammonia should be measured in the porewaters of the three homogenized sediment treatment levels examined in whole-sediment benthic toxicity and bioaccumulation assays. Collect porewater for these analyses while setting up experimental chambers.

Determination of specific sediment contaminants, e.g. target analytes in tissue (Tables 4-4A through 4-4C) may be required for certain project areas. Applicants may opt to conduct sediment analyses. Methods and detection limits are provided in Tables 4-2B and 4-2C. Report data and MDLs on as follows: organics, ng/g dry weight except dioxins and furans, pg/g dry weight; metals µg/g dry weight except the MDL for mercury which is on a wet weight basis. Organics in sediments are

extracted and prepared for analysis as described in NOAA (1989). They are then analyzed either by capillary gas chromatography with electron capture detection (PCBs and pesticides) or by GC/MS (dichlorobenzene and PAHs). Congeners of concern (#8,18,28,44,49,52,66,87,101,105,118,128,138, 153,170,180,183,184,187,195,206,209) are those in the NOAA Mussel Watch list and the highest priority list of McFarland and Clarke specified in Table 9-3 of the Green Book, with slight modification. The coplanar congeners requiring carbon adsorption separation may be excluded from regular analyses until an alternative, routine and economically feasible process standarizes this analysis. It is possible, that these congeners (77,126,156,169) would be requested on a case by case basis, following a screening process for the other 22 congeners when there is reason for significant concern. Except for mercury, total recoverable metals in sediments are determined by the methods specified in Tables 4-2B following the digestions of the samples by the procedures in Method 200.2 (EPA, 1991a). Mercury in sediment is determined by Method 245.5 (EPA, 1991a). The analytical values are reported to two significant figures.

Table 4-2A. REQUIRED CONSTITUTENTS IN SEDIMENT SAMPLES
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

Constituent	MDL	Method
Total org carbon (TOC)	0.01% (dry wt)	EPA 1992a
Total sulfides	0.1 mg/kg	Parsons et al. 1984
Ammonia	0.1 mg/kg	Parsons et al. 1984

Chromatograms should be scrutinized for the presence of compounds not included on the target analyte list to ensure that these "unknown" compounds be characterized and reported. Identify any contaminant which consistently appears in samples but which is not on the required list of inorganic or organic analytes. For 1% of the samples analyzed, report any constituent that is more than thrice the baseline.

Dioxin analyses will be required on a case by case basis. The MDL for sediment is 1 pptr (dry wt.). Any material documented with concentrations equal to or greater than 1 pptr 2,3,7,8-TCDD requires 28-day bioaccumulation testing with Nereis for dioxin. LPC compliance is met only when tissue residues are below the MDL (1 pptr wet wt). As new MDLs or guidelines are set, they will override the forementioned interim criteria.

If alternative methods are used, written New York District approval is required. Approved methods and MDLs for many other priority pollutants are given in EPA (1986). Refer to Green Book Section 9.3: Chemical Analysis of Sediment, for further information on analytical targets for dredged material and the selection of appropriate methods.

Table 4-2B. OPTIONAL INORGANICS IN SEDIMENT SAMPLES
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD[1]	METHOD DETECTION LIMIT[2]
Acid volatile sulfides (AVS)	Allen et al. 1991	0.01 µmol/g
		(µg/g dry weight)
Metals:		
Arsenic	EPA-200.9	0.1
Cadmium	EPA-200.9	0.01
Chromium	EPA-200.9	0.02
Copper	EPA-200.9	0.1
Lead	EPA-200.9	0.1
Mercury	EPA-245.5	0.02*
Nickel	EPA-200.9	0.1
Silver	EPA-200.9	0.1
Zinc	EPA-200.9	0.1
SEM	Allen et al. 1991	

[1] Except for mercury, sediment samples must be digested by Method 200.3 (EPA, 1991a) prior to analysis by Method 200.9 (EPA, 1991a). For mercury, the digestion is a part of the procedure.

[2] Except for mercury, the detection limits were estimated from the MDLs of the analytes in water as stated in EPA, 1991a, assuming a sample weight of 1.0 g and a final digestate volume of 100 ml. The quantitation limit for mercury is that given in the method. The MDL for mercury is per gram wet weight (*).

Table 4-2C. OPTIONAL ORGANICS IN SEDIMENT SAMPLES
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD[1]	METHOD DETECTION LIMIT[2]
Pesticides:		(ng/g dry weight)
Aldrin	EPA-8080	1
Alpha Chlordane	EPA-8080	1
Trans nonachlor	EPA-8080	1
Dieldrin	EPA-8080	1
p,p'-DDT	EPA-8080	1
o,p'-DDT	EPA-8080	1
p,p'-DDD	EPA-8080	1
o,p'-DDD	EPA-8080	1
p,p'-DDE	EPA-8080	1
o,p'-DDE	EPA-8080	1
Endosulfan I	EPA-8080	1
Endosulfan II	EPA-8080	1
Endosulfan sulfate	EPA-8080	1
Heptachlor	EPA-8080	1
Heptachlor epoxide	EPA-8080	1
Industrial Chemicals:		
PCBs	CS[3]	1[4]
1,4-Dichlorobenzene	EPA-8270	1*
2,3,7,8-TCDD, -TCDF	EPA-8290	0.001
PAHs (Low Molecular Wt):		
Acenapthene	EPA-8270	10
Acenaphthylene	EPA-8270	10
Anthracene	EPA-8270	10
Fluorene	EPA-8270	10
Naphthalene	EPA-8270	10
Phenanthrene	EPA-8270	10
PAHs (High Molecular Wt):		
Benzo(a)anthracene	EPA-8270	10
Benzo(a)pyrene	EPA-8270	10
Benzo(g,h,i)perylene	EPA-8270	10
Benzo(b)fluoranthene	EPA-8270	10
Benzo(k)fluoranthene	EPA-8270	10
Chrysene	EPA-8270	10
Dibenzo(a,h)anthracene	EPA-8270	10
Fluoranthene	EPA-8270	10
Indeno(1,2,3-c,d)pyrene	EPA-8270	10
Pyrene	EPA-8270	10

[1] Sediment samples are extracted and cleaned-up using the methods described in NOAA (1989) prior to following the methods itemized here. Methods 8080 and 8270 are described in EPA (1986). Freeze-dry to constant weight.

[2] Detection limits were those published in EPA (1992b).

[3] NYSDEC (1991). Congener-specific method #91-11. See discussion of PCB congeners under Section 4.3.2.

[4] MDL is per congener. Report values for each congener and as a sum of the congeners where $\leq$PCBs=2.19x + 2.19 (T. Wade, pers. comm. 1992)

* Semi-volatile compound. Recovery may be incomplete. MDL suggested.

4.3.3 Chemical Analysis of Water (Sediment Elutriate)

The dredged-material elutriate preparation is conducted according to the methods presented in Green Book Section 10.1.2.1: Dredged-Material Preparation (Standard Elutriate). The chemical analysis of the elutriate and dredging site water is discussed in Green Book Section 9.4: Chemical Analysis of Water.

Particular note should be taken of the size of the water samples required to meet the MDLs for water analysis. As a general rule, 1 liter water samples are necessary for each organic analysis and 1 liter for metal analyses to provide MDLs that are below the applicable marine WQC. The methods recommended for metal analyses are free of interferences and the specified detection limits are achievable in coastal and estuarine waters. The procedures referenced in Tables 4-3A through 4-3C should be consulted when selecting methods for water analysis. No water analysis should be conducted without prior written New York District approval because new methods are under development.

At a minimum, chemical analysis must be conducted for the inorganic and organic analytes given in Table 4-3A and 4-3B. Additional organics are listed in Table 4-3C. These may be requested for specific projects. Both dredging site water and elutriate are to be tested in triplicate. Disposal site water should be tested in triplicate and is used in the calculation to determine WQC compliance or existing data in the vicinity of the disposal site may be substituted.

Except for mercury, total recoverable metals in water are determined by the methods specified in Tables 4-3A, following digestion of the samples by the procedures in Method 200.2 (EPA, 1991a). Mercury in water is determined by the Bloom and Crecelius (1983) method. The analytical values are reported to two significant values. In Table 4-3B, the pesticides are extracted from the water by Methods 3510 (EPA, 1986) and analyzed by Method 8080 (EPA, 1986). PCBs are extracted and analyzed by the congener method (NYSDEC, 1991). Congeners of concern (#8,18,28,44,49,52,66,87,101, 105,118,128,138,153,170,180,183,184,187,195,206,209) are those in the NOAA Mussel Watch list and the highest priority list of McFarland and Clarke specified in Table 9-3 of the Green Book, with slight modification. The coplanar congeners requiring carbon adsorption separation may be excluded from regular analyses until an alternative, routine and economically feasible process standarizes this analysis. It is likely, that these congeners (77,126,156,169) would be requested initially on a case by case basis, following a screening process for the other 22 congeners when there is reason for significant concern.

Refer to Green Book Section 9.4: Chemical Analysis of Water, and Green Book Section 10.0: Guidance for Performing Tier II Evaluations, for further information.

4.3.4 Chemical Analysis of Tissue

Tissue of organisms used for the bioaccumulation evaluations in Tiers III must, at a minimum, be chemically analyzed for contaminants listed in Tables 4-4A and 4-4B. The New York District may request additional target analytes.

Minimum MDLs for the analytes and New York District-approved methods for the analyses are also presented in Tables 4-4A through 4-4C. Except for mercury, metals in tissue samples are digested according to Method 200.3 (EPA, 1991a) and analyzed according to the methods specified in Table 4-4A. Mercury is analyzed by Method 245.6 (EPA, 1991a). MDLs are to be based on wet weight concentrations. Report tissue levels on wet and dry weight basis along with tissue moisture content as follows: organics, ng/g except dioxins and furans, pg/g; metals, µg/g. Prior to analysis, organics in tissue are extracted and prepared according to NOAA (1989). PCBs are analyzed by the NYSDEC (1991) method. Congeners of concern (#8,18,28,44,49,52,66,87,101,105,118, 128,138,153,170,180,183,184,187,195,206,209) are those in the NOAA Mussel Watch list and the highest priority list of McFarland and Clarke specified in Table 9-3 of the Green Book, with slight modification. The coplanar congeners requiring carbon adsorption separation may be excluded from regular analyses until an alternative, routine and economically feasible process standarizes this analysis. It is likely that these congeners (77,126,156,169) would be requested initially on a case by case basis, following a screening process for the other 22 congeners when there is reason for significant concern. Pesticides are to be analyzed by Method 8080 (EPA, 1986). The PAHs and 1,4-dichlorobenzene require Method 8270 (EPA, 1986).

Chromatograms should be scrutinized for the presence of compounds not included on the target analyte list to ensure that these "unknown" compounds be characterized and reported. Identify any contaminant which consistently appears in samples but which is not on the required list of inorganic or organic analytes. For 1% of the samples analyzed, report any constituent that is more

than three times above baseline. The aim is to identify additional constituents which may be of environmental concern.

New methods are under development. Written approval by the New York District is required in advance when there is a request to utilize alternative methods.

Test, reference, control and pre-test tissue replicates are to be analyzed separately. Tissue samples must be kept frozen until six months after announcement of test results in a New York District Public Notice. Pre-test tissue analyses are used to confirm that the contaminants of interest are below detection limits. Failure to meet this requirement causes all subsequent bioaccumulation results to be called into question. All pre-test organisms must be depurated for 24 hours in "clean" sand. Pre-test tissue should be analyzed prior to conducting 28 day testing to obviate repeating the test(s) because test organisms exhibited tissue contaminant levels above detection levels. Reference tissue concentrations must be below guidance values for all contaminants of concern. If these requirements are not met, it will be the responsibility of the laboratory or the private applicant to rerun required tests including the 28 day bioassay / bioaccumulation study. If there are any questions regarding the quality or validity of the bioaccumulation test due to pretest, control or reference contaminant levels, please contact the NYD before proceeding.

Sufficient sample size is required to achieve the required MDLs. Inability to meet the required MDLs or to conduct the appropriate number of replicate analyses because of insufficient sample size will not be accepted.

Refer to Green Book Section 9.5: Chemical Analysis of Tissues, for additional guidance.

Table 4-3A. REQUIRED METALS IN COASTAL AND ESTUARINE WATER
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT[1]	TEST METHOD[2]	METHOD DETECTION LIMIT (µg/l)[3]
Metals		
Cadmium	EPA-200.9	0.0025
Chromium	EPA-218.3	1.0
Copper	EPA-200.9	0.035
Lead	EPA-200.9	0.035
Mercury	*	0.0002
Nickel	EPA-200.9	0.03
Silver	EPA-200.9	0.025
Zinc	EPA-200.9	0.015

1 Determined as "total recoverable metals".

2 Except for chromium and mercury, samples must have been digested by Method 200.2 (EPA, 1991a) and extracted by chelation/extraction as described under "Metals-14" S 9.2 (EPA, 1979, revised 1983), prior to analysis by Method 200.9. Chromium method 218.3 is described in EPA, 1979 (Revised 1983).

* Use the Bloom, Crecelius and E.A. Berman (1983) method for determining mercury concentrations.

3 Except for chromium and mercury, the detection limits were estimated by dividing the cited literature MDL values by the concentration factor 20, obtained by the chelation/extraction procedure.

Table 4-38. REQUIRED ORGANICS IN COASTAL AND ESTUARINE WATER
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD[1]	METHOD DETECTION LIMIT (µg/l)
Pesticides:		
Aldrin	608	0.004
Dieldrin	6608	0.002
Alpha chlordane	608	0.014
Trans nonachlor	608	0.014
o,p'-DDT	608	0.02
p,p'-DDT	608	0.012
o,p'-DDD	608	0.02
p,p'-DDD	608	0.011
o,p'-DDE	608	0.02
p,p'-DDE	608	0.004
Endosulfan I	608	0.014
Endosulfan II	608	0.004
Endosulfan sulfate	608	0.01
Heptachlor	608	0.003
Heptachlor epoxide	608	0.1
Industrial Chemicals:		
PCBs	CS[2]	0.0005*

[1] 40 CFR § 135, Appendix A, Method 608

[2] NYSDEC (1991). Congener-specific method #91-11. See discussion under Section 4.3.3

* Estimated for each congener. Report values for each congener and as a sum of the congeners where $\leq PCBs = 2.19x + 2.19$ (T. Wade, pers. comm. 1992)

Table 4-3C. OPTIONAL ORGANICS IN COASTAL AND ESTUARINE WATER
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD[1]	METHOD DETECTION LIMIT[2]
		(µg/l)
PAHs (Low Molecular Wt):		
Acenapthene	625	1.9
Acenaphthylene	625	3.5
Anthracene	625	1.9
Fluorene	625	1.9
Naphthalene	625	1.6
Phenanthrene	625	5.4
PAHs (High Molecular Wt):		
Benzo(a)anthracene	625	7.8
Benzo(a)pyrene	625	2.5
Benzo(g,h,i)perylene	625	4.1
Benzo(b)fluoranthene and/or Benzo(k)fluoranthene	625	4.8
Chrysene	625	2.5
Dibenzo(a,h)anthracene	625	3.7
Fluoranthene	625	2.2
Indeno(1,2,3-c,d)pyrene	625	3.7
Pyrene	625	1.9
2,3,7,8-TCDD, -TCDF	EPA 8290	0.000010

4.4 BIOLOGICAL TESTING

Organisms required by the New York District for use in Tier III evaluations are summarized in Table 4-5. Proposed dredged material used in biological tests consists of a composite of all sediment samples collected within the proposed area to be dredged. Projects may be broken up into reaches or units if 1) the area to be dredged is large, 2) the hydrography influencing the area to be dredged varies, 3) there are too many samples to composite, 4) the sediment exhibits heterogeneous characteristics in different sections of the proposed project area or 5) there is known contamination at specific sites. Cored samples are to be composited within a particular reach or subunit.

Proper disposal measures must be adhered to in order to ensure that test species not native to this region are not released into the local environment.

There should be no feeding of bivalve larvae, silversides, amphipods, Macoma or Nereis once the assays have begun. Mysids must be fed as a precaution against cannibalism. Amphipod bioassays must be conducted with a continuous photoperiod of normal laboratory lighting to maximize organism contact with sediment. Bioaccumulation assays must follow a 16L:8D photoperiod. Pre- and post-treatment organisms must be depurated in "clean" sand for 24 hours. Do not exceed the 24 hour depuration to minimize loss of contaminants from the tissues. All organisms must be acclimated prior to initiation of experiments. Test conditions and acceptability criteria for bioassays and bioaccumulation assays are provided in Appendix B of this guidance. ASTM (1991a-e) and EPA (1991b) methods may be substituted. Modifications to any of these procedures and test conditions outlined in Appendix B must be cleared by EPA, Edison, New Jersey before they are incorporated as standard operating procedures.

Table 4-4A. REQUIRED METALS IN TISSUE SAMPLES
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD[1]	METHOD DETECTION LIMIT[2]
Percent Solids	2540 G	N/A
		(µg/g wet weight)
Metals:		
Arsenic	EPA-200.9	0.1
Cadmium	EPA-200.9	0.01
Chromium	EPA-200.9	0.02
Copper	EPA-200.9	0.1
Lead	EPA-200.9	0.1
Mercury	EPA-245.6	0.02
Nickel	EPA-200.9	0.1
Silver	EPA-200.9	0.1
Zinc	EPA-200.9	0.1

[1] Except for mercury, tissue samples must be digested by Method 200.3 (EPA, 1991a) prior to analysis by Method 200.9 (EPA, 1991a). For mercury, the digestion is a part of the procedure. Method 2540 G is described in APHA (1989).

[2] Except for mercury, the detection limits were estimated from the MDLs of the analytes in water using a "dilution factor" of 40. For mercury, the factor was based upon the response of the 0.3 gram sample specified in the cited method.

Table 4-48. REQUIRED ORGANICS IN TISSUE SAMPLES
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD[1]	METHOD DETECTION LIMIT[2]
Percent Moisture	Freeze-Dry	N/A
Pesticides:		(ng/g wet weight)
Aldrin	EPA-8080	.4
Alpha Chlordane	EPA-8080	.4
Trans nonachlor	EPA-8080	.4
Dieldrin	EPA-8080	.4
p,p'-DDT	EPA-8080	.4
o,p'-DDT	EPA-8080	.4
p,p'-DDD	EPA-8080	.4
o,p'-DDD	EPA-8080	.4
p,p'-DDE	EPA-8080	.4
o,p'-DDE	EPA-8080	.4
Endosulfan I	EPA-8080	.4
Endosulfan II	EPA-8080	.4
Endosulfan sulfate	EPA-8080	.4
Heptachlor	EPA-8080	.4
Heptachlor epoxide	EPA-8080	.4
Industrial Chemicals:		
PCBs	CS[3]	.4
1,4-Dichlorobenzene	EPA-8270	.4*
PAHs (Low Molecular Wt):		
Acenapthene	EPA-8270	4
Acenaphthylene	EPA-8270	4
Anthracene	EPA-8270	4
Fluorene	EPA-8270	4
Naphthalene	EPA-8270	4
Phenanthrene	EPA-8270	4
PAHs (High Molecular Wt):		
Benzo(a)anthracene	EPA-8270	4
Benzo(a)pyrene	EPA-8270	4
Benzo(g,h,i)perylene	EPA-8270	4
Benzo(b)fluoranthene	EPA-8270	4
Benzo(k)fluoranthene	EPA-8270	4
Chrysene	EPA-8270	4
Dibenzo(a,h)anthracene	EPA-8270	4
Fluoranthene	EPA-8270	4
Indeno(1,2,3-c,d)pyrene	EPA-8270	4
Pyrene	EPA-8270	4

[1] Sample extraction and clean-up by methods described in NOAA (1989) followed by the analyses shown above. Methods 8080 and 8270 are described in EPA, (1986). Freeze-dry to constant weight.

[2] Detection limits are those published in EPA (1992b).

[3] NYSDEC (1991). Congener-specific method #91-11. See Section 4.3.3. MDL is per congener. Report values for each congener and as a sum of the congeners where $\leq$PCBs=2.19x + 2.19 (T. Wade, pers. comm 1992)

* Semi-volatile compound. Recovery may be incomplete. MDL suggested.

Table 4-4C. OPTIONAL ORGANICS IN TISSUE SAMPLES
List of Analytical Methods and Method Detection Limits
USACE New York District/EPA Region II

CONSTITUENT	TEST METHOD	METHOD DETECTION LIMIT[2]
Total lipids	Lee et al. 1989	0.1%
		(pg/g wet weight)
2,3,7,8-TCDD, -TCDF	EPA-8290	1

4.4.1 Water-Column Tests

Technical guidance on conducting water-column bioassays is provided in Green Book Section 11.1: Tier III Water Column Bioassays. Three series of tests are necessary; tests must be run using silverside fish (Menidia menidia, M. beryllina, or M. peninsulae), a crustacean (Mysidopsis bahia) and a bivalve larvae, (Mytilus edulis, Mercenaria mercenaria, Crassostrea virginica, or Mulinia lateralis). Feed mysids as prescribed by EPA (1991b) and ASTM (1991b,c). Bivalve larvae and silversides must not be fed (ASTM 1991a-c). Test duration is 96 h (48 h-72 h for bivalve larvae). The procedure for preparing the suspended particulate phase is given in Section 11.1.4 of the Green Book. The suspended particulate phase must be prepared using water collected from the proposed dredging site. The necessary dilutions may be made using water collected from clean seawater or aged artificial seawater. Each series should include 100%, 50%, and 10% suspended particulate treatments and a 0% suspended particulate treatment (=100% dilution-water treatment). Clean seawater in which the organisms were held prior to testing must be run as a control. If the diluent is the same water the organisms are held in prior to testing, then the control and 0% treatment are one and the same. There is no reference water in the water column toxicity test.

A minimum of five replicates per treatment and a minimum of 20 organisms per replicate are required for all test organisms except bivalve larvae. The number of surviving fish and mysids for each replicate must be recorded at 0, 4, 24, 48, 72, and 96 h.

A minimum of five replicates per treatment are required for the bivalve larvae bioassay. A suspension of fertilized eggs is used in the preparation of the test solutions. These test solutions should contain 20-30 embryos/ml. Follow ASTM (1991a) protocol for the bivalve water-column toxicity test. Use a light box or dissecting microscope to record the number of live animals. The Green Book Section 11.1.4 requirement that "it may be necessary to centrifuge the supernatant until the suspension is clear enough at the first observation time for the organisms to be visible in the testing chamber" is waived. Bivalve larvae mortality/abnormality must be recorded at time 0 hr and at the end of the exposure period (42-72 hr). The test is terminated when larvae reach the prodissoconch I (D shape) stage of development.

For all test organisms, any sublethal effects such as physical or behavioral anomalies must also be reported. Daily water quality records must be kept for salinity, temperature, DO, and pH.

4.4.2 Benthic Toxicity Tests

Section 11.2 of the Green Book: Whole-Sediment Bioassays provides technical guidance on performing benthic toxicity tests. Three parallel series of test exposures are necessary: one series using the amphipod Ampelisca abdita, one using either Rhepoxynius abronius or Eohaustorius estuarius, and a third using the mysids Mysidopsis bahia. Amphipods must not be fed once testing commences. Feed mysids as prescribed by EPA (1991b) and ASTM (1991b,c). Test exposure periods are 10 days

and the minimum requisite size of test chamber is 1 L for the amphipod tests and 1 L for mysid tests. Sediment should cover the entire bottom of the test chambers to a depth sufficient to meet the needs of the test organisms. For these tests, the sediment-to-water ratio should be 200cc (~175 ml): ~725 ml per 1L beaker. Flow-through exposure chambers rather than static water is requisite. There should be a minimum of 90% replacement of water volume every 4 hours, thereby exchanging the water 6 times a day. The flow is to be directed downward at least 2 inches below the air-water interface to achieve good mixing and to minimize disturbance to the sediment surface. Use a minimum amount of water when wet sieving whole-sediments (see Green Book Section 11.2.1.5). If sieving is part of the preparatory process, then control, reference and dredged sediments must be sieved.

Each series must include a minimum of 5 replicates of test sediment, 5 replicates of reference sediment, and 5 replicates of control sediment. A minimum of 20 organisms per replicate are required. The number of live organisms present at the end of the 10 days is to be reported for each control, reference and test replicate. Daily records must be kept of salinity, temperature, DO, pH, flow rate, obvious mortalities, and any sublethal effects. Formation of tubes or burrows, amphipod emergence from sediment, and any physical or behavioral abnormalities must also be recorded. Amphipod reburial after the experiment is terminated is another endpoint that may be consider.

Table 4-5. Required Test Species for New York District Dredged Material Evaluations.

This table lists the required test organisms for water-column impact, benthic impact, and bioaccumulation evaluations. Other test species may be suitable for testing and the New York District may approve of substitute organisms and/or require that additional organisms be tested, depending on circumstances. However, in most cases the use of the organisms listed below will be sufficient to make LPC determinations.

Water-Column Toxicity Evaluations
Crustacean
Mysids, *Mysidopsis bahia* – 1-5 days old; age difference within batch to be 24 h. or less
Fish
Silverside, *Menidia menidia*, *M. beryllina*, or *M. peninsulae* - 9-14 days old; age difference within batch to be 24 h. or less
Zooplankton (one of the following)
-Bivalve larvae (*Mytilus edulis*, *Mercenaria mercenaria*, *Crassostrea virginica*, or *Mulinia lateralis*) - Embryos within four hours of fertilization
Benthic Toxicity Evaluations
Infaunal amphipod (two of the following) - subadults (~3-5 mm), retained on a 1mm sieve
-*Ampelisca abdita* and -*Rhepoxynius abronius*, or *Eohaustorius estuarius*
Crustacean
Mysids, *Mysidopsis bahia* – 1-5 days old; age difference within batch to be 24 h. or less
Bioaccumulation Evaluations
Burrowing Polychaete
Sand worm, *Nereis virens*
Bivalve
Bent-nose clam, *Macoma* sp. (*M. secta* or *M. nasuta*)- relatively uniform in size

4.4.3 Bioaccumulation Tests

Technical guidance on conducting bioaccumulation tests is given in Green Book Section 12.1: Tier III: Determination of Bioavailability and SOPs are provided in Appendix B of this manual. The organisms to be used are the sand worm Nereis virens and the clam Macoma sp. If dioxin burden levels are required (see pg. 4-5, par. 4), then a separate 28 day Nereis setup is required to provide adequate tissue for analyses. All tests must be run with each species inhabiting separate test chambers. Aquaria of 37 L or larger are recommended. Sediment should cover the entire bottom of the test chambers to a depth sufficient to meet the needs of the test organisms. For these tests, a minimum of 5 cm are required; however, more may be needed to provide adequate pressure on the shells of Macoma and to provide adequate nutritional resources to Nereis and Macoma for 28 days. Organisms must not be fed during the 28 days of testing. Five replicates are required for each test sediment, 5 for the reference sediment, and 3 for the control sediment in each test series. At least 20 of each species are required in each test chamber, although more may be necessary to conduct the prescribed tissue analyses at the end of the test exposure. **The number of organisms required at the beginning of the bioaccumulation experiment can be increased to provide 25% more tissue than is required for chemical analysis. In determining the appropriate quantity, the loading factor per tank should be considered** (ASTM 1991e). A 28 day bioaccumulation test is required for organic contaminants as well as for metals. Daily records must be kept of salinity, temperature, DO, pH, flow rate, obvious mortalities and any sublethal effects. Failure of organisms to burrow into the sediment or any other physical or behavioral abnormalities must also be recorded. All organisms (whether pre or post-test) must be depurated for 24 hours in "clean sand" prior to freezing. Required tissues extraction procedures are given in NOAA (1989). Tissues of organisms randomly selected prior to initiation of bioaccumulation testing (pre-test analyses) must be analyzed for all contaminants analyzed for in the exposed organisms. Three aliquots per species are to be analyzed and reported. Refer to Section 4.3.4 of this manual for criteria which must be met regarding pre-test tissue contaminant levels.

4.5 STATISTICAL ANALYSIS

The following information supplements the National guidance in Green Book Section 13.0: Statistical Analysis.

The New York District will conduct statistical analyses of all of data utilized for Tiers I, II, and III water-column and benthic evaluations. As part of this analysis, the District will closely consider the appropriateness of statistical analyses that are conducted on data used to support Tier I decisions.

All applicants are required to submit to the New York District tables of validated data points that the District will use to conduct its analyses. This data must be supplied both as a hard copy and on a 3 1/2" or 5 1/4" disk (preferably high density). Format will be described by the NYD. The applicants may submit their own data summaries and analyses; however, they must also submit the original data and copies of sampling logs so that the District can conduct independent analyses. All submitted data must be clearly presented and traceable to the original samples and subsamples. No permit will be issued based solely on an applicant's data analysis.

4.6 NUMERICAL MODELS FOR INITIAL-MIXING EVALUATIONS

The following information supplements the National guidance in Green Book Appendix B: Numerical Models for Initial-Mixing Evaluations.

Numerical models are new components of the Tiers II and III water-column evaluations. The three models are contained in the Automated Dredging and Disposal Alternatives Management System (ADDAMS) (Schroeder and Palermo, 1990) software that was distributed with the Green Book.

The model is available for unrestricted distribution from the USACE, and applicants can request copies of the model from the USACE Waterways Experiment Station.[1] Some applicants may find it beneficial to conduct the modelling evaluations themselves in advance of submitting their water-column data to the New York District.

The appropriate model is run only for the contaminant of concern that requires the greatest dilution. If the contaminant requiring the greatest dilution is shown to meet the LPC, all of the other contaminants that require less dilution will also meet the LPC.

The three initial-mixing models, identified below, are run on IBM®-compatible personal computers (PC).

- **DIFID (Disposal from an Instantaneous Dump)**
  DIFID computes the movement of dredged material from an instantaneous dump that falls as a hemispherical cloud. To properly apply this model, the total time required for the dredged material to leave the disposal vessel should not be greater than the time required for the material to reach the bottom. The New York District will use this model for split-hull barge disposal.
- **DIFCD (Disposal from a Continuous Discharge)**
  DIFCD computes movement of dredged material that is disposed continuously at a constant discharge rate. Thus, it can be applied to pipeline disposal operations in which the discharge jet is below the water surface or perhaps to the discharge of material from a single bin of a hopper dredge. The New York District will use this model whenever a pumped-disposal technique is planned.
- **DIFHD (Disposal from a Hopper Dredge)**
  DIFHD simulates the movement of dredged material disposed from stationary hopper dredges and pocket barges, such as where the normal mode of disposal is to open first one pair of doors, then another, etc., until the complete dump has been made, which normally takes only a few minutes. The New York District will used this model for stationary hopper-dredge and pocket-barge disposals.

All of these models account for the physical processes that determine the short-term fate of dredged material in the water column as it is disposed at open-water sites. The models assume that the dredged material behaves as dense liquid, and simulate the movement of the disposed material as it falls through the water column and spreads over the bottom. They do not account for resuspension or other long-term postdisposal phenomena on the water-column or benthic environment.

Input data for the models are grouped into the following general areas:

- Description of the disposal operation
- Description of the disposal site
- Description of the dredged materials
- Model coefficients
- Controls for input, execution, and output

Green Book Appendix B: Numerical Models for Initial-Mixing Evaluations, Table B-1 lists each model's necessary input parameters and their corresponding units. Applicants must provide the following parameters: volume in barge, vessel course and speed, barge length and width, and post-disposal draft of barge. Additional descriptions and guidance for selection of values for many of the model parameters is provided in the Appendix B text and directly on-line in ADDAMS.

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[1] Contact: Dr. Paul R. Schroeder or Dr. Michael R. Palermo, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

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40 CFR 136. Code of Federal Regulation, Volume 40, Part 136, Appendix A, Method 608 and 625.

APPENDIX A: STANDARD OPERATING PROCEDURE

DETERMINATION OF TOTAL ORGANIC CARBON

Mention of trade names, commercial products, or suppliers does not constitute an endorsement or recommendation for use.

DETERMINATION OF TOTAL ORGANIC CARBON

1.0 APPLICATION AND SCOPE

This method, developed by the U.S. Environmental Protection Agency, Region II, Environmental Services Division laboratory in Edison, New Jersey, describes protocols for the determination of organic carbon in ocean sediments. Although the detection limit may vary with procedure or instrument, a minimum reporting value of 100 mg/kg will be required for the ocean dumping/dredging program. Several types of determinations, which are considered equivalent, are presented in this procedure. However, wet combustion methods are not considered to be equivalent to the pyrolytic methods described.

In this method, inorganic carbon from carbonates and bicarbonates is removed by acid treatment. The organic compounds are decomposed by pyrolysis in the presence of oxygen or air. The carbon dioxide that is formed is determined by direct nondispersive infrared detection, flame ionization gas chromatography after catalytic conversion of the carbon dioxide to methane; thermal conductivity gas chromatography, differential thermal conductivity detection by sequential removal of water and carbon dioxide; or thermal conductivity detection following removal of vater with magnesium perchlorate.

Water content is determined on a separate portion of sediment and data are reported in mg/kg on a dry weight basis.

2.0 DEFINITIONS

The following terms and acronyms are associated with this procedure:

LRB	Laboratory record book
TOC	Total organic carbon

3.0 PROCEDURE

3.1 Sample collection

Collect sediments in glass jars with lids lined with Teflon or aluminum foil. Cool samples and maintain at 4°C. Analyze samples within 14 days. If unrepresentative material is to be removed from the sample, it should be removed in the field under the supervision of the chief scientist and noted in the LRB on the field log sheet.

3.2 Apparatus and Reagents

- Drying oven maintained at 103° to 105°C.
- Analytical instrument. No specific TOC analyzer is recommended as superior. The following listing is for information on instrument options only, and is not intended to restrict the use of other unlisted instruments capable of analyzing TOC. The instrument to be used must meet the following specifications:
  - A combustion boat that is heated in a stream of oxygen or air in a resistance or induction-type furnace to completely convert organic substances to CO_2 and water.
  - A means to physically or by measurement technique to separate water and other interferants from CO_2.
  - A means to quantitatively determine CO_2 with adequate sensitivity (100 mg/kg), and precision (25% at the 95% confidence level as demonstrated by repetitive measurements of a well-mixed ocean sediment sample).
  - A strip chart or other permanent recording device to document the analysis.

(1.) Perkin Elmer Model 240C Elemental Analyzer or equivalent. In this instrument, the sample from Section 3.5 is pyrolyzed under pure oxygen, vater is removed by magnesium perchlorate and the carbon dioxide is removed by ascarite. The decrease in signal obtained by differential thermal conductivity detectors placed between the combustion gas stream before and after the ascarite tube is a measure of the organic carbon content.

(2.) Carlo Erba Model 1106 CHN Analyzer, or equivalent. In this apparatus, the sample is pyrolyzed in an induction-type furnace, and the resultant carbon dioxide is chromatographically separated and analyzed by a differential thermal conductivity

detector.

(3.) LECO Models WR12, WR112, or CR-12 carbon determinators, or Models 600 or 800 CHN analyzers. In the LECO WR-12, the sample is burned in high frequency induction furnace, and the carbon dioxide is selectively absorbed at room temperature in a molecular sieve. It is subsequently released by heating and is measured by a thermal conductivity detector. The WR-112 is an upgraded WR-12 employing microprocessor electronics and a printer to replace the electronic digital voltmeter.

In the LECO CR-12 carbon determinator, the sample is combusted in oxygen, moisture and dust are removed by appropriate traps, and the carbon dioxide is measured by a selective, solid state, infrared detector. The signal from the detector is then processed by a microprocessor and the carbon content is displayed on a digital readout and recorded on an integral printer.

In the LECO CHN-600 and CHN-800 elemental analyzers, the sample is burned under oxygen in a resistance furnace and the carbon dioxide is measured by a selective infrared detector.

(4.) Dohrman Model DC85 Digital High Temperature TOC Analyzer. In this instrument, the sample is burned in resistance furnace under oxygen, the interfering gases are removed by a sparger/scrubber system, and the carbon dioxide is measured by a non-dispersive infrared detector and shown on a digital display in concentration units.

- Reagents

(1.) Distilled water used in preparation of standards and for dilution of samples should be ultrapure to reduce the carbon concentration of the blank.

(2.) Potassium hydrogen phthalate, stock solution, 1000 mg carbon/L: Dissolve 0.2128 g of potassium hydrogen phthalate (Primary Standard Grade) in distilled water and dilute to 100.0 mL.

NOTE: Sodium oxalate and acetic acid are not recommended as stock solutions.

(3.) Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with distilled water.

(4.) Phosphoric acid solution, 1:1 by volume.

3.3 Interferences

3.3.1 Volatile organics in the sediments may be lost in the decarbonation step resulting in a low bias.

3.3.2 Bacterial decomposition and volatilization of the organic compounds are minimized by maintaining the sample at 4 °C, analyzing within the specified holding time, and analyzing the wet sample.

3.4 Sample Preparation

3.4.1 Allow frozen samples to warm to room temperature. Homogenize each sample mechanically, incorporating any overlying water.

3.4.2 Weigh the well-mixed sample (up to 500 mg) into the combustion boat or cup. Add 1:1 phosphoric acid dropwise until effervescence stops. Heat to 75°C.

NOTE: This procedure will convert inorganic carbonates and bicarbonates to carbon dioxide and eliminate it from the sample.

3.5 Sample Analysis

Analyze the residue according to the instrument manufacturer's instructions.

3.6 Percent Residue Determination

Determine percent residue on a separate sample aliquot as follows:

3.6.1 Heat a clean 25-mL beaker at 103° to 105°C for 1 h. Cool in a desiccator, weigh to

the nearest mg, and store in desiccator until use.

3.6.2 Add 1 g, weighed to the nearest mg, of an aliquot of the well-mixed sample .

3.6.3 Dry and heat in the 103° to 105°C oven for 1 h. Cool in a desiccator. Weigh to the nearest mg.

3.7 Calibration

Follow instrument manufacturer's instructions for calibration. Prepare a calibration curve by plotting mg carbon vs. instrument response using four standards and a blank, covering the analytical range of interest.

3.8 Data Recording

Record all data and sample information in LRBs or on project-specific data forms.

All transfers of data to forms and data reductions (e.g., concentration calculations, means, standard deviations) should be checked by the analyst and approved by a lab manager, project manager, or principal investigator. Hard copies of sample data and spreadsheet reports should be kept in the testing laboratory's central files.

3.9 QA/QC Procedures

3.9.1 **Precision and Accuracy** The precision and accuracy will differ with the various instruments and matrices, and must be determined by the laboratories reporting data. A representative sample of well-mixed, meshed, sediment should be analyzed in quadruplicate for 4 days to determine the analytical precision.

3.9.2 It is critical that each sample be thoroughly homogenized in the laboratory before a subsample is taken for analysis. Laboratory homogenization should be conducted even if samples were homogenized in the field.

3.9.3 Dried samples should be cooled in a desiccator and held there until they are weighed. If a desiccator is not used, the sediment will accumulate ambient moisture and the sample weight will be overestimated. A color-indicating desiccant is recommended so that spent desiccant can be detected easily. Also, the seal on the desiccator should be checked periodically and, if necessary, the ground glass rims should be greased or the "O" rings replaced.

4.0 DATA REDUCTION, DOCUMENTATION, AND REPORTING

4.1 Data Reduction

Data analysis and calculations will be performed whenever possible on computers using commercial spreadsheet software such as Lotus 1-2-3, Quattro Pro, or Microsoft Excel.

4.2 Documentation

Keep all laboratory records, test results, measurements, other and supporting documentation for each sediment test in a LRB or project file dedicated to that purpose.

4.3 Reporting

A report should be prepared including, but not limited to, the following information:

- Sources of samples
- Description of methods
- Summary of sample analysis results
- Summary of any deviations from the project test plan
- Copies raw data, observations, or data forms

Total organic carbon should be reported as a percentage of the dry weight of the unacidified sample to the nearest 0.1 unit. The laboratory should report the results of all samples (including QC replicates, method blanks, and standard reference measurements) and should note any problems that may have influenced sample quality. The laboratory should also provide a summary of the calibration procedure and results (e.g., range covered, regression equation, coefficient of determination).

5.0 QUALITY ASSURANCE/QUALITY CONTROL

5.1 Sample Custody

Custody of sediment sample should be documented using chain-of-custody forms. These forms should be initiated at the time of sample collection and signed by testing laboratory personnel at the time of sample receipt.

5.2 Quality Assurance Audits

The testing laboratory should have a quality assurance program in place that provides for the following quality assurance considerations:

- Tests are performed in accordance with the SOP
- Laboratory personnel are appropriately qualified and adequately trained and sufficient training records are maintained
- Data are verified to ensure traceability between raw and reported data

Routine audits should be conducted by the laboratory's quality assurance unit to ensure that all aspects of the testing accurately reflect the work that was planned and completed, and that all necessary information, as defined by regulations, SOPs, or program-specific plans, is included. Results of audits should become a part of the testing laboratory's project files.

6.0 SAFETY

All analysts following this procedure should be aware of routine laboratory safety concerns. Protective clothing and eyeglasses should be worn when appropriate.

7.0 REFERENCES

EPA. 1986. Determination of Total Organic Carbon in Sediment. U.S. Environmental Protection Agency Region II. Environmental Services Division, Monitoring Management Branch, Edison, NJ.

APPENDIX B: Test Conditions and Acceptability Criteria for Acute Toxicity and Bioaccumulation Assays

WATER COLUMN BIOASSAYS

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Mysids, *Mysidopsis bahia*

1. Test type:	Static non-renewal
2. Test duration:	96 hours
3. Temperature:	20°C ± 2°C
4. Light quality:	Ambient laboratory illumination
5. Photoperiod:	16 hour light, 8 hour dark
6. Test chamber size:	1 L
7. Test solution volume:	750 ml
8. Age of test organisms:	1-5 days; 24-hour range in age
9. No. of organisms per test chamber:	20
10. No. of replicates per concentration:	5
11. No. of organisms per concentration:	100
12. Feeding regime:	*Artemia* nauplii are made available while holding prior to the test; add 0.2ml *Artemia* nauplii concentrate hours prior to test solution renewal at 48 hours
13. Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min; if aeration is necessary, all chambers must receive the same treatment
14. Suspended particulate phase:	Use unfiltered near (sub)surface dredging site water. Dredged sediment and water are combined in a sediment-to-water ratio of 1:4 (v/v)
15. Dilution water:	Modified GP2, Forty Fathoms®, or equivalent, artificial seawater

	prepared with Milli-Q® or equivalent DI water, or clean natural seawater
16. Salinity:	30‰±2‰
17. pH:	7.8±0.5
18. DO:	DO concentrations in each chamber must not fall below 40% saturation
19. Test concentrations:	Minimum of four suspended particulate treatment levels (%): 0, 10, 50, 100 In addition, clean seawater in which the organisms were held prior to testing must be run as the control. If the dilution and holding waters are the same, then the control= [0%]
20. Endpoint:	Mortality (LC50) Record survivorship per replicate at 0, 4, 24, 48, 72 and 96 hours
21. Test acceptability criterion:	90% or greater survival in controls

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Silversides, Menidia beryllina, M. menidia, and M. peninsulae

1.	Test type:	Static non-renewal
2.	Test duration:	96 hours
3.	Temperature:	20°C ± 2°C
4.	Light quality:	Ambient laboratory illumination
5.	Photoperiod:	16 hour light, 8 hour dark
6.	Test chamber size:	250 ml minimum
7.	Test solution volume:	200 ml minimum
8.	Age of test organisms:	9-14 days; 24-hour range in age
9.	No. of organisms per test chamber:	20
10.	No. of replicates per concentration:	5
11.	No. of organisms per concentration:	100
12.	Feeding regime:	Artemia nauplii are made available while holding prior to the test; no feeding during test
13.	Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min; if aeration is necessary, all chambers must receive the same treatment
14.	Suspended particulate phase:	Use unfiltered near (sub)surface dredging site water. Dredged sediment and water are combined in a sediment-to-water ratio of 1:4 (v/v)
15.	Dilution water:	Modified GP2, Forty Fathoms®, or equivalent, artificial seawater prepared with Milli-Q® or equivalent DI water, or clean natural seawater:

16. Salinity:	30%±2%
17. pH:	7.8±0.5
18. DO:	DO concentrations in each chamber must not fall below 40% saturation
19. Test concentrations:	Minimum of four suspended particulate treatment levels (%): 0, 10, 50, 100 In addition, clean seawater in which the organisms were held prior to testing must be run as the control. If the dilution and holding waters are the same, then the control= [0%]
20. Endpoint:	Mortality (LC50) Record survivorship per replicate at 0, 4, 24, 48, 72 and 96 hours
21. Test acceptability criterion:	90% or greater survival in controls

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Bivalve Larvae, Mytilus edulis, M. mercenaria, Crassostrea virginica and Mulinia lateralis

1.	Test type:	Static non-renewal
2.	Test duration:	48-72 hours, Development into straight hinge prodissoconch I larvae (D-shape stage)
3.	Temperature:	
	Mytilus edulis	16°C ± 2°C
	M. mercenaria	25°C ± 2°C
	Crassostrea virginica	25°C ± 2°C
	Mulinia lateralis	22°C ± 2°C
4.	Light quality:	Ambient laboratory illumination
5.	Photoperiod:	16 hour light, 8 hour dark
6.	Test chamber size:	250 ml minimum
7.	Test solution volume:	200 ml minimum
8.	Age of test organisms:	Use embryos within 4 hours of fertilization
9.	Density of organisms in stock suspension:	20-30 embryos/ml (do not exceed 30 embryos/ml)
10.	No. of replicates per concentration:	5
11.	No. of organisms per test chamber:	N=S(Vs/Vt), where: N=embryo density in test chamber S=mean embryo density in stock suspension Vs=volume of stock added to test chamber Vt=total volume of test solution Embryos/ . Embryos/ml = ml stock/ test chamber. in stock chamber
12.	Feeding regime:	None during test as uneaten food might decrease DO and biological activity of some test materials, and the embryos/larvae can survive

	without feeding for 72+ hours
13. Test solution aeration:	None since bubbles can collect within larval mantle cavity. Aerate only if DO falls below acceptable levels
14. Suspended particulate phase:	Use unfiltered near (sub)surface dredging site water. Dredged sediment and water are combined in a sediment-to-water ratio of 1:4 (v/v)
15. Dilution water:	Modified GP2, Forty Fathoms^{R}, or equivalent, artificial seawater prepared with Milli-Q^{R} or equivalent DI water, or clean natural seawater:
16. Salinity:	30‰±3‰
17. pH:	7.8±0.5
18. DO:	DO concentrations in each test chamber must be between 60 and 100% saturation at all times
19. Test concentrations:	Minimum of four suspended particulate treatment levels (%): 0, 10, 50, 100 In addition, clean seawater in which the organisms were held prior to testing must be run as the control. If the dilution and holding waters are the same, then the control= [0%]
20. Endpoint:	Mortality (LC50) Mortality / abnormality (EC50) Record survivorship/abnormalities per replicate at 0 and 48 hrs (may be up to 72 hrs depending on when exposure terminated).
21. Test acceptability criterion:	The number of embryos that result in live larvae with completely developed shells at the end of the control test must be at least 70% of the initial number for oysters and mussels or 60% for clams and at least 90% of all introduced embryos should be alive at the end of test

WHOLE-SEDIMENT BIOASSAYS

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Mysids, *Mysidopsis bahia*

1. Test type:	Flow-through, minimum of six exchanges per day
2. Test duration:	10 days
3. Temperature:	20°C ± 2°C
4. Light quality:	Ambient laboratory illumination
5. Photoperiod:	16 hour light, 8 hour dark
6. Test chamber size:	1 L
7 . Sediment-Water Ratio:	To 200cc (~175 ml) homogenized whole-sediment add ~725 ml water
8. Age of test organisms:	1-5 days; 24-hour range in age
9. No. of organisms per test chamber:	20
10. Treatment levels:	Control, reference and test sediment
11. No. of replicates per treatment:	5
12. No. of organisms per treatment:	100
13. Feeding regime:	*Artemia* nauplii are made available while holding prior to the test; add *Artemia* nauplii concentrate at least once a day during bioassay
14. Test solution aeration:	Aerate if DO concentration falls below 4.0 mg/L
15. Dilution water:	Modified GP2, Forty Fathoms^{R}, or equivalent, artificial seawater prepared with Milli-Q^{R} or equivalent DI water, or clean seawater
16. Salinity:	30‰±2‰

17. pH:	7.8±0.5
18. DO:	DO concentrations in each chamber must not fall below 40% saturation
19. Loading factor:	Should not exceed 0.5g/(L/day) or 5g/L
20. Endpoint:	Mortality Record total number of live organisms at the end of the test
21. Test acceptability criterion:	90% or greater survival in controls

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Amphipods, Ampelisca abdita, Rhepoxynius abronius, and Eohaustorius estuarius

1.	Test type:	Flow-through
2.	Test duration:	10 days
3.	Temperature:	
	Ampelisca abdita	20°C ± 2°C
	Rhepoxynius abronius	15°C ± 2°C
	Eohaustorius estuarius	15°C ± 2°C
4.	Light quality:	Ambient laboratory illumination
5.	Photoperiod:	Constant light
6.	Test chamber size:	1 L
7 .	Sediment-Water Ratio:	To 200cc (~175 ml) homogenized whole-sediment add ~725 ml water
8.	Age of test organisms:	Subadults, uniform in size and age, retained on a 1mm sieve size
9.	No. of organisms per test chamber:	20
10.	Treatment levels:	Control, reference and test sediment
11.	No. of replicates per treatment:	5
12.	No. of organisms per treatment:	100
13.	Feeding regime:	Must not be fed during 10-day bioassay
14.	Test solution aeration:	Gently aerate all chambers to maintain ≥90% saturation
15.	Dilution water:	Modified GP2, Forty Fathoms^{R}, or equivalent, artificial seawater prepared with Milli-Q^{R} or equivalent DI water, or clean seawater
16.	Salinity:	
	Ampelisca abdita	28%±2%
	Rhepoxynius abronius	28%±2%

Eohaustorius estuarius	28%±2%
17. pH:	7.8±0.5
18. DO:	DO concentrations in each chamber should be maintained at or near saturation (≥90%)
19. Endpoint:	Mortality Record total number of live organisms at the end of the test Ability to rebury in sediment once the bioassay is terminated
20. Test acceptability criterion:	90% or greater mean survival in controls where no individual chamber exhibits greater than 20% mortality

BIOACCUMULATION ASSAYS

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Sand Worms, Nereis virens

1.	Test type:	Flow-through, minimum of six exchanges per day
2.	Test duration:	28 days
3.	Temperature:	20°C ± 2°C
4.	Light quality:	Ambient laboratory illumination
5.	Photoperiod:	16 hour light, 8 hour dark
6.	Test chamber size:	37L
7.	Sediment-Water Ratio:	Minimum of 5 cm of sediment/tank
8.	No. of organisms per test chamber:	20
9.	Treatment levels:	Control, reference and test sediment
10.	No. of replicates per treatment:	3 control, 5 reference, 5 test
12.	No. of organisms per treatment:	60 control, 100 reference, 100 test
13.	Feeding regime:	None
14.	Test aeration:	Aerate if DO concentration falls below 4.0 mg/L
15.	Dilution water:	Modified GP2, Forty Fathoms^{R}, or equivalent, artificial seawater prepared with Milli-Q^{R} or equivalent DI water, or clean seawater
16.	Salinity:	30%±2%
17.	pH:	7.8±0.5
18.	DO:	DO concentrations in each chamber must not fall below 60% saturation
19.	Loading factor:	Should not exceed 0.5g/(L/day) or 5g/L

20. Endpoint:	Mortality Record total number of live organisms at the end of the test
21. Test acceptability criterion:	If less than 90% survival in controls, then determine whether a) there are adequate replicates to obtain sufficient statistical power b) organisms stressed c) there is contamination of the system d) the control sediment is contaminated e) there are other quality control problems

Summary of Test Conditions and Test Acceptability Criteria for Acute Toxicity Tests with Blunt-Nose Clams, Macoma nasuta or Macoma secta

1.	Test type:	Flow-through, minimum of six exchanges per day
2.	Test duration:	28 days
3.	Temperature:	12°C - 14°C
4.	Light quality:	Ambient laboratory illumination
5.	Photoperiod:	16 hour light, 8 hour dark
6.	Test chamber size:	37L
7.	Sediment-Water Ratio:	Minimum of 5 cm of sediment/tank For sediment with high silt content, may need up to 11 cm of sediment/tank
8.	No. of organisms per test chamber:	20
9.	Treatment levels:	Control, reference and test sediment
10.	No. of replicates per treatment:	3 control, 5 reference, 5 test
12.	No. of organisms per treatment:	60 control, 100 reference, 100 test
13.	Feeding regime:	None
14.	Test aeration:	Aerate if DO concentration falls below 4.0 mg/L
15.	Dilution water:	Modified GP2, Forty Fathoms®, or equivalent, artificial seawater prepared with Milli-Q® or equivalent DI water, or clean seawater
16.	Salinity:	30‰±2‰
17.	pH:	7.8±0.5
18.	DO:	DO concentrations in each chamber must not fall below 60% saturation

19. Loading factor:	Should not exceed 0.5g/(L/day) or 5g/L
20. Endpoint:	Mortality Record total number of live organisms at the end of the test
21. Test acceptability criterion:	If less than 90% survival in controls, then determine whether a) there are adequate replicates to obtain sufficient statistical power b) organisms stressed c) there is contamination of the system d) the control sediment is contaminated e) there are other quality control problems

APPENDIX C: SUPPLEMENTAL TERMS AND CONDITIONS

SUPPLEMENTAL TERMS AND CONDITIONS

1. If water or sediment are collected by the New York District for a particular project, the applicant or their contractor must pick up the samples within one business day following notification by Corps of Engineers personnel. Samples must be picked up between the hours of 9:00 AM and 3:00 PM, Monday through Friday, at:

US Army Corps of Engineers Marine Base Caven Point Terminal Foot of Chapel Avenue Jersey City, New Jersey
ATTN: Water Quality Compliance Branch Laboratory 201-434-3484

2. If water or sediment are collected by an applicant or their contractor for a particular project, they must pick up the samples or have the samples delivered to them within one business day after sampling is complete.

3. Samples must be maintained at 2° to 4° C immediately after collection (on ice or refrigerate), but should not be frozen prior to bioassay testing.

4. The contracted laboratory must supply the appropriate test organisms, chemical standards, testing apparatus, reagents, standards, analytical instrumentation, sampling vessels, and control and reference sediments.

5. In all analyses the New York District has final approval of the species chosen. If the laboratory needs to use a test species other than those listed in Table 4-5 because of unavailability, then it is the applicant's or their contractor's responsibility to contact the New York District as soon as possible prior to initiation of testing of a need to substitute a test species. If testing is initiated without New York District approval of alternate test species, the New York District may require retesting using species of choice at no cost to the government.

6. The applicant or their contractor must comply with the requirements of the Quality Assurance Program outlined in the 1991 Green Book and the current version of New York District's Guidance Manual. If the applicant or their contractor does not comply, they will be required to repeat all tests conducted during the time of non- compliance at no cost to the government, or pay the cost of having the samples rerun by another laboratory.

7. The applicant or their contractor will furnish test reports, to:

Chief, Water Quality Compliance BranchUSACE, Operations Division
CENAN-OP-E
26 Federal Plaza, Rm. 1937
New York, New York 10278-0090

8. Testing of items is to commence according to the following schedule:
   a. **PHYSICAL SEDIMENT**- within 10 calendar days of sample collection
   b. **BULK SEDIMENT**- within 10 calendar days of sample collection
   c. **WATER-COLUMN BIOASSAYS**- within 30 calendar days of sample collection
   d. **WHOLE-SEDIMENT BIOASSAYS**- within 30 calendar days of sample collection
   e. **ELUTRIATE and SITE WATER**- within 10 calendar days of sample collection
   f. **BIOACCUMULATION ASSAY**- within 30 calendar days of sample collection
   g. **TISSUE**- within 10 calendar days of completion of bioaccumulation assays
   h. **SEDIMENT & WATER SAMPLING**-within 6 months of receipt of sampling and testing scheme
   i. **LIPID CONTENT**- within 10 calendar days of completion of bioaccumulation assays
   j. **ADDITIONAL PCB CONGENERS**- to be specified for specific projects

9. Sediment and water sampling must be completed in as short a time as possible, but no more than five calendar days from start date. All starting dates for testing are calculated from the first day of collection.

10. The usual number of sediment sampling stations 3 to 12 samples per reach. Occasionally, though, this number may be larger.

11. Results of all testing should be submitted to the NYD in a timely fashion. We suggest that all test results that do not include bioaccumulation analyses be submitted to the New York District within 60 days of sample collection. Results that include bioaccumulation assays should be submitted within 90 days after sample collection. Postponing release of this information to our office delays the review of the results and lengthens the determination period for permit approval.

12. Contact the Water Quality Compliance Branch of the NYD if you have any concerns or questions regarding test conditions and acceptability criteria prior to, during or after completion of required assays and analyses.

13. In order for the New York District to maintain a quality control program during the life of this contract, the following will be required:

(a) Laboratory supervisors of both bioassay and chemical testing labs must be available for questions and conferences with New York District personnel between the hours of 8:30 AM to 5:00 PM, Monday through Friday.

(b) The New York District reserves the right to visit laboratories unannounced between the hours of 8:30 AM to 5:00 PM, Monday through Friday.

(c) In order for government personnel to make periodic quality control inspections during the chemical testing (water, sediment and tissue analyses), at least some of the work must be performed between the hours of 8:30 AM and 5:00 PM, Monday through Friday.

(d) Original copies of data, records, and quality control information concerning sediment and water sampling and testing must be maintained for a period of at least three (3) years from test start date and must be available during laboratory inspections.

14. QA/QC procedures as described in the 1991 Green Book and the current version of New York District's Guidance Manual must be strictly adhered to.

15. When more than one test sediment samples are being tested at the same time, one control treatment and one reference treatment can be run. All control and reference treatments must be run simultaneously with their corresponding test samples.

16. Sediment and elutriate samples must be stored at $4^{o}\pm2^{o}$ C for up to one (1) year from sample collection. If during the course of that year, chemical analyses must be repeated in order to confirm the validity of the original data, the applicant or their contractor must perform these analyses at no cost to the government.

17. Frozen tissue samples left over from each replicate of each treatment of the bioaccumulation assays must be stored in the dark at -20^{o} C for up to one (1) year from bioassay completion. If during the course of that year, chemical analyses must be repeated in order to confirm the validity of the original data, the applicant or their contractor must perform these analyses at no cost to the government.

18. The applicant or their contractor must document field temperature during sample collection and laboratory temperature during storage and testing.

19. All chain of custody forms, sampling log sheets and raw data sheets must be provided in the test report. All subcontractors must be identified in the report.

20. The applicant or their contractor must notify the New York District at least one month prior to test start-up if a different chemical or biological subcontractor is to be used. The New York District reserves the right to inspect all subcontractors and, if a prospective subcontractor does not comply with the requirements of the Quality Assurance Program, require that another subcontractor be used. If a laboratory does not comply with any of these terms, then they must redo all affected testing, or hire another contractor with New York District's approval, at the contractor's cost.

21. The applicant or their contractor is responsible for assuring proper handling and transport of sediment, water and tissue samples. If results are deemed unacceptable due to improper handling or transport, it will be the applicant or their contractor's financial responsibility to repeat the affected items.

22. Contracted laboratories must ensure the health and safety of their workers, inform their staff of the potential hazards associated with handling and testing dredged sediments, and dispose of all wastes in a responsible manner. Laboratories must, at a minimum, abide by state and federal OSHA and DOT standards for the work environment and disposal procedures.