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FINAL

AQUATIC ASSESSMENT FOR STONE BAY

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	microgram per kilogram
µg/L	microgram per liter
AET	apparent effects threshold
Baker	Baker Environmental, Inc.
BSAF	biota to soil/water/sediment accumulation factor
cm	centimeter
CLP	contract laboratory program
DO	dissolved oxygen
DQO	data quality objective
ECOC	ecological contaminant of concern
EMD	Environmental Management Division
ER-L	effects range - low
ER-M	effects range - median
GPS	global positioning system
HQ	hazard quotient
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LCS	laboratory control sample
LD_{50}	mean lethal dose
LOAEL	lowest-observed-adverse -effect level
MCB	Marine Corps Base, Camp Lejeune, North Carolina
mg/kg	milligram per kilogram
mg/L	milligram per liter
mm	millimeter
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	no-observed-adverse-effect level
ppm	parts per million
ppt	parts per thousand
QA	quality assurance
SSV	sediment screening value
SU	standard unit
TAL	target analyte list
TOC	total organic carbon
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

The New River system is an important resource to Marine Corps Base (MCB), Camp Lejeune and the general public. The estuary is used for many purposes including recreational activities and commercial fishing. MCB, Camp Lejeune takes a pro-active stance to ensure that none of the activities related to base operations cause an adverse impact to the surrounding environment.

In the interest of maintaining a healthy ecosystem, the base has completed an aquatic assessment in a section of the river known as Stone Bay. The investigation was completed to address potential impact to the bay from ongoing operations at the Stone Bay Rifle Range. In particular, concerns were expressed as to the effect of spent ammunition on the aquatic environment. This study has evaluated the potential impact of copper and lead from spent ammunition at the rifle range on the aquatic environment.

Prior to initiating this detailed study, a previous investigation was completed by CH2M Hill during the summer of 1998. The CH2M Hill study entailed the collection of surface water and sediment samples which were analyzed for metals. The results of this study indicated that metal concentrations were below screening criteria established for the protection of aquatic species, suggesting that operations at the rifle range have not had an adverse impact upon ecological receptors in Stone Bay. Although the 1998 CH2M Hill study suggested that range operations had not negatively impacted the bay, it was felt that a more rigorous study be undertaken in Stone Bay to ensure that the range is not posing a risk to the aquatic environment.

Therefore, as a follow-up to the investigation completed by CH2M Hill, Baker Environmental completed the aquatic assessment presented herein. This assessment was performed using guidance established by the United States Environmental Protection Agency (USEPA) and included the collection of sediment and shellfish species. The shellfish for this study included: clams, mussels, and oysters. Sediment and shellfish were collected from locations within the safety fan portion of Stone Bay (referred to as the study area). The sediment and shellfish tissue were analyzed in the laboratory for copper and lead concentrations.

In addition to the sediment and shellfish samples collected within the study area, sediment and shellfish were collected from two areas within the bay outside the rifle range safety fan. These reference areas were selected to represent background conditions within the New River. The reference area information was used for comparative purposes to distinguish between baseline conditions within the New River system and the study area.

Sediment collected in the study area was evaluated in three ways: 1) detected copper and lead concentrations were compared with USEPA Region IV sediment screening values for the protection of benthic species, 2) detected copper and lead concentrations were compared to reference area sediment concentrations, and 3) detected copper and lead concentrations were evaluated in aquatic receptor models.

Shellfish tissue collected from the study area also was evaluated in three ways: 1) detected copper and lead concentrations were compared with concentrations detected in nationwide National Oceanic and Atmospheric Administration (NOAA) Status and Trend studies, 2) detected copper and lead concentrations were compared to reference area benthic tissue concentrations, and 3) detected copper and lead concentrations were evaluated in aquatic receptor models.

Aquatic receptor models were used in this study as another tool to assess the detected concentrations of copper and lead in the sediment and shellfish samples. These aquatic receptor models are USEPA-accepted, mathematically-generated models that represent different species of animals potentially inhabiting the area that may ingest sediment and shellfish within the bay. The great blue heron and the mink were the receptor models selected for this assessment. The models use species-specific ingestion rates in conjunction with site-specific sediment and shellfish copper and lead concentrations to determine potential risks to the specified animal.

Two versions of the models were calculated for the original aquatic assessment: a worst case and a more realistic version; however, based on continued concern of potential risk to the heron, an additional best approximation model was prepared. The additional great blue heron model represents a site-specific version of the model. Details of the site-specific heron model are presented in the memorandum included as Attachment F.

Results from the Stone Bay aquatic assessment are summarized below. These conclusions are based upon previous data collected, site-specific data obtained in January 1999, USEPA-accepted methods, and relevant scientific literature.

- The contaminants of concern from the rifle range, copper and lead, were detected below conservative sediment screening values, indicating that the shellfish communities within the study area are not adversely impacted by rifle range activities.

- Both copper and lead were detected below reference concentrations among oyster tissue samples and only slightly greater than reference concentrations in the clam and mussel tissue samples.

- A qualitative comparison of copper and lead concentrations to literature values suggests that there is no difference in copper and lead concentrations between the study area and literature values.

- The results of the heron and mink models indicate that there are no risks present to these animals greater than the risks present in reference areas.

- No risk was indicated in the site-specific heron model.

Results from this aquatic assessment indicate no significant differences between study area and reference area ecological conditions. An evaluation of sediment samples, biota tissue samples, and results of the ecological receptor models indicate no harmful effects from copper and lead concentrations to shellfish inhabiting Stone Bay. Models of animals eating the shellfish demonstrated a slight risk to the great blue heron in the study area as well as in the reference areas. These results prompted preparation of a site-specific great blue heron model for the Study Area. The results of the site-specific model indicated no risks to the heron; therefore, no comparison to the reference areas was necessary.

1.0 INTRODUCTION

This document presents the analytical results and findings from an aquatic assessment of Stone Bay at Marine Corps Base (MCB) Camp Lejeune, North Carolina. The report has been prepared by Baker Environmental, Inc. (Baker) for the Atlantic Division, Naval Facilities Engineering Command (LANTDIV) and MCB, Camp Lejeune.

1.1 General Description

Located in Onslow County, North Carolina, MCB Camp Lejeune is the host to six Marine Corps commands and two Navy commands. The entire facility includes approximately 236 square miles and is located within the generally flat, Atlantic Coastal Plain. As shown in Figure 1-1, MCB, Camp Lejeune is bisected by the New River which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. Stone Bay is part of the large estuary formed by the New River.

1.2 Purpose

This aquatic assessment of Stone Bay has been performed to address concerns regarding the possible impact of ongoing operations at the Stone Bay Rifle Range. Specifically, that copper and lead present in spent ammunition from the rifle range, may be impacting the aquatic environment of Stone Bay. Two factors have brought about the concerns: (1) the rifle range fan, which delineates the area of projectile impact, extends into a portion of Stone Bay, and (2) the rifle range does not employ target backstops or projectile recycling; therefore, a portion of the total number of projectiles enter the bay during range operations.

The purpose of this investigation is to determine the potential impact of copper and lead in spent ammunition, on the aquatic environment. Analytical results from the sampling effort have been used to conduct a semi-quantitative ecological risk assessment on the aquatic habitat of Stone Bay. The portion of Stone Bay located within the rifle range fan, which is referred to as the "study area" throughout this report, was of primary concern during the project planning phase and during preparation of this report.

This aquatic assessment focuses upon the potential of copper and lead, to impact benthic organisms (i.e., organisms living in or on the bottom of a water body) within the study area. The target benthic organisms for this study are oysters, clams, and mussels. The target organisms were selected because of the following characteristics:

- The organisms are sedentary; therefore, they are constantly exposed to the surface water and sediment within the study area.

- The organisms represent an important intermediate trophic level in the aquatic food chain.

- Each of the target organisms are known to inhabit Stone Bay. Several planting sites managed by the state of North Carolina are located adjacent to the study area. The areas are used by commercial fisherman to harvest oysters and clams.

- Oyster, clams, and mussels are known to be sensitive to contamination.

Note: Further details of the selected species are presented in Section 2.0.

The aquatic assessment contained in this report consists of sediment and biota tissue analyses of target organisms obtained from five sampling locations within the study area and from two reference sampling locations. The reference locations are not expected to be impacted by rifle range activities. Copper and lead concentrations detected in the sediment have been compared to sediment screening values developed for the protection of benthic species. The concentration of copper and lead in sediment samples collected from the study area have also been compared with concentrations in sediment obtained from the reference stations. The biota tissue samples collected from the study area have been compared to the biota tissue samples collected from the reference stations. In addition, copper and lead tissue samples have been compared to literature residue values for concentrations that are typical nationwide.

2.0 SPECIES PROFILES

The following sections present a brief description and profile of each target organism used in the aquatic assessment of Stone Bay.

2.1 Hard Clam (*Mercenaria mercenaria*)

The hard clam, or Quohog is found from the Gulf of St. Lawrence in Canada throughout the Gulf of Mexico to Texas. Hard clams are abundant from Virginia to Massachusetts and support isolated breeding communities above Cape Cod. They occur throughout the South Atlantic in estuaries from the intertidal zone to a water depth of 15 meters or more (NCDENR, 1997).

Hard clams support an important commercial fishery along the Atlantic coast. Among the species of clams harvested in the United States, hard clams yield the highest dollar value, and are exceeded only by surf clams and ocean quohogs, in kilograms of meats harvested. The harvest value of hard clams in North Carolina increased significantly from 1971 to 1995. The sustained increase may be attributed to a rise in both price and landings over that time frame. Annual dockside value reached an all time peak in 1987, with a nominal value of approximately $8.4 million. Expressed in constant dollars (i.e., removing the effects of inflation by using consumer price index values from 1982 - 1984), the value of hard clams rose 1,789% from 1971 to the peak in 1987, then declined 44% between 1987 and 1995. Most of the decline can be attributed to a decrease in the number of mechanical harvest fisheries and closure of many harvest areas due to red tide in 1988. With respect to gear used by clammers for harvesting, during the period 1979 - 1993, hand harvesting accounted for 69% of the total production. Prices received by fisherman vary by different sizes, or grades, of hard clams. In general, the average price for hard clams has increased from 1 cent per clam in 1971 to 13 cents per clam in 1995 (NCDENR, 1997).

Hard clams live in the substrate with the long shell axis 25°-45° from vertical. The average depth at which clams live is 2 centimeter (cm) in sand and 1 cm in mud; smaller clams burrow deeper than large clams. Horizontal movement of adult clams is limited and the distance traveled is generally correlated with clam size, smaller clams being more active (Eversole, 1987).

Suspension feeding bivalves, such as the hard clam, obtain food by filtering suspended particulate matter and absorbing dissolved organics from the water. Water enters through the ventral inhalant siphon, passes through the gills to an exhalent cavity and out the forsal exhalent siphon. Food particles suspended on the inhalant surface of the gills are sorted and passed to the gill edges and moved to the anterior of the labial palps (Eversole, 1987).

Crabs appear to be the major predators of the hard clam in the South Atlantic region. The blue crab is probably the most destructive predator among crabs; mud crabs and stone crabs prey less on hard clams (Eversole, 1987).

Temperature has been considered the most important environmental requirement in determining the time of spawning, because a certain degree of gonad ripeness or maturation must be attained before hard clams can respond to specific spawning stimuli. The hard clam has been found growing in waters of 4 parts per thousand (ppt) to over 35 ppt salinity, but growth is optimal at 24 - 28 ppt. Native clam beds are known to occur at salinities of 10 - 28 ppt in North Carolina. Dissolved oxygen concentrations of 6.8 - 7.4 milligrams per liter (mg/L) are recommended for successful culture of the hard clam and are critical to the larval life stages. Adult hard clams encounter a wide range of dissolved oxygen (DO) concentrations and have evolved several metabolic mechanisms to handle such conditions. The hard clam usually lives in well-buffered areas; however, pH may decrease below 7.0 Standard Units (S.U.) in tide pools and estuaries with poor circulation, heavy siltation, pollution, and hydrogen sulfide production. Substrate type and the degree of sorting appears to be an important factor influencing the setting of hard clam larvae. It has been observed in the laboratory that hard clams prefer to set in sand rather than in mud. Adult hard clams occur most frequently in sandy bottoms with shells (Eversole, 1987).

2.2 Little Black Mussel (*Musculus niger*)

Mussels have a wide range of habitat and are found from the Arctic Ocean to North Carolina. They are most diverse in eastern North America. They spend their entire life partially or wholly buried in mud, sand, or gravel in permanent bodies of water. Mussels prefer salinity ranging from 0 ppt to 35 ppt. The vast majority of species are found in streams, but a few are present in ponds or lakes. Although they can be found in almost any type of stream bottom, mussels are usually absent from, or rare in, areas of shifting sand or deep silt (FMM, 1999). The shells of mussels are thin and oval shaped. The beak of the mussel is located close to the front end. They have rather prominent radiating lines at both ends with a relatively smooth area at the center of each valve. Mussels typically are a deep brownish black color with a rusty brown peristracum and a pearly white interior. The mussel moves from place to place using its foot as a prehensile organ and spinning a new byssus (mass of filament used for attachment) when a satisfactory situation has been found (Morris, 1973). Mussels attach to plant stems, rhizomes, stones, or shells by means of their byssus (White C.P., 1997).

Mussels continuously pump water through their bodies filtering food from the incoming tide. The food consists of detritus, which is organic matter found on the stream or lake bottom, and plankton, composed of microscopic plants and animals suspended in the water. Water enters via the incurrent or branchial siphon and exits via the excurrent or anal siphon (FMM, 1999).

Mussels are long-lived, with many species living more than 10 years and some reported to live more than 100 years. In many species, the surface of the shell has distinct black lines or ridges, which are believed to represent winter rest periods. The rest periods, or growth rings, are often used to estimate the age of a mussel. Mussels are an important food source for many animals, including muskrats, minks, otters, fishes, and some birds (FMM, 1999).

Mussels are one of the most endangered groups of animals in North America. Surveys conducted over the past few decades have documented significant declines in mussel populations across North America. Among the factors thought to be responsible for the declines are over harvest; siltation of habitat from agriculture, poor land management, channelization, and impoundments; competition from exotic species such as the zebra mussel; and pollution by herbicides, pesticides, and other chemicals (FMM, 1999).

2.3 American Oyster (*Crassostrea virginica*)

The American oyster, also referred to as the eastern oyster or the common oyster, plays a valuable role in the estuaries of North Carolina because its colonization of bottom lands creates a productive habitat, and the animal itself is harvested as a food item. The commercial oyster fishery is one of the most valuable seafood industries in the nation. Oyster production in 1991 was valued at $98 million, which represents about 3% of the $3.3 billion dockside value of the U.S. commercial seafood industry. Oyster production in North Carolina during 1991 ($1.2 million) comprised 1.8% of the total state commercial edible seafood production of $66.8 million. The average price per pound of dockside oyster meat harvested in North Carolina during 1991 was $3.35; above the national average of $3.08. Nationally, oysters are among the top ten species in annual harvest value, as well as in price per pound (NCDENR, 1995).

The American oyster may be found in coastal areas from the Gulf of St. Lawrence in Canada throughout along the eastern seaboard. The American oyster may also be found in the Gulf of Mexico, the Bay of Campeche, Mexico and throughout the West Indies. Optimum salinity range for the species falls between 10 and 28 ppt, although oysters may be found in salinities as low as 5 ppt and as high as 32 ppt. Salinities of less than 10 to 12 ppt can prevent larval setting even though adult oysters may continue to exist. Low levels of DO may also cause mortality of set oysters. Adult oysters can survive for several days when DO concentrations are less than 1.0 mg/L, but survival times vary inversely with temperature. Although water temperature may affect larval development and is important in the annual growth and development of parasites, it only directly affects oyster stocks in extreme cases. Oysters can tolerate ambient water temperatures from 1° to 36° C (NCDENR, 1997).

Oysters are dioecious, (having male reproductive organs in one individual and female in another) but have the ability to change sexes once each year. Formation of eggs and sperm is stimulated by increasing water temperatures during spring. Fertilized eggs develop through trochophore and veliger larval stages over a period of two to three weeks. Larvae can migrate vertically in the water column and may be able to maintain their position in the estuary by avoiding certain temperature or salinity changes. Oyster larvae have been known to travel at least 30 miles. Dispersion of the larvae is largely dependent upon prevailing currents and flushing rates of estuaries. As the larval stage ends, oysters must locate a suitable attachment point or perish. Oyster growth is highest during the first six months after setting and gradually declines throughout the life of the oyster (NCDENR, 1997).

Gastropods, primarily oyster drills, are among the most destructive oyster predators. Another predator, blue crabs can readily consume up to 19 oysters per day. Of the fish that are known to feed on oysters, perhaps the most impressive is the black drum. Oysters up to 112 millimeters (mm) in length have been consumed by large drum (i.e., drum over 90+ cm in length). Other fish that consume oysters, include Atlantic croaker, spot, toad fish, and sheepshead. In addition the cownose ray has been found to prey on oysters as well (NCDENR, 1997).

Petroleum products, heavy metals, pesticides, chlorine, and detergents can negatively impact oyster populations. The increased use of these organic compounds and metals in and around suitable estuaries has been shown to adversely impact oysters (NCDENR, 1997).

The most critical habitat areas for oyster populations are the oyster beds or rocks which form by the accumulation of oyster shells over the course of many years. Significant concentrations of oysters can also be found on outcropping of fossil shell beds, hard clam and bay scallop shells also on exposed roots. Rock jetties, sea walls, and pilings also contribute to oyster habitat (NCDENR, 1995).

3.0 INVESTIGATION ACTIVITIES

This section presents analytical results and findings from investigations conducted at Stone Bay by CH2M Hill during 1998 and Baker 1999. Findings from this aquatic assessment are based upon the field investigation conducted by Baker in January 1999. The section that follows defines reference stations used for comparison in the study and identifies the individual tasks completed as part of the January 1999 field investigation at Stone Bay. In general, the study utilizes biota (i.e., benthic species) and sediment samples collected from within the rifle range fan area of Stone Bay. Biota samples were collected, identified, measured, weighed, and recorded during the field investigation. Field photographs are included in Attachment A as additional site information. Each sample station was field surveyed using Global Positioning System (GPS) technology. Sediment samples were collected from approximately the same depths and locations as the benthic samples. Sediment analytical results were used to correlate the concentrations of metals in the sediment to corresponding tissue analytical results.

The subsections that follow provide details regarding the sampling strategy, established criteria, and quality control procedures.

3.1 <u>Previous Investigation</u>

During the summer of 1998, surface water and sediment samples were collected in the Stone Bay area of the New River at MCB, Camp Lejeune (CH2M Hill, 1998). This investigation was conducted as part of a baseline evaluation of the New River in support of the construction of the new advanced wastewater treatment facilities at the base. Surface water and sediment samples from five locations in Stone Bay were collected and analyzed for metals. Surface water samples were analyzed for total and dissolved metals and sediment samples were analyzed for total metals, total organic carbon (TOC), percent solids, acid volatile sulfide, and grain size. The analytical results of copper and lead detected in the surface water are presented in Table 3-1 and sediment is presented in Table 3-2. A complete report of the analytical results are presented in the CH2M Hill letter report contained within in Attachment B. Water quality parameters, which are provided in Table 3-3, were also collected at the time of this study. The locations of the sampling points are depicted in Figure 3-1.

The results of the initial study were compared to sediment screening values developed for the protection of aquatic species. As shown on Table 3-2, in each case, concentrations observed in the sediment were below the established screening criteria, suggesting that the operations at the rifle range have not had a significant impact upon ecological receptors in Stone Bay. As a follow-up to the preliminary sediment and surface water investigation, this investigation includes a tissue study of benthic species to provide a more thorough evaluation of the potential impact of copper and lead from the rifle range on aquatic receptors and the habitat of Stone Bay.

3.2 Aquatic Assessment Field Investigation

The subsections that follow describe the field investigation activities conducted during January 1999 as part of the Aquatic Assessment of Stone Bay.

3.2.1 Reference Stations

As a part of the January 1999 investigation, two areas were used as reference stations. The reference stations are areas that are ecologically similar to the study area (i.e., habitat, species potentially present, salinity, substrate type), but that are most likely not impacted by rifle range activities. The reference stations provide information regarding naturally occurring metals and the existence of any regional metal contamination, independent of the rifle range. The locations of the reference samples are shown in Figure 3-1.

Samples obtained from the reference stations were used for a qualitative comparison of the analytical data obtained from the study area to determine significant differences in the sediment and biota tissue between the study area and the ecologically similar reference area.

3.2.2 Study Area Reconnaissance

Prior to commencement of sampling activities in January 1999, the study area was reviewed with range personnel and Environmental Management Division (EMD) personnel to discuss general operations and proposed sampling methods and locations. Additional topics of discussion included, time of work on-site, site access points, verification that the reference stations selected were appropriate for this study, and formulation of a general overview of the surrounding habitat. During the preliminary activities, the exact benthic species to be collected were determined. The target species were oysters, clams, and mussels. Several organisms were collected and examined to determine the size range available.

3.2.3 Water Quality Measurements

Prior to the collection of biota and sediment samples, depth of water and water quality parameters were measured. At each sampling station, surface water was measured for pH, specific conductance, temperature, salinity, turbidity and dissolved oxygen. All readings were measured in-situ by submerging a probe to the appropriate depth. The measurements were recorded on field data sheets during site operations and later tabulated. The results of these measurements are provided in Table 3-4.

3.3 Sediment Sampling

Sediment samples were collected from approximately the same depths and locations as biota samples. In general, the sediment samples were collected from a depth of approximately zero to six inches below the surface of the sediment.

A total of seven sediment samples was collected during the investigation. Five of the samples were collected within the study area of Stone Bay and two samples were collected from the reference locations. Figure 3-1 depicts the locations of each of the sediment samples. Figure 3-2 provides a detailed illustration of the study area and sampling locations. Each sediment sample was visually classified in the field to determine general soil type. Each of the sediment samples was analyzed for Target Analyte List (TAL) metals. Sediment characteristic analyses (i.e., grain size and TOC) were not performed on the samples obtained within the study area because similar information was obtained during the 1998 sampling event (CH2M Hill, 1998). Sediment obtained from the two reference stations were analyzed for grain size, Atterberg limits, and TOC to ensure that similar substrate conditions had been utilized. Substrate conditions at the reference stations are similar to what was observed in the study area, however the sediment sample collected from reference station RF-SD02 exhibited some clay. Results of the copper and lead sediment analyses are provided on Table 3-5. In general, the substrate material within the study area is comprised of varying amounts of silt and sand. The bottom material is comprised of mostly sand in the central portion of the study area and in the area near sediment sample SB-SD01. More fine material was observed near station SB-SD02 near the entrance of Stone Creek.

Each sediment sample was collected using a stainless steel sediment corer with a dedicated acetate sleeve. The samples were collected by manually pushing the sediment corer into the river bed and extracting an appropriate volume of sediment. The sample was transferred directly from the acetate sleeve of the sediment corer to a laboratory-prepared glass container.

3.4 Biota Sampling

The locations of the biota sampling stations were based upon the availability of benthic species in the area. Because the benthic species collected were shellfish (oysters, clams, and mussels), the sampling stations coincided with locations of shellfish beds to ensure an adequate sample volume was obtained.

A total of 14 biota composite samples was collected during this investigation, comprised of different biota species from seven sample locations. Five of the samples were collected from within the study area of Stone Bay and two samples were obtained at the reference locations. Each biota composite sample consisted of several individual organisms to meet the weight requirements of the laboratory analytical procedures. Figures 3-1 and 3-2 depict the locations of each biota sample. As shown in Figure 3-2, shellfish were not present in the central portion of the study area. The substrate material observed in this portion of the study area was entirely comprised of a thick layer of small sticks, branches, and roots. It is assumed that this layer of organic debris may inhibit the species from populating this area. It was noted by the commercial fisherman hired to assist during the biota collection, that the debris observed in the central portion of Stone Bay may be due to the fact that fishermen typically do not harvest shellfish in this area due to range operations. During normal shellfish harvesting, the methods used to collect species frequently remove debris from the bottom.

The collection of biota samples was conducted with the assistance of a commercial shell fisherman who is familiar with the New River. Biota samples were obtained using boat-mounted rakes, tongs, and grab samplers. The biota samples were collected in accordance with Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Volume I Fish and Sampling Analyses (USEPA, 1993).

Each of the biota samples was analyzed for TAL metals and percent lipids. Table 3-6 presents the results of clam tissue copper and lead analyses and Tables 3-7 and 3-8 provide a summary of copper and lead analytical results for mussel and oyster tissue samples, respectively. Results are presented for both the study area and the designated reference stations. A complete listing of the analytical results is provided in Attachment B. Form I's associated with the analytical results are contained in Attachment C.

3.5 Sample Station Surveying

Each sampling station was surveyed using a global positioning system. Spatial data were collected using code signals from satellites and then were differentially corrected with exact time interval data from a known base station. The resulting data yields point accuracies within the submeter (i.e., less than 40 to 75 centimeters) range. Upon differential correction, spatial data were exported into existing data files to produce the appropriate figures.

3.6 Sample Preparation

Sediment samples were taken directly from the sediment corer device and placed into laboratory prepared sample jars. Each jar was properly labeled and sealed and the samples were kept on wet ice prior to and during shipment to the analytical laboratory.

Biota samples were analyzed via a tissue composite method. Individual organisms were composited to acquire 20 to 30 grams of tissue sample for metal analyses. Each benthic organism collected was measured and weighed individually. The exterior shells of each benthic organism were scrubbed and rinsed with deionized water to remove the sediment and prevent possible cross contamination. The organisms intended for each composite sample were placed in a labeled, reclosable, freezer bags with the shells left intact. The samples were shipped on ice to the analytical laboratory. Upon receipt, the benthic samples were shucked and composite samples were formulated prior to chemical analysis of the tissue samples.

3.7 Quality Assurance

The purpose of Quality Assurance (QA) is to establish internal means for data generation and review to ensure that the work performed is completed at the highest professional standard. The objectives of the QA program include the following items:

- To generate data in accordance with procedures appropriate for the intended data use.
- To obtain data of sufficient quality to meet reasonable scientific scrutiny.
- To obtain data of acceptable precision, accuracy, completeness, representativeness, and comparability as required by the project.

The fundamental mechanisms that were employed to achieve the quality goals can be categorized as prevention, assessment, and correction where:

- Prevention of errors occurs through planning, following documented instructions and procedures, and careful selection of trained personnel.
- Assessment of all QA sampling reports furnished by the laboratory.
- Correction of noted conditions adverse to data quality.

3.7.1 Data Quality Objectives

Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data users to specify the quality of data needed from a particular data collection activity. The DQOs are expressed in terms of precision, accuracy, representativeness, completeness, comparability and uncertainty; which are defined as follows:

- Precision - A measure of mutual agreement among individual measurements of the same property, usually prescribed similar conditions. Precision is usually expressed in terms of the standard deviation, however, various measures of precision exist depending upon the prescribed conditions.

- Accuracy - The degree of agreement of a measurement or an average of measurements, X, with an accepted reference or true value, T, expressed as the difference between the two values, X-T. Accuracy is a measure of the bias in a system.

- Representativeness - Expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental concern.

- Completeness - A measure of the amount of the valid data obtained from the measurement system compared to the amount that was expected under normal conditions.

- Comparability - Expresses the confidence with which one data set can be compared with another.

- Uncertainty - The likelihood of all types of errors associated with a particular decision.

DQOs are intended to help develop sampling and analytical strategies designed to support the objectives of this assessment. DQOs define the level of certainty in the data that is acceptable for this assessment. The variables associated with sampling and analysis contribute to some level of uncertainty in any data generated. The objectives of this study included keeping the total uncertainty within an acceptable range. To achieve this objective, specific data quality requirements such as detections limits have to be specified. The expected detection limits of media were provided to the laboratory to ensure this requirement was met.

The data collected during this assessment was used to assess the following items:

- Identify the presence or absence of metals based upon the samples collected.

- Assess potential bioaccumulation of metals in aquatic receptors.

- Determine the potential impacts, if any, to the aquatic environment from metals that may be the result of ongoing range operations.

The DQOs for the aquatic assessment of Stone Bay have been met through several methods. Sediment samples collected within the study area and reference stations were analyzed using standard Contract Laboratory Procedures (CLP) typically used for environmental samples collected at MCB, Camp Lejeune. The quality control standards for trace metals undergoing CLP analyses are provided in Attachment D. Biota sample analyses employed the use of a Standard Reference Material (SRM), a method commonly used by marine scientists in the analysis of tissue samples. This is a proven method prepared by the National Institute of Standards and Technology (NIST) and is described in the Certificate of Analysis (SRM 1566a for Oyster Tissue) provided in Attachment D. The SRM is used for calibrating instrumentation and validating methods for the chemical analysis of marine bivalve tissue. The SRM gives acceptance ranges of elemental concentrations. In some cases, these acceptance ranges may not be met using the standard CLP type digestion and analysis. In such cases, the analysis includes a Laboratory Control Sample (LCS) to establish the remaining acceptance ranges and percent recoveries. The SRM and LCS will be used to ensure proper digestion procedures, analyses, and reporting of the tissue sample results.

4.0 AQUATIC ASSESSMENT

The section that follows provides a qualitative and quantitative evaluation of aquatic samples collected from within the study area. This assessment provides risk-based conclusions that address whether ecological risks to the aquatic environment are the result of copper and lead detected in the sample media. The methodology used in the assessment is provided first (Section 4.1), followed by the actual results of the applied methods (Sections 4.2 through 4.5).

4.1 Methods

The methodologies used in this evaluation mirror the procedures outlined in the Ecological Risk Assessment Guidance for Superfund (USEPA, 1997) and the Guidelines for Ecological Risk Assessment (USEPA, 1998). This aquatic assessment was conducted using a qualitative and quantitative analysis of sediment, clam tissue, mussel tissue, and oyster tissue collected from Stone Bay within the study area. The aquatic environment was evaluated using the following methods:

- Comparison of the study area sediment concentrations to Region IV sediment screening values (SSVs).
- Comparison of study area sediment concentrations to reference area sediment concentrations.
- Comparison of study area tissue concentrations to literature values for nationwide concentrations detected in shellfish tissue.
- Comparison of study area tissue concentrations to reference area tissue concentrations.
- Calculation of aquatic species receptor models for species potentially inhabiting Stone Bay that may ingest surface water, sediment and shellfish from the study area.

The following information provides a detailed description of the methods used to assess the aquatic environment.

4.1.1 Comparison to Sediment Screening Values

Sediment values were used to select ecological contaminants of concern (ECOC) in samples collected from the study area. Concentrations detected above an SSV were retained as ECOCs in this assessment. The SSVs used in this assessment were obtained from the Supplemental Guidance to RAGS: Region 4 Bulletins - Ecological Risk Assessment (USEPA, 1995). The sediment values presented in this document were derived from statistical interpretation of effects reported in literature for direct toxicity. The values were derived from marine environment studies; however, freshwater environment studies may also have been used. In addition to Region IV sediment values, effects-range low (ER-L) and Effects-range median (ER-M) values (Long et al., 1995) were used to assess the sediment collected from Stone Bay.

Concentrations detected below the ER-L/SSV represent a minimal effects range (i.e., effects that would rarely be observed). Concentrations above the ER-L/SSV, but below the ER-M represent a possible effects range (i.e., effects that would occasionally be observed). Concentrations detected above the ER-M present a probable-effects range (i.e., effects that would frequently be observed). Hazard quotients (HQs) were calculated for each detected inorganic. The HQs represent the magnitude by which a contaminant exceeds an SSV. The HQs for this assessment were calculated by dividing the maximum detected sediment concentration by the lowest SSV available for that metal. An HQ calculated above one represents a potential risk to the aquatic environment from concentrations of that contaminant.

4.1.2 Comparison to Benthic Literature Values

Literature values established for copper and lead concentrations in benthic tissue were used to qualitatively assess the concentrations detected in the benthic tissue obtained from the study area. The literature values represent body burden residues detected in benthic species that have been demonstrated to impact the health of the organism itself (Irwin, 1997a/1997b). Maximum and mean concentrations found in biota tissue collected as a part of the National Oceanic and Atmospheric Administration (NOAA) Status and Trends Studies (1990) were used for comparative purposes.

4.1.3 Comparison of Study Area Results to Reference Area Results

The ranges of detected concentrations in the sediment, clam, mussel, and oyster samples collected from the study area were directly compared to the range of detected concentrations in corresponding samples collected from the reference areas. Two reference locations were sampled during this investigation; however, not every shellfish specie was found at each proposed location (See Section 3.4).

A comparison of copper and lead concentrations found within the study area to reference concentrations was used to select the ECOCs for the benthic organisms. Reference concentrations were used as selection criteria because there are no specific screening values established for the protection of the target organisms.

4.1.4 Ecological Receptor Models

Ecological receptor models were used to evaluate potential risks to higher trophic levels in the aquatic food chain. Potential risks posed to prey species from ingestion of surface water, sediment, and benthic species from within the study area were evaluated in the models. Sediment and benthic analytical results obtained during the field investigation and surface water analytical results from the previous CH2M Hill study (see Section 3.1) were used as input values for the receptor models. Two species were selected for modeling: the great blue heron and the mink. A summary of life history information for the modeled species is presented in Attachment E.

Several different versions of the receptor models were calculated. The differences in the versions reflect the conservatism incorporated within the models. The most conservative models used the maximum detected concentrations compared with toxicity dose concentrations found to have no adverse effects. The comparative toxicity dose concentrations are referred to as no-observed adverse-effects levels (NOAELs). The least conservative models used arithmetic means of the detected concentrations compared to toxicity dose concentrations found to have the least observed effects to the species or a similar species. The comparative least effects toxicity doses are referred to as lowest-observed-adverse effects levels (LOAELs). The comparative NOAEL and LOAEL for copper and lead concentrations used in the receptor models calculated for this assessment are presented on Table 4-1. A summary of the studies from which these numbers are based on is presented in Attachment E.

The ecological receptor models and the assumptions made within the models are presented in the sections that follow.

4.1.4.1 Receptor Model Hazard Quotients

The HQ method was used to estimate potential risks to ecological receptors within the study area. This method compares exposure concentrations with ecological endpoints such as reproductive failure or reduced growth. The following equation was used to calculate HQs:

$$Hazard\ Quotient = \frac{Maximum\ Exposure\ /\ Mean\ Exposure\ Concentration}{NOAEL\ /\ LOAEL}$$

Where:

Mean Exposure Concentration	=	Arithmetic Mean Concentration Calculated
Maximum Exposure Concentration	=	Maximum Concentration Detected
NOAEL	=	No Observed Adverse Effect Level
LOAEL	=	Lowest Observed Adverse Effect Level

An HQ equal to or greater than one indicates that exposure to the particular metal has the potential to cause adverse effects to the species. An HQ less than one indicates that the metal is not expected to cause adverse effects to the species. The greater the HQ, the greater the magnitude of potential risk to the species; however, for this assessment, any HQ greater than one was evaluated as a potential risk.

4.1.4.2 Receptor Model Assumptions

This aquatic assessment evaluates exposure to contaminants through food, water, and incidental ingestion of sediment. The following assumptions were made during preparation of the aquatic models calculated for this study:

- Maximum concentrations and arithmetic mean concentrations were used to represent site-wide concentrations in the receptor model calculations.

- A biota to soil/water/sediment accumulation factor (BSAF) of 1 was assumed for the vegetation, invertebrates, fish, and small mammals.

- Copper and lead were assumed to be 100 percent bioavailable.

- Because toxicity values could not be found for the specific receptor species, values reported for closely related species were used.

- If chronic NOAEL values were not available for copper and lead, LOAEL values were used. A factor of 10 was used to convert reported LOAEL values to NOAEL values. If several toxicity values were reported for a receptor species, the most conservative value was used in the risk calculations regardless of the toxic mechanism. Toxicity values obtained from long-term feeding studies were preferable to those obtained from single dose oral studies.

- Some doses were originally reported as part per million contaminants in a diet. These were converted to daily intakes (in units of mg/kg-day) by using the following formula:

  Daily Intake (mg/kg-day) = ECOC Dose (mg/kg diet) x Ingestion Rate (kg/day) x 1/Body Weight (kg)

Dietary toxicity levels for species were converted to a daily dose based on body weight. For the ecological assessment, incidental sediment ingestion was also included in the calculation to determine the total daily intake for the receptor species. This daily dose was then used to evaluate the risk to other species if no specific toxicity data were available for a target receptor.

4.1.5 Uncertainties

As with any such ecological assessment, this investigation of Stone Bay is subject to uncertainties. Uncertainty exists in several steps of the process including: correlation of tissue concentrations to adverse effects to species, study of lead in shellfish, use of screening levels, and the use of ecological receptor models.

4.1.5.1 Correlation of Tissue Concentrations to Adverse Effects in Species

There is uncertainty associated with correlating tissue concentrations to adverse effects on benthic species. Tissue concentrations do not infer adverse effects; however, tissue data has been used for qualitative evaluation of copper and lead.

4.1.5.2 Study of Lead in Shellfish

Uncertainty is associated with the study of rifle range contaminants of concern, specifically lead. Lead, when taken into living organisms, reacts similar to calcium and will most likely mineralize in bones, or in this case, the shells of the organism. However, it is recognized that organisms from polluted areas can build up substantial concentrations of lead in muscle tissue.

4.1.5.3 Screening Levels

Potential adverse impacts to aquatic receptors from contaminants in the sediments were evaluated by comparing sediment concentrations to SSVs. These SSVs have uncertainty associated with them because the procedures for developing them are not as established as those used in developing water screening values. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) also has a significant impact on the bioavailability and toxicity of contaminants. The SSVs were developed using data obtained from freshwater, tidal freshwater, and marine environments. Therefore, their applicability in evaluating potential effects to aquatic organisms from contaminants in marine habitats introduces uncertainty due to differences in the toxicity of individual contaminants to freshwater and saltwater organisms and the bioavailability of contaminants in the two aquatic systems.

4.1.5.4 Ecological Receptor Models

There are some differences of opinion found in the literature as to the effectiveness of using ecological receptor models to predict concentrations of contaminants found in ecological species.

The food chain models currently used incorporate simplistic assumptions that may not represent conditions at the site, bioavailability of contaminants, or site-specific behavior of the receptors.

In some instances, NOAEL values were not found in the literature. If NOAEL values were not reported, then LOAEL values were used to calculate a NOAEL. A LOAEL was divided by a factor of ten to obtain NOAEL values. There is uncertainty in this calculation of NOAELs; however, the uncertainty most likely errs on the conservative side.

Doses in toxicological studies are typically reported in units of mg of contaminant/kg diet, or in units of mg contaminant/kg body weight/day. All doses reported as mg/kg in diet were converted to units of mg/kg-body weight/day. If body weights were reported for the test animals in a given study, these values were used for making this conversion. Otherwise, the body weight and ingestion rate for the species reported in other literature sources were used.

There is uncertainty associated with some of the toxicity values derived from a single species. Prediction of ecosystem effects from laboratory studies is difficult. Laboratory studies cannot take into account the effects of environmental factors which may add to the effects of contaminant stress. NOAELs were generally selected from studies using single contaminant exposure scenarios.

There is uncertainty in the total daily intake models used to evaluate a reduction of receptor populations or sub-populations. Many input parameters are based on default values (i.e., ingestion rates) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the level to which the indicator species will represent other species potentially exposed to copper and lead concentrations at the site.

4.2 Sediment Evaluation

As presented in Table 4-2, sediment ECOCs within the study area were identified by a comparison of detected concentrations to SSVs. If a concentration exceeded an SSV, the inorganic was retained as a sediment ECOC. Reference area sediment concentrations are also presented in Table 4-2 for comparative purposes.

Study area sediment concentrations of copper and lead were detected below SSVs, indicating no potential risks to aquatic receptors from sediment concentrations. Therefore, no ECOCs were identified in the sediment collected from the study area. Sediment concentrations of copper and lead detected in the CH2M Hill study (see Section 3.1) were similar to concentrations detected during this investigation.

4.3 Benthic Tissue Evaluation

Three species were evaluated for this aquatic assessment: the hard clam, little black mussel, and the American oyster. Life history information for these species is provided in the profiles presented in Section 2.0. As discussed in Section 3.4, two species per sampling station were proposed for analysis. However, due to conditions in the field, two of the same species were not available from every location within the study and reference areas. Two species were collected from every sampling station; however, the two species are not the same at every station. Benthic tissue from the study area was analyzed by comparison to reference area tissue concentrations.

Tissue concentrations detected among clam, mussel, and oyster samples were compared to reference concentrations. The following sections present the ECOCs identified in each of the species based upon the reference comparison.

4.3.1 Clam Tissue

Table 4-3 presents copper and lead detected in the clam tissue collected from the study area and the ECOCs selected. Copper and lead were detected slightly above reference area tissue concentrations and retained as clam ECOCs. It is noted that the clam tissue evaluation is based on one composite sample collected from the study area. A clam sample was only collected from one station in the study area, most likely due to the low salinity in this portion of Stone Bay (see Section 3.2.3).

4.3.2 Mussel Tissue

Table 4-4 presents copper and lead detected in the mussel tissue collected from the study area and the ECOCs selected. Copper and lead concentrations in mussel tissue were above reference station concentrations and retained as mussel ECOCs. The mussel comparison of study area tissue to reference area tissue is based on one composite sample collected in the reference areas.

4.3.3 Oyster Tissue

Table 4-5 presents the concentrations of copper and lead detected in oyster tissue collected from the study area compared to concentrations detected in the reference areas. The concentrations from the study area were below reference concentrations; therefore, no ECOCs were identified for the oyster species in this assessment.

4.4 Qualitative Benthic Evaluation of Copper and Lead Concentrations

Tables 4-6 and 4-7 present qualitative comparisons of the copper and lead concentrations (respectively) detected in the oyster and mussel tissue versus literature values. No literature values for the clam were available. The literature values are NOAA Status and Trends Studies (1990) (Irwin, 1997a and Irwin, 1997b). Study area oyster concentrations were below literature copper values. Study area mussel concentrations only slightly exceed literature copper values.

The study area oyster and mussel tissue lead concentrations only slightly exceed the maximum literature values. Reference oyster tissue concentrations also exceed the literature value for lead. This qualitative comparison does not show a significant difference between study area copper and lead concentrations and nationwide NOAA Status and Trends concentrations.

4.5 Ecological Receptor Models

Ecological receptor models for the heron and mink were calculated with site-specific concentrations from the study area. As discussed in Section 4.1.4, receptor models were calculated for ECOCs identified in sediment, oyster, clams, and mussels. Table 4-8 presents a summary of the ECOCs identified per sample media. Data input into the receptor models included surface water, sediment, and biota tissue. It is noted that although no ECOCs were identified in the sediment and oyster samples collected from the study area, copper and lead concentrations from these media were evaluated in the receptor models. Only the concentrations detected in one of the biota species could be used in the model. Therefore, to remain conservative, the highest ECOC concentration for the three different benthic species was used to represent biota. The input values and receptor models are presented in Attachment E. The following paragraphs present the results of both the conservative and less conservative versions of the receptor models.

The most conservative receptor models, maximum concentrations and NOAEL values are presented in the NOAEL columns in Table 4-9. Sediment and biota concentrations of copper and lead resulted in HQs greater than one in the two receptor species. Surface water concentrations were also incorporated into the models; however, due to the low ingestion rates, surface water does not provide a significant effect to receptor risk. The highest risks (HQs greater than 10) to the receptor species were identified in the heron due to copper concentrations (HQ = 44) and in the mink due to copper (HQ = 13) and lead concentrations (HQ = 20).

The least conservative receptor models, mean concentrations and LOAEL values, are presented in the LOAEL columns in Table 4-10. The only HQ over one was calculated for copper in the heron model (HQ = 3), indicating only a slight potential for risk to the heron.

Table 4-11 presents results from the least conservative receptor models calculated using reference area sediment and tissue concentrations. Risks due to copper concentrations were higher in the reference area receptor models than the risks identified in the study area. The reference receptor models were calculated to demonstrate that areas considered to be unimpacted by the rifle range produced greater risks to the receptor species from sediment and tissue concentrations of copper and lead, indicating that the rifle range is not posing any adverse risk to the existing aquatic habitat within the bay.

5.0 SUMMARY OF FINDINGS

The purpose of this assessment was to determine the potential impact of copper and lead from the spent ammunition, upon the aquatic environment of Stone Bay. A summary of the results from the aquatic assessment presented in Section 4.0 is provided below.

5.1 Sediment Evaluation

The contaminants of concern from the rifle range, copper and lead, were detected below conservative sediment screening values, indicating that the benthic macroinvertebrate communities within the study area are not adversely impacted by rifle range activities. The detections and comparison to screening values are presented in Table 4-2 and discussed in detail in Section 4.2. These data indicate no adverse impact due to exposure to copper and lead in the study area.

5.2 Biota Tissue Evaluation

As presented on Tables 4-3 through 4-5 and discussed in Section 4.3, study area tissue concentrations versus reference area tissue concentrations suggest the following inorganics were elevated for each of the identified species:

- Hard Clam: copper and lead
- Little Black Mussel: copper and lead
- American Oyster: none

The contaminants of concern from rifle range activities were identified as copper and lead. Both copper and lead were detected below reference concentrations among oyster tissue samples and not significantly greater than reference concentrations in the clam and mussel tissue samples. In addition, the qualitative comparison of copper and lead concentrations to literature values suggests that there is no significant difference in copper and lead concentrations between the study area and literature values. A majority of the highest inorganic concentrations among mussel and clam tissue samples were detected in the sample obtained from the edge of the rifle range fan, SB-MU04-99A.

5.3 Ecological Receptor Models

Mean inorganic concentrations and LOAEL values were used to calculate the following HQs used to assess potential risks to receptor species from consuming sediment and biota within the study area. An HQ greater than one indicates a potential risk to the receptor species.

- Great Blue Heron - copper and lead resulted in HQs above one. Reference concentrations demonstrated similar risks to the heron from concentrations of copper and lead. The results of the heron model indicate that there are no significant risks above the risks present in reference areas.

- Mink - No risk to the mink model was demonstrated in the least conservative receptor models. It is noted that a slight risk from copper was calculated in the reference mink model.

5.4 Conclusion

This assessment was conducted to determine whether rifle range contaminants of concern (copper and lead) are adversely impacting the aquatic habitat within the identified study area within Stone Bay. This assessment was conducted in accordance with the methodologies presented in Ecological Risk Assessment Guidance for Superfund (USEPA, 1997) and the Guidelines for Ecological Risk Assessment (USEPA, 1998). Data used to assess the study area included sediment, clam tissue, mussel tissue, and oyster tissue analyzed for copper and lead concentrations. The assessment used data collected from reference areas within Stone Bay identified to be unimpacted by rifle range activities. The reference area data were used for comparative purposes to determine whether potential contamination is site-related or the result of regional conditions within the bay.

Results from this assessment indicate no significant differences between study area and reference area ecological conditions. An evaluation of sediment samples, biota tissue samples, and results of the ecological receptor models indicate no deleterious effects from the potential contaminants of concern, copper and lead, to benthic organisms inhabiting Stone Bay.

6.0 REFERENCES

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Baker

Baker Environmental, Inc.

TABLES

TABLE 3-1

CH2M HILL ANALYTICAL DATA - SURFACE WATER METAL RESULTS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Units	Trip Blank		Sampling Stations										W.Q. Stds
				CLMSWSB101		CLMSWSB201		CLMSWSB301		CLMSWSB401		CLMSWSB501		
		Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Aquatic Life
Copper	µg/L	0.08	0.03	0.71	0.62	0.88	0.61	0.91	0.61	1.53	0.86	0.95	0.58	3 (AL)
Lead	µg/L	ND	ND	0.22	ND	0.415	ND	0.437	ND	0.926	ND	0.641	ND	25 (N)

Notes:

ND = Not Detected
AL = Values represent action levels as specified in 15A NCAC 2B.0220
N = See 15A NCAC 2B.0220 for narrative description of limits.
µg/L = microgram per liter
W.Q. Stds = Water Quality Standards

TABLE 3-2

CH2M HILL ANALYTICAL DATA - SEDIMENT METAL RESULTS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Units	Sampling Stations					NOAA Guidelines	
		CLMSDSB101	CLMSDSB201	CLMSDSB301	CLMSDSB401	CLMSDSB501	ER-L	ER-M
Copper	mg/kg	ND	18	5.7	15	ND	70	390
Lead	mg/kg	1.5	12	4	3.5	3.5	35	110

Notes:

mg/kg = milligram per kilogram
NOAA = National Oceanic and Atmospheric Administration
ER-L = Effects range - low
ER-M = Effects Range - median
ND = Not Detected

TABLE 3-3

CH2M HILL WATER QUALITY MEASUREMENTS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample ID	Depth (feet)	Position	Latitude (N)	Longitude (W)	Sample Depth	Temperature (C^0)	SPC (ms/cm)	Cond (ms/cm)	Salinity (ppm)	DO (%)	DO (mg/L)	Depth (feet)	pH (S.U.)	ORP (mV)
SB-101					Bottom:	31.57	16.98	19.02	9.86	123.1	8.58	3.78	8.42	183.9
	Total: 4'9"	Initial:	34° 36' 49.576"	77° 26' 18.704"	Middle:	31.64	16.79	18.87	9.77	127.1	8.86	2.30	8.48	186.5
	Secchi: 1'8"	Final:	34° 36' 49.705"	77° 26' 19.168"	Surface:	31.67	16.45	18.52	9.55	127.9	8.93	1.22	8.50	188.6
SB-201					Bottom:	31.47	17.24	19.41	10.08	121.0	8.45	3.46	8.44	232.1
	Total: 4'4"	Initial:	34° 36' 42.566"	77° 26' 44.151"	Middle:	31.54	17.05	19.20	9.96	122.5	8.54	2.10	8.48	233.5
	Secchi: 1'6"	Final:	34° 36' 42.539"	77° 26' 44.164"	Surface:	31.55	17.21	19.37	10.00	122.6	8.54	0.93	8.49	234.7
SB-301	Total: 3'6"	Initial:	34° 36' 39.766"	77° 26' 42.329"	Bottom:	31.35	17.07	19.14	9.96	120.4	8.40	2.53	8.43	208.6
	Secchi: 1'2"	Final:	34° 36' 39.050"	77° 26' 43.261"	Surface:	31.49	17.00	19.06	9.91	123.4	8.62	0.98	8.47	210.1
SB-401	Total: 2'	Initial:	34° 36' 33.365"	77° 26' 37.203"	Surface:	31.95	16.26	18.42	116.10	8.07	9.45	1.017	8.47	234.3
	Secchi: 1'	Final:	34° 36' 33.336"	77° 26' 36.763"										
SB-501	Total: 2'4"	Initial:	34° 36' 19.066"	77° 26' 20.169"	Surface:	32.35	16.08	18.32	9.31	110.6	7.62	0.99	8.41	234.7
	Secchi: 1'	Final:	34° 36' 19.240"	77° 26' 20.141"										

Notes:

ID = Sample Identification
N = North
W = West
Secchi = Sechhi disk measurement
SPC = Specific Conductance
ms/cm = milliohms per centimeter
Cond = Conductivity
ppm = parts per million
mg/L = milligram per liter
S.U. = Standard Units
DO = Dissolved Oxygen
ORP = Oxidation-Reduction Potential
mV = millivolts

TABLE 3-4

WATER QUALITY MEASUREMENTS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample ID	Depth (feet)	Temperature (C^o)	Cond (ms/cm)	Salinity (ppt)	DO (mg/L)	pH (S.U.)
SB-SD01	1.5	9.5	35.9	22.6	11.32	8.36
SB-SD02	5.0	12.2	32.4	19.9	9.85	8.30
SB-SD03	2.0	12.9	33.2	20.7	10.33	8.27
SB-SD04	6.0	11.70	34.8	22.0	10.80	8.38
SB-SD05	3.0	9.3	33.5	20.6	11.30	8.54
RF-SD01	4.0	9.8	39.3	24.5	10.43	8.45
RF-SD02	4.0	9.7	36.0	22.6	11.26	8.53

Notes:

ID = Sample Identification
ms/cm = milliohms per centimeter
Cond = Conductivity
ppt = parts per thousand
mg/L = milligram per liter
S.U. = Standard Units
DO = Dissolved Oxygen

TABLE 3-5

POSITIVE DETECTIONS IN SEDIMENT
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-SD01-99A	SB-SD02-99A	SB-SD03-99A	SB-SD04-99A	SB-SD05-99A
SAMPLE DATE	1/14/99	1/15/99	1/15/99	1/15/99	1/16/99
INORGANICS (mg/kg)					
Copper	2.67 U	16.6	2.4 J	8.7 J	2.35 U
Lead	6	5.7	2.5	20.7	3.4

TABLE 3-5 (continued)

POSITIVE DETECTIONS IN SEDIMENT
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	2.35 U	2.67 U	2.4 J	16.6	SB-SD02-99A	3/5	9.23	8.7
Lead	ND	ND	2.5	20.7	SB-SD04-99A	5/5	7.66	5.7

TABLE 3-5 (continued)

POSITIVE DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-SD01-99A	RF-SD02-99A
SAMPLE DATE	1/16/99	1/16/99
INORGANICS (mg/kg)		
Copper	2.4 U	4.6 J
Lead	4.6	10.5

TABLE 3-5 (continued)

POSITIVE DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	2.4 U	2.4 U	4.6 J	4.6 J	RF-SD02-99A	1/2	4.6	4.6
Lead	ND	ND	4.6	10.5	RF-SD02-99A	2/2	7.55	7.55

TABLE 3-5 (continued)

POSITIVE DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-SD01-99A	RF-SD02-99A
SAMPLE DATE	1/16/99	1/16/99
TOC (mg/kg)		
Total Organic Carbon	4930	12400

TABLE 3-5 (continued)

POSITIVE DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
TOC (mg/kg)								
Total Organic Carbon	ND	ND	4930	12400	RF-SD02-99A	2/2	8665	8665

TABLE 3-6

POSITIVE DETECTIONS IN CLAM TISSUE
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-CL04-99A
SAMPLE DATE	1/15/99
INORGANICS (mg/kg)	
Copper	12.6
Lead	1.8
WET WEIGHT BASIS	
Percent Lipids (%)	0.2
Moisture (%)	89

TABLE 3-6 (continued)

POSITIVE DETECTIONS IN CLAM TISSUE
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	ND	ND	12.6	12.6	SB-CL04-99A	1/1	12.6	12.6
Lead	ND	ND	1.8	1.8	SB-CL04-99A	1/1	1.8	1.8
WET WEIGHT BASIS								
Percent Lipids (%)	ND	ND	0.2	0.2	SB-CL04-99A	1/1	0.2	0.2
Moisture (%)	ND	ND	89	89	SB-CL04-99A	1/1	89	89

TABLE 3-6 (continued)

POSITIVE DETECTIONS IN CLAM TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-CL01-99A	RF-CL02-99A
SAMPLE DATE	1/16/99	1/16/99
INORGANICS (mg/kg)		
Copper	9.5	10.1
Lead	1	0.7
WET WEIGHT BASIS		
Percent Lipids (%)	0.2	0.1
Moisture (%)	85	88

TABLE 3-6 (continued)

POSITIVE DETECTIONS IN CLAM TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	ND	ND	9.5	10.1	RF-CL02-99A	2/2	9.8	9.8
Lead	ND	ND	0.7	1	RF-CL01-99A	2/2	0.85	0.85
WET WEIGHT BASIS								
Percent Lipids (%)	ND	ND	0.1	0.2	RF-CL01-99A	2/2	0.15	0.15
Moisture (%)	ND	ND	85	88	RF-CL02-99A	2/2	86.5	86.5

TABLE 3-7

POSITIVE DETECTIONS IN MUSSEL TISSUE
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-MU01/02-99A	SB-MU04-99A	SB-MU05-99A
SAMPLE DATE	1/16/99	1/16/99	1/15/99
INORGANICS (mg/kg)			
Copper	12.5	12.9	4.1
Lead	4.8	1.6	1.3
WET WEIGHT BASIS			
Percent Lipids (%)	1.6	1	2.1
Moisture (%)	85	93	81

TABLE 3-7 (continued)

POSITIVE DETECTIONS IN MUSSEL TISSUE
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	ND	ND	4.1	12.9	SB-MU04-99A	3/3	9.83	12.5
Lead	ND	ND	1.3	4.8	SB-MU01/02-99A	3/3	2.57	1.6
WET WEIGHT BASIS	ND	ND	1	2.1	SB-MU05-99A	3/3	1.56667	1.6
Percent Lipids (%)	ND	ND	81	93	SB-MU04-99A	3/3	86.33333	85
Moisture (%)								

TABLE 3-7 (continued)

POSITIVE DETECTIONS IN MUSSEL TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-MU02-99A
SAMPLE DATE	1/16/99
INORGANICS (mg/kg)	
Copper	4.1
Lead	1
WET WEIGHT BASIS	
Percent Lipids (%)	1.1
Moisture (%)	82

TABLE 3-7 (continued)

POSITIVE DETECTIONS IN MUSSEL TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	ND	ND	4.1	4.1	RF-MU02-99A	1/1	4.1	4.1
Lead	ND	ND	1	1	RF-MU02-99A	1/1	1	1
WET WEIGHT BASIS								
Percent Lipids (%)	ND	ND	1.1	1.1	RF-MU02-99A	1/1	1.1	1.1
Moisture (%)	ND	ND	82	82	RF-MU02-99A	1/1	82	82

TABLE 3-8

POSITIVE DETECTIONS IN OYSTER TISSUE
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-OY01-99A	SB-OY02-99A	SB-OY03-99A	SB-OY04-99A	SB-OY05-99A
SAMPLE DATE	01/14/99	01/15/99	01/15/99	01/15/99	01/15/99
INORGANICS (mg/kg)					
Copper	50.3	45.1	46	21.4	17.1
Lead	1.6	0.69	1	0.82	0.4
WET WEIGHT BASIS					
Percent Lipids (%)	0.2	0.3	0.6	0.6	0.4
Moisture (%)	85	84	88	89	80

TABLE 3-8 (continued)

POSITIVE DETECTIONS IN OYSTER TISSUE
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	ND	ND	17.1	50.3	SB-OY01-99A	5/5	35.98	45.1
Lead	ND	ND	0.4	1.6	SB-OY01-99A	5/5	0.9	0.82
WET WEIGHT BASIS								
Percent Lipids (%)	ND	ND	0.2	0.6	SB-OY03-99A,SB-OY04-99A	5/5	0.42	0.4
Moisture (%)	ND	ND	80	89	SB-OY04-99A	5/5	85.2	85

TABLE 3-8 (continued)

POSITIVE DETECTIONS IN OYSTER TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-OY01-99A	RF-OY02-99A
SAMPLE DATE	1/16/99	1/16/99
INORGANICS (mg/kg)		
Copper	8.2	88.2
Lead	2	1.2
WET WEIGHT BASIS		
Percent Lipids (%)	0.1	0.6
Moisture (%)		

TABLE 3-8 (continued)

POSITIVE DETECTIONS IN OYSTER TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Copper	ND	ND	8.2	88.2	RF-OY02-99A	2/2	48.2	48.2
Lead	ND	ND	1.2	2	RF-OY01-99A	2/2	1.6	1.6
WET WEIGHT BASIS								
Percent Lipids (%)	ND	ND	0.1	0.6	RF-OY02-99A	2/2	0.35	0.35
Moisture (%)	ND	ND	ND	ND		0/0	ND	ND

TABLE 4-1

LOWEST OBSERVED ADVERSE EFFECT LEVELS /
NO OBSERVED ADVERSE EFFECT LEVELS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Concern	Heron		Mink	
	LOAEL	NOAEL	LOAEL	NOAEL
Copper	2.35	0.235	10	1
Lead	3	0.3	1.5	0.15

Notes:

The studies from which these toxicity numbers are based can be found in Appendix F.

LOAELs and NOAELS are reported in mg/kg/day
LOAEL - Lowest Observed Adverse Effects Level
NOAEL - No Observed Adverse Effects Level

TABLE 4-2

FREQUENCY AND RANGE OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING LEVELS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		No. of Positive Detects Above SSV		Max. HQ	Reference Areas			Ecological Contaminant of Concern?	Comments
	SSV/ ER-L (1)	ER-M (2)	No. of Positive Detects/No. of Samples	Range of Positive Detections	ER-L	ER-M		Range	Mean	No. of Positive Detects Above Reference		
Copper	18.7	270	3/5	2.4J - 16.6	0	0	0.89	4.6J	4.6J	2	No	Below SSV
Lead	30.2	218	5/5	2.5 - 20.7	0	0	0.69	4.6 - 10.5	7.55	1	No	Below SSV

Notes:

J - value reported is estimated
mg/kg - milligram per kilogram
SSV - Sediment Screening Value
HQ - Hazard Quotient (maximum detected value divided by the lowest screening value)

(1) Region IV Sediment Screening Value (USEPA, 1995), unless otherwise noted
(2) Long et al. (1995) value, unless otherwise noted

TABLE 4-3

FREQUENCY AND RANGE OF CLAM TISSUE DATA COMPARED TO REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte (mg/kg)	Contaminant Frequency/Range		Reference Areas			Ecological Contaminant of Concern?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range	Mean	No. of Positive Detects Above Reference		
Copper	1/1	12.6	9.5 - 10.1	9.8	1	Yes	
Lead	1/1	1.8	0.7 - 1	0.85	1	Yes	

Notes:

Shaded area represents selected ecological contaminants of concern

Clams were only found at one station in the study area

mg/kg - milligram per kilogram

TABLE 4-4

FREQUENCY AND RANGE OF MUSSEL TISSUE DATA COMPARED TO REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte (mg/kg)	Contaminant Frequency/Range		Reference Areas		Ecological Contaminant of Concern?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Detection	No. of Positive Detects Above Reference		
Copper	3/3	4.1 - 12.9	4.1	2	Yes	
Lead	3/3	1.3 - 4.8	1	3	Yes	

Notes:

Shaded area represents selected ecological contaminants of concern

Reference is based on one sample: therefore, the mean value is not calculated.

mg/kg - milligram per kilogram

TABLE 4-5

FREQUENCY AND RANGE OF OYSTER TISSUE DATA COMPARED TO REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte (mg/kg)	Contaminant Frequency/Range		Reference Areas			Ecological Contaminant of Concern?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range	Mean	No. of Positive Detects Above Reference		
Copper	5/5	17.1 - 50.3	8.2 - 88.2	48.2	0	No	Below Reference
Lead	5/5	0.4 - 1.6	1.2 - 2	1.6	0	No	Below Reference

Notes:

mg/kg - milligram per kilogram

TABLE 4-6

QUALITATIVE COMPARISON OF COPPER CONCENTRATIONS DETECTED IN BENTHIC SAMPLES
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Range of Detections (mg/kg)	Mean Concentration (mg/kg)	Literature Values		No. of Detects Above Literature Values	Reference Areas	
			Maximum (mg/kg)	Mean (mg/kg)		Range (mg/kg)	Mean (mg/kg)
Oyster	17.1 - 50.3	35.98	360	150	0	8.2 - 88.2	48.2
Clam	12.6	12.6	NF	NF	NA	9.5 - 10.1	9.8
Mussel	4.1 - 12.9	9.83	11	8.9	2	4.1	4.1

Notes:

mg/kg - milligram per kilogram
NF - Not Found
NA - Not applicable

Source: Irwin, 1997a

TABLE 4-7

QUALITATIVE COMPARISON OF LEAD CONCENTRATIONS DETECTED IN BENTHIC SAMPLES
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Range of Detections (mg/kg)	Mean Concentration (mg/kg)	Literature Values		No. of Detects Above Literature Values	Reference Areas	
			Maximum (mg/kg)	Mean (mg/kg)		Range (mg/kg)	Mean (mg/kg)
Oyster	0.44 - 1.6	0.9	0.94	0.52	2	1.2 - 2	1.6
Clam	1.8	1.8	NF	NF	NA	0.7 - 1	0.85
Mussel	1.3 - 4.8	2.57	4.3	1.8	1	1	1

Notes:

mg/kg - milligram per kilogram
NF - Not Found
NA - Not applicable

Source: Irwin, 1997b

TABLE 4-8

SUMMARY OF ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment	Clam	Mussel	Oyster
Copper		X	X	
Lead		X	X	

TABLE 4-9

AQUATIC SPECIES - CONSERVATIVE MODELS
MAXIMUM CONCENTRATION HAZARD QUOTIENT VALUES
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminants of Concern	Heron		Mink	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Copper	44.0	4.0	13.0	1.0
Lead	4.0	0.4	20.0	2.0

Highlighted values represent Hazard Quotients (HQs) greater than 1.0

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

TABLE 4-10

AQUATIC SPECIES - LESS CONSERVATIVE MODELS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminants of Concern	Heron		Mink	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Copper	31.0	3.0	9.0	0.9
Lead	2.0	0.2	9.0	0.9

Highlighted values represent Hazard Quotients (HQs) greater than 1.0

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

TABLE 4-11

AQUATIC SPECIES - LESS CONSERVATIVE MODELS
MEAN CONCENTRATION HAZARD QUOTIENT VALUES
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminants of Concern	Heron		Mink	
	NOAEL HQ_n	LOAEL HQ_l	NOAEL HQ_n	LOAEL HQ_l
Copper	41.0	4.0	12.0	1.0
Lead	2.0	0.2	7.0	0.7

Highlighted values represent Hazard Quotients (HQs) greater than 1.0

HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

FIGURES

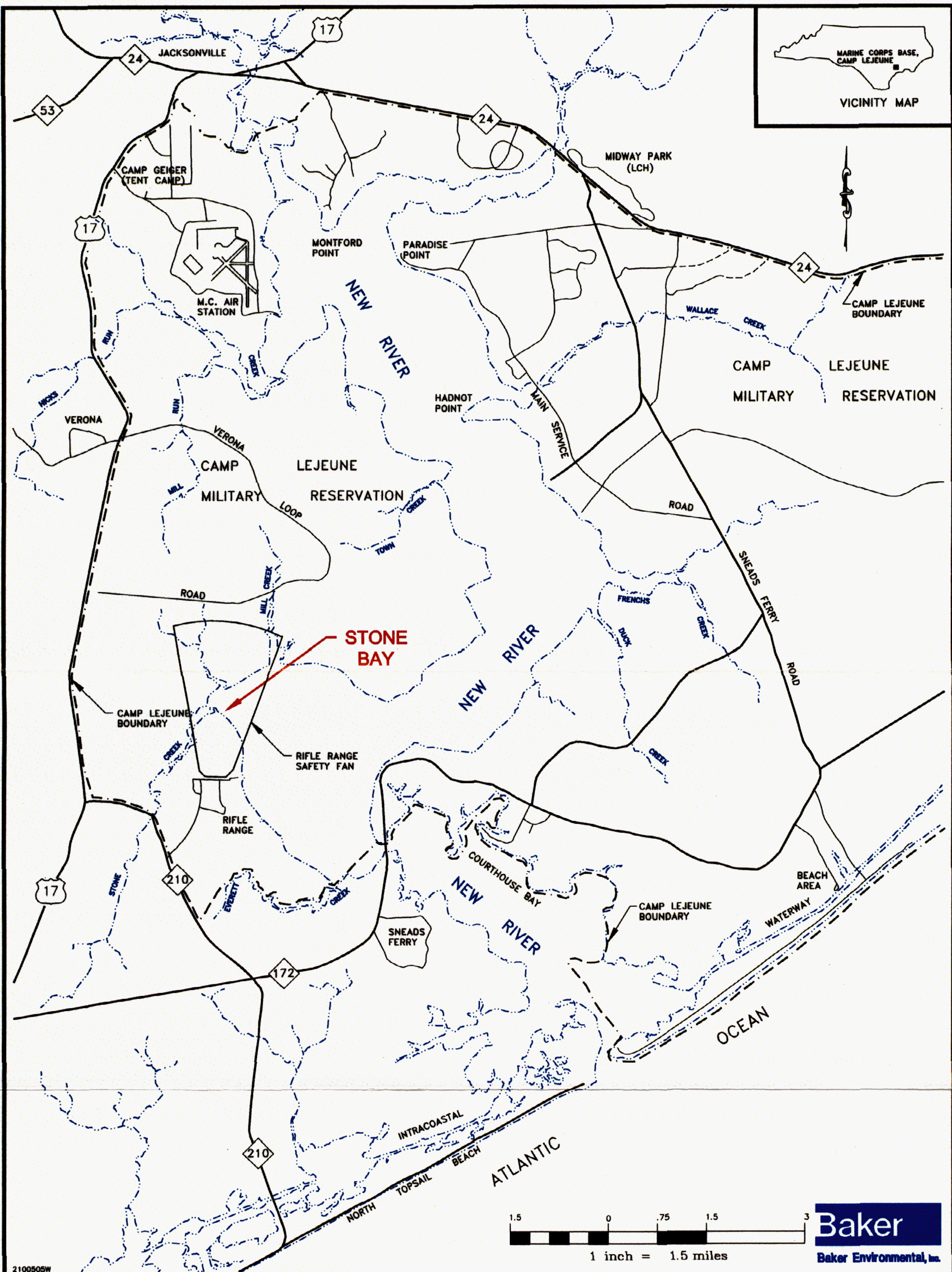
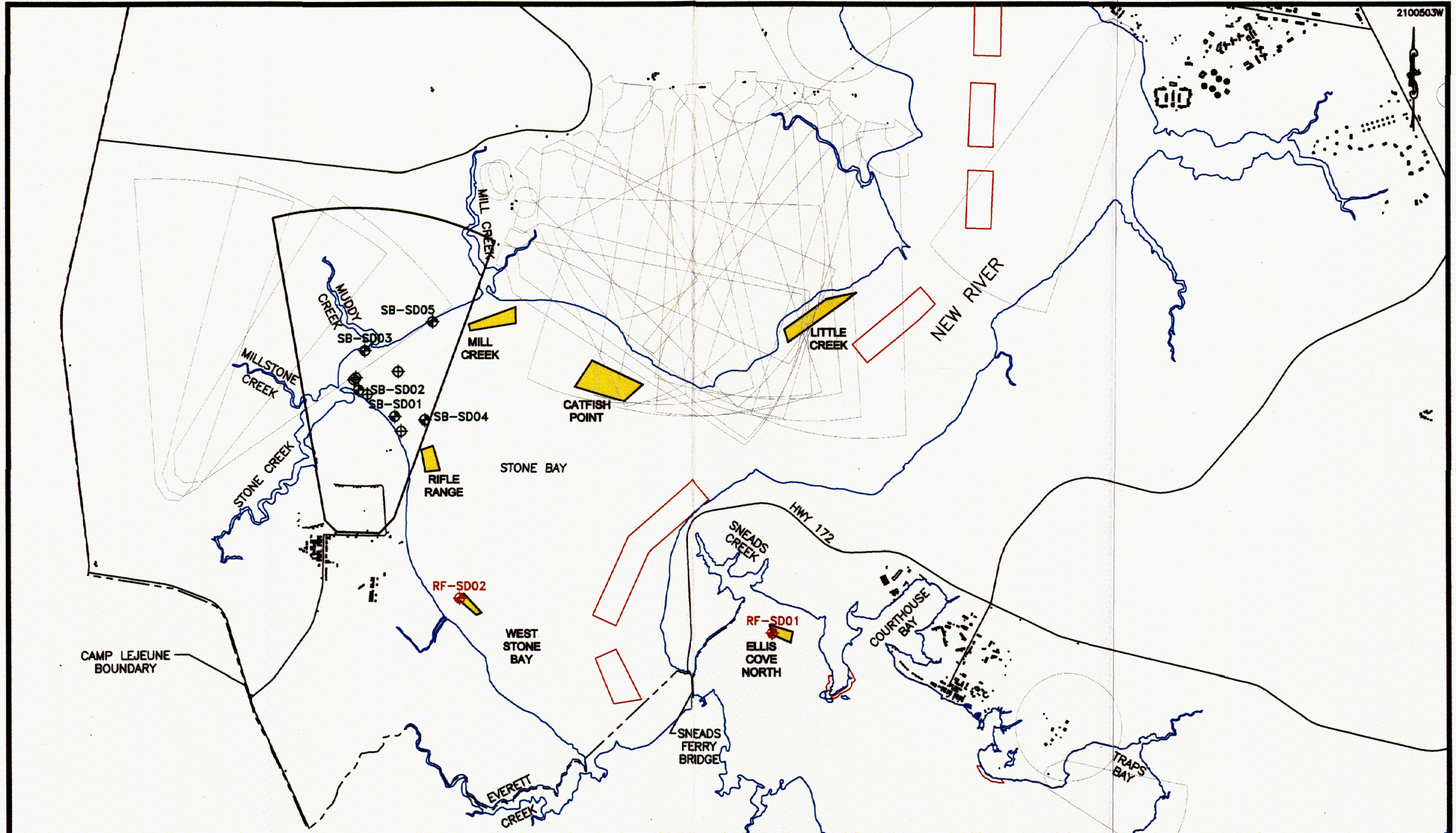


FIGURE 1-1
SITE LOCATION MAP
STONE BAY AQUATIC ASSESSMENT
CTO-100

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00633VB1Y



LEGEND

- SEDIMENT/BIOTA SAMPLE STATION
- SEDIMENT/BIOTA REFERENCE STATION
- CH2M HILL SEDIMENT SAMPLE STATION
- APPROXIMATE LOCATION OF SHELLFISH PLANTING SITES
- RIFLE RANGE FAN
- STONE BAY RIFLE RANGE FAN
- SPOIL AREA

1200 0 600 1200
1 inch = 1200 ft.

SOURCE OF BASE MAPPING: MCB CAMP LEJEUNE, 1998.

Baker
Baker Environmental, Inc.

FIGURE 3-1
SAMPLE LOCATION MAP
STONE BAY AQUATIC ASSESSMENT
CTO-100
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

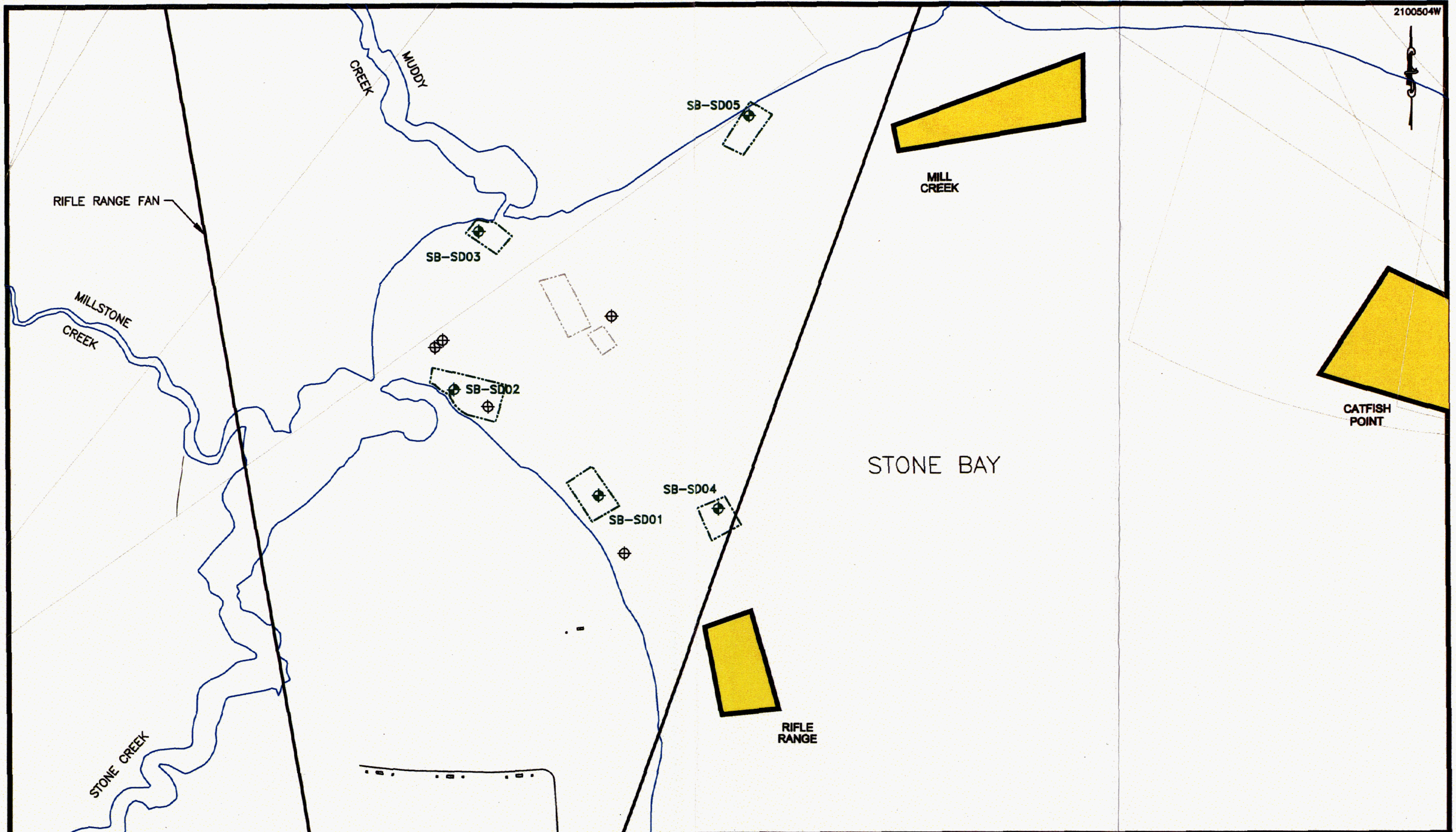


FIGURE 3-2
STUDY AREA LOCATION MAP
STONE BAY AQUATIC ASSESSMENT
CTO-100
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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ATTACHMENT A

Site Photographs

Rifle Range

1999.01

This photograph of Bravo Range was taken facing down range (north). The target backstop seen in the background is approximately 500 meters away.

1999.02

Bravo Range. The asphalt road leads to the target area, which is commonly referred to as the "Butts".

00633VB2Y

Rifle Range

1999.03

This photograph was taken behind the target back-stop area or "Butts". Personnel protected by the backstop raise and lower targets for the shooters.

1999.04

This photograph was taken from the top of the range backstop, looking north in the direction of Stone Bay. Note that the tree line height is diminished, due to the number of rounds traveling over the area.

Stone Bay

1999.05

Sampling in deep water was accomplished using "shellfish tongs" to retrieve clams, oysters, and mussels from the bottom of the bay.

1999.06

Some shellfish samples were collected by hand, as samplers waded in shallow water. This photograph was taken at the end of the rifle range near Stone Creek.

1999.07

This photograph was taken from Stone Bay facing toward the edge of the rifle range. The flag pole seen in the center of the photograph is used to warn civilian personnel when the rifle range is in operation.

1999.08

This photograph was taken from reference station number one. Sneads Ferry Bridge can be seen in the background.

Baker

Baker Environmental, Inc.

ATTACHMENT B

Analytical Results

B.1
CH2M Hill Letter Report

TECHNICAL MEMORANDUM **CH2MHILL**

Stones Bay Sediment and Water Quality Sampling Results

PREPARED FOR: Mr. D.J. Cotnoir/Commander Atlantic Division

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Mike Mischuk/CH2M HILL-MKE
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Steven Lehmann/CH2M HILL-CLT

DATE: October 28, 1998

Introduction and Background

Marine Corp Base (MCB), Camp Lejeune provides specialized training to prepare troops for amphibious and land combat operations. The buildings and facilities onsite support 144,000 marines, sailors and their families. A new 15-million gallon per day (mgd) advanced wastewater treatment facility is being constructed; and due to strong public reaction, the North Carolina Department of Environment and Natural Resources (NCDENR), Division of Coastal Management, has required Camp Lejeune to conduct in-stream sediment and water quality monitoring.

A monitoring program was initiated in June 1998 to quantify the discharge's impact, if any, on the estuarine environment. Ten transects were sampled at locations between Wilson Bay and Courthouse Bay. A modification to the monitoring program was requested by LANTDIV and required additional sediment and water quality sampling at five stations in an area of the New River Estuary known as Stones Bay.

Field Sampling

On September 16, 1998, CH2M HILL collected sediment and water quality samples from five stations in Stones Bay. Bob Deppen navigated the boat provided by Camp Lejeune. Dave Marasco, Camp Lejeune contact, was also in attendance. The sampling plan, Attachment 1, identifies the sampling locations, the sample matrix, chemical analysis that was performed, and the sampling methods used. The plan was followed as described with the exception of the following deviations.

- SB-3 could not be reached due to a water depth of less than two feet. SB-3 was sampled at an alternate location that was at the mouth of the stream. The final locations of all sites are noted on the attached map.
- As noted in Exhibit 3 of the attached sampling plan, a new polyethylene pail and spoon, each of which had been decontaminated previously, were supplied and used at each site instead of completing the decontamination process on a single pail and spoon between sites.
- The metals samples were filtered between 26 and 29 hours after the samples were first taken.
- Sampling was completed two weeks after Hurricane Bonnie, and the river was still turbid.

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To JEFF TEPSIC	From KATE LANDMAN
Co.	Co.
Dept.	Phone #
Fax # 412 269 2002	Fax #

Results

The tables below summarize the sediment and water quality results from the attached lab reports from En Chem and Frontier Geosciences. Table 1, Sediment Inorganic Results, includes the metals, solids percent, acid volatile sulfide (AVS) and total organic carbon (TOC) results from the sediment samples, as well as the ER-L and ER-M levels established by the National Oceanic and Atmospheric Administration (NOAA). Graph 1, Grain Size Distribution, represents the grain size distribution from the same sediment samples, and the graph reveals that more fines are present at stations SB-3 and SB-4, while more sand is present at stations SB-1 and SB-5. Table 2, Water Quality Metals Results, summarizes the water quality results, as well as includes the NCDENR Water Quality Standards for tidal saltwaters with a classification of SA. There are no sediment standards to report in Table 1.

TABLE 1: SEDIMENT INORGANIC RESULTS								
		Sampling Staions					NOAA Guidlines	
Analyte	**Units**	**CLMSDSB101**	**CLMSDSB201**	**CLMSDSB301**	**CLMSDSB401**	**CLMSDSB501**	**ER-L**	**ER-M**
As	mg/kg	< 1.3	3.6	2.2	< 1.4	< 1.4	33	85
Cd	mg/kg	< 0.13	< 0.21	< 0.15	< 0.14	< 0.14	5	9
Cr	mg/kg	2.4	15	4.6	3.6	4.7	80	145
Cu	mg/kg	< 1.3	18	5.7	15	< 1.4	70	390
Pb	mg/kg	1.5	12	4	3.5	3.5	35	110
Hg	mg/kg	< 0.13	< 0.21	< 0.15	< 0.14	< 0.14	0.15	1.30
Ni	mg/kg	< 0.67	3.10	< 0.77	< 0.70	0.98	30	50
Se	mg/kg	< 1.3	< 2.1	< 1.5	< 1.4	< 1.4	NA	NA
Ag	mg/kg	< 0.67	< 1.1	< 0.77	< 0.70	< 0.70	1	2.2
Zn	mg/kg	3.7	19	5.5	4.2	4.0	120	270
Solids	%	74.4	47	65.3	71.8	71.9	NA	NA
TOC as NPOC	mg/kg	2000	11000	3300	2600	2000	NA	NA
AVS	mg/kg	130	270	< 61	51	< 56	NA	NA

TOC = Total Organic Carbon
NPOC = Non-purgeable Organic Carbon
AVS = Acid Volatile Sulfide

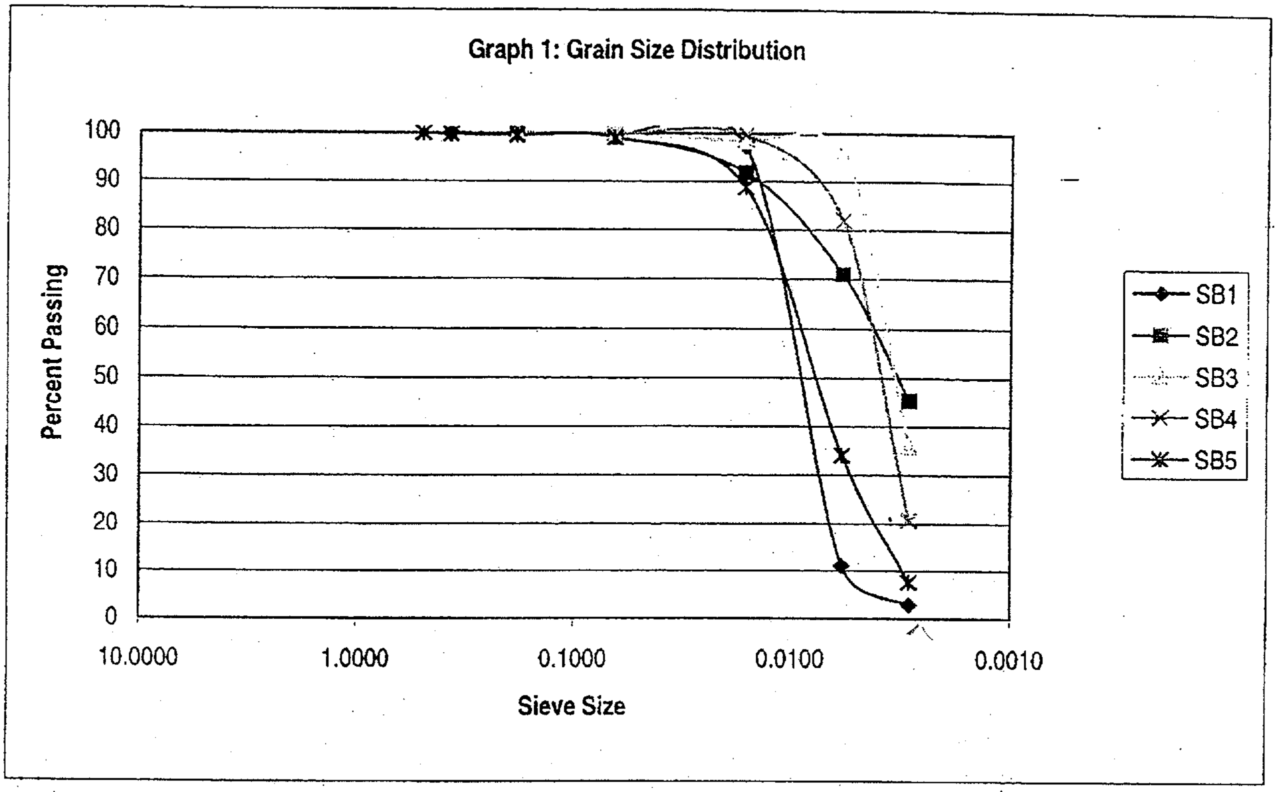
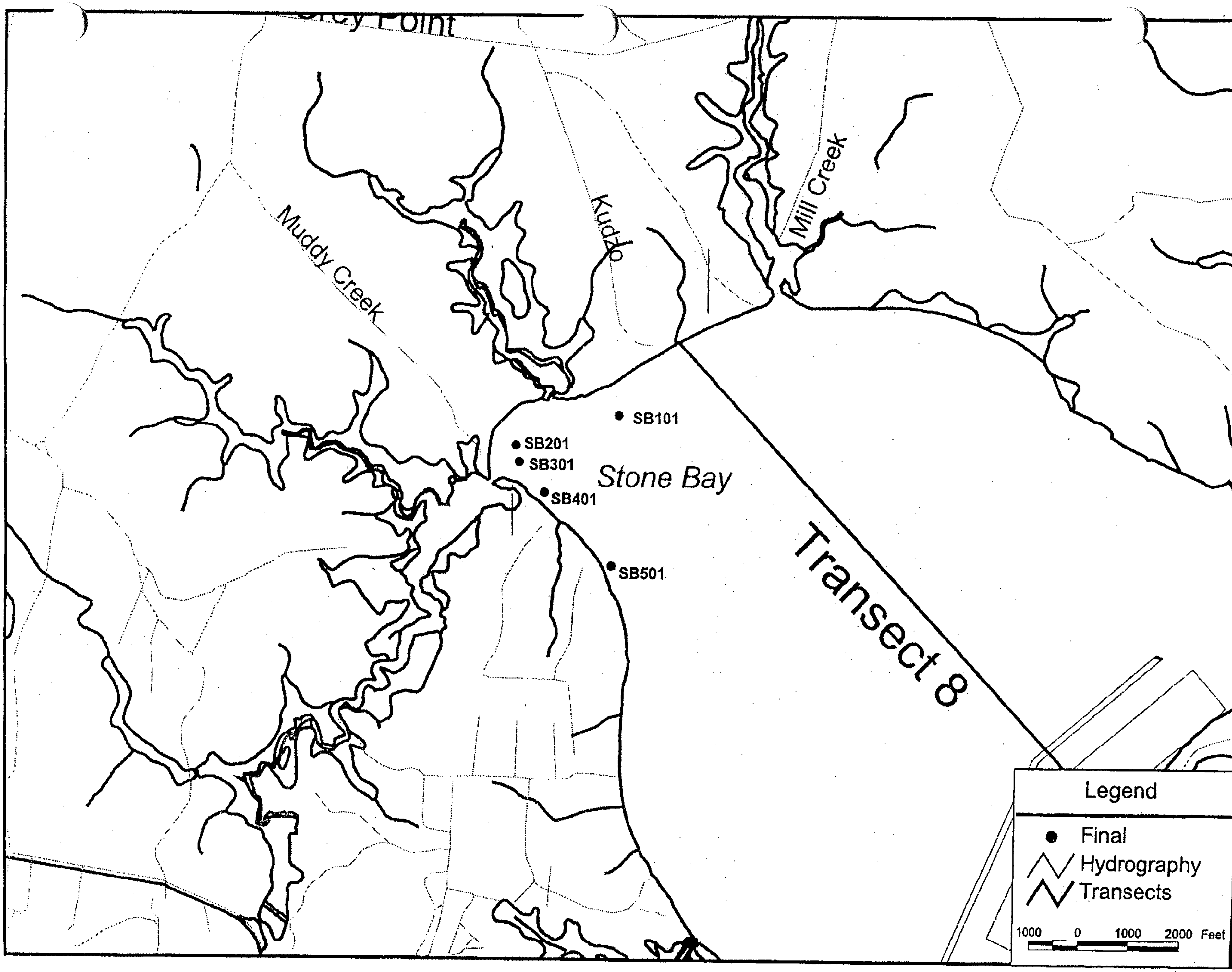


TABLE 3: WATER QUALITY METALS RESULTS														
Metal	Units	Trip Blank		CLMSWSB101		CLMSWSB201		CLMSWSB301		CLMSWSB401		CLMSWSB501		W. Q. Stds.
		Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Aquatic Life
As	µg/L	ND	ND	1.06	0.943	1.16	1.03	1.27	1.02	1.44	1.04	1.37	1.05	50
Cd	µg/L	0.001	0	0.011	0.004	0.011	0.004	0.012	0.003	0.017	0.004	0.014	0.003	5.0
Cr	µg/L	ND	ND	0.29	0.13	0.56	0.10	0.72	0.06	1.37	0.06	1.30	0.07	20
Cu	µg/L	0.08	0.03	0.71	0.62	0.88	0.61	0.91	0.61	1.53	0.86	0.95	0.58	3 (AL)
Pb	µg/L	ND	ND	0.220	ND	0.415	ND	0.437	ND	0.926	ND	0.641	ND	25 (N)
Hg	ng/L	0.04	0.39	1.81	0.90	2.28	0.89	2.21	0.85	2.29	1.02	2.59	1.00	25
Ni	µg/L	0.02	0.02	0.24	0.24	0.30	0.25	0.31	0.26	0.48	0.25	0.44	0.29	8.3
Se	µg/L	ND	ND	0.120	0.095	0.126	0.099	0.122	0.103	0.157	0.102	0.153	0.102	71
Ag	µg/L	ND	ND	0.001	ND	0.004	ND	0.004	ND	0.005	ND	0.004	ND	0.1 (AL)
Zn	µg/L	ND	ND	0.84	ND	1.33	ND	1.28	ND	2.29	0.24	1.75	0.15	86 (AL)

ND = Analyte not detected above the estimated method detection limit (MDL)

AL = Values represent action levels as specified in 15A NCAC 2B .0220

N = See 15A NCAC 2B.0220 for narrative description of limits



Muddy Creek
Kudzo
Mill Creek
SB101
SB201
SB301
SB401
SB501
Stone Bay
Transect 8
Legend
Final
Hydrography
Transects
1000 0 1000 2000 Feet

B.2
Aquatic Assessment Data

FREQUENCY OF DETECTIONS IN SEDIMENT
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-SD01-99A	SB-SD02-99A	SB-SD03-99A	SB-SD04-99A	SB-SD05-99A
SAMPLE DATE	1/14/99	1/15/99	1/15/99	1/15/99	1/16/99
INORGANICS (mg/kg)					
Aluminum	1750	1780	1580	14800	1580
Antimony	0.66 U	0.61 U	0.57 U	1.36 U	0.58 U
Arsenic	1.1 J	0.85 J	0.68 U	6.8	0.84 J
Barium	2.9 J	2.1 J	2.2 J	14.4 J	2.7 J
Beryllium	0.25 U	0.23 U	0.22 U	0.52 U	0.22 U
Cadmium	0.1 U	0.09 U	0.09 U	0.21 U	0.09 U
Calcium	484 J	161 J	323 J	4930	1320
Chromium	5.6	4.2	3.2	29.8	3.9
Cobalt	1.37 U	1.26 U	1.18 U	2.82 U	1.21 U
Copper	2.67 U	16.6	2.4 J	8.7 J	2.35 U
Iron	2380	2120	1480	17400	1660
Lead	6	5.7	2.5	20.7	3.4
Magnesium	843 J	592 J	511 J	5280	475 J
Manganese	8.9	6.3	4.2	88	8.7
Mercury	0.05 U	0.06 U	0.06 U	0.13 U	0.06 U
Nickel	2.54 U	2.33 U	2.19 U	5.8 J	2.24 U
Potassium	430 J	341 J	285 J	2510 J	273 J
Selenium	0.81 U	0.75 U	0.7 U	1.67 U	0.72 U
Silver	0.75 J	0.9 J	0.46 J	4.6 J	0.6 J
Sodium	3980	2530	2080	15000	1860
Thallium	0.51 U	0.47 U	0.44 U	1.3 J	0.45 U
Vanadium	5.3 J	4.5 J	3.7 J	25.7 J	3.6 J
Zinc	5.8	5.6	2.9 J	38.8	3.3 J

FREQUENCY OF DETECTIONS IN SEDIMENT
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	1580	14800	SB-SD04-99A	5/5	4298	1750
Antimony	0.57 U	1.36 U	ND	ND		0/5	ND	ND
Arsenic	0.68 U	0.68 U	0.84 J	6.8	SB-SD04-99A	4/5	2.4	0.98
Barium	ND	ND	2.1 J	14.4 J	SB-SD04-99A	5/5	4.86	2.7
Beryllium	0.22 U	0.52 U	ND	ND		0/5	ND	ND
Cadmium	0.09 U	0.21 U	ND	ND		0/5	ND	ND
Calcium	ND	ND	161 J	4930	SB-SD04-99A	5/5	1443.6	484
Chromium	ND	ND	3.2	29.8	SB-SD04-99A	5/5	9.34	4.2
Cobalt	1.18 U	2.82 U	ND	ND		0/5	ND	ND
Copper	2.35 U	2.67 U	2.4 J	16.6	SB-SD02-99A	3/5	9.23	8.7
Iron	ND	ND	1480	17400	SB-SD04-99A	5/5	5008	2120
Lead	ND	ND	2.5	20.7	SB-SD04-99A	5/5	7.66	5.7
Magnesium	ND	ND	475 J	5280	SB-SD04-99A	5/5	1540.2	592
Manganese	ND	ND	4.2	88	SB-SD04-99A	5/5	23.22	8.7
Mercury	0.05 U	0.13 U	ND	ND		0/5	ND	ND
Nickel	2.19 U	2.54 U	5.8 J	5.8 J	SB-SD04-99A	1/5	5.8	5.8
Potassium	ND	ND	273 J	2510 J	SB-SD04-99A	5/5	767.8	341
Selenium	0.7 U	1.67 U	ND	ND		0/5	ND	ND
Silver	ND	ND	0.46 J	4.6 J	SB-SD04-99A	5/5	1.46	0.75
Sodium	ND	ND	1860	15000	SB-SD04-99A	5/5	5090	2530
Thallium	0.44 U	0.51 U	1.3 J	1.3 J	SB-SD04-99A	1/5	1.3	1.3
Vanadium	ND	ND	3.6 J	25.7 J	SB-SD04-99A	5/5	8.56	4.5
Zinc	ND	ND	2.9 J	38.8	SB-SD04-99A	5/5	11.28	5.6

FREQUENCY OF DETECTIONS IN CLAM TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-CL04-99A	
SAMPLE DATE	1/15/99	
INORGANICS (mg/kg)		
Aluminum	275	
Antimony	1.85	U
Arsenic	12.4	
Barium	1.7	J
Beryllium	0.71	U
Cadmium	0.47	
Calcium	12400	
Chromium	1.2	
Cobalt	2.3	J
Copper	12.6	
Iron	442	
Lead	1.8	
Magnesium	8370	
Manganese	33.5	
Mercury	0.048	
Nickel	4.1	
Potassium	11600	
Selenium	2.8	
Silver	0.57	U
Sodium	71900	
Thallium	1.42	U
Vanadium	1.9	J
Zinc	117	

FREQUENCY OF DETECTIONS IN CLAM TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	275	275	SB-CL04-99A	1/1	275	275
Antimony	1.85 U	1.85 U	ND	ND		0/1	ND	ND
Arsenic	ND	ND	12.4	12.4	SB-CL04-99A	1/1	12.4	12.4
Barium	ND	ND	1.7 J	1.7 J	SB-CL04-99A	1/1	1.7	1.7
Beryllium	0.71 U	0.71 U	ND	ND		0/1	ND	ND
Cadmium	ND	ND	0.47	0.47	SB-CL04-99A	1/1	0.47	0.47
Calcium	ND	ND	12400	12400	SB-CL04-99A	1/1	12400	12400
Chromium	ND	ND	1.2	1.2	SB-CL04-99A	1/1	1.2	1.2
Cobalt	ND	ND	2.3 J	2.3 J	SB-CL04-99A	1/1	2.3	2.3
Copper	ND	ND	12.6	12.6	SB-CL04-99A	1/1	12.6	12.6
Iron	ND	ND	442	442	SB-CL04-99A	1/1	442	442
Lead	ND	ND	1.8	1.8	SB-CL04-99A	1/1	1.8	1.8
Magnesium	ND	ND	8370	8370	SB-CL04-99A	1/1	8370	8370
Manganese	ND	ND	33.5	33.5	SB-CL04-99A	1/1	33.5	33.5
Mercury	ND	ND	0.048	0.048	SB-CL04-99A	1/1	0.05	0.05
Nickel	ND	ND	4.1	4.1	SB-CL04-99A	1/1	4.1	4.1
Potassium	ND	ND	11600	11600	SB-CL04-99A	1/1	11600	11600
Selenium	ND	ND	2.8	2.8	SB-CL04-99A	1/1	2.8	2.8
Silver	0.57 U	0.57 U	ND	ND		0/1	ND	ND
Sodium	ND	ND	71900	71900	SB-CL04-99A	1/1	71900	71900
Thallium	1.42 U	1.42 U	ND	ND		0/1	ND	ND
Vanadium	ND	ND	1.9 J	1.9 J	SB-CL04-99A	1/1	1.9	1.9
Zinc	ND	ND	117	117	SB-CL04-99A	1/1	117	117

FREQUENCY OF DETECTIONS IN CLAM TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-CL04-99A
SAMPLE DATE	1/15/99
WET WEIGHT BASIS	
Percent Lipids (%)	0.2
Moisture (%)	89

FREQUENCY OF DETECTIONS IN MUSSEL TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-MU01/02-99A	SB-MU04-99A	SB-MU05-99A
SAMPLE DATE	1/16/99	1/16/99	1/15/99
INORGANICS (mg/kg)			
Aluminum	1010	455	317
Antimony	1.11 U	38.81 U	0.09 U
Arsenic	11	37.4	11.3
Barium	1.5 J	2.3 J	0.83 J
Beryllium	0.05 J	14.93 U	0.03 U
Cadmium	0.24	0.52	0.19
Calcium	19500	24100	8470
Chromium	1.9	2	0.82
Cobalt	0.55 J	0.64 J	0.35 J
Copper	12.5	12.9	4.1
Iron	1100	643	366
Lead	4.8	1.6	1.3
Magnesium	3080	7950	3010
Manganese	26.3	91.9	18.1
Mercury	0.088	0.157	0.086
Nickel	3	3 J	0.73 J
Potassium	7130	18900	6080
Selenium	3.4	9.4	3.3
Silver	0.34 U	11.94 U	0.03 U
Sodium	24100	69800	27600
Thallium	0.86 U	29.85 U	0.07 U
Vanadium	3.3	4.9	1.9
Zinc	45	101	34.1

FREQUENCY OF DETECTIONS IN MUSSEL TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	317	1010	SB-MU01/02-99A	3/3	594	455
Antimony	0.09 U	38.81 U	ND	ND		0/3	ND	ND
Arsenic	ND	ND	11	37.4	SB-MU04-99A	3/3	19.9	11.3
Barium	ND	ND	0.83 J	2.3 J	SB-MU04-99A	3/3	1.54	1.5
Beryllium	0.03 U	14.93 U	0.05 J	0.05 J	SB-MU01/02-99A	1/3	0.05	0.05
Cadmium	ND	ND	0.19	0.52	SB-MU04-99A	3/3	0.32	0.24
Calcium	ND	ND	8470	24100	SB-MU04-99A	3/3	17356.67	19500
Chromium	ND	ND	0.82	2	SB-MU04-99A	3/3	1.57	1.9
Cobalt	ND	ND	0.35 J	0.64 J	SB-MU04-99A	3/3	0.51	0.55
Copper	ND	ND	4.1	12.9	SB-MU04-99A	3/3	9.83	12.5
Iron	ND	ND	366	1100	SB-MU01/02-99A	3/3	703	643
Lead	ND	ND	1.3	4.8	SB-MU01/02-99A	3/3	2.57	1.6
Magnesium	ND	ND	3010	7950	SB-MU04-99A	3/3	4680	3080
Manganese	ND	ND	18.1	91.9	SB-MU04-99A	3/3	45.43	26.3
Mercury	ND	ND	0.086	0.157	SB-MU04-99A	3/3	0.11	0.09
Nickel	ND	ND	0.73 J	3 J	SB-MU01/02-99A,SB-MU04-99A	3/3	2.24	3
Potassium	ND	ND	6080	18900	SB-MU04-99A	3/3	10703.33	7130
Selenium	ND	ND	3.3	9.4	SB-MU04-99A	3/3	5.37	3.4
Silver	0.03 U	11.94 U	ND	ND		0/3	ND	ND
Sodium	ND	ND	24100	69800	SB-MU04-99A	3/3	40500	27600
Thallium	0.07 U	29.85 U	ND	ND		0/3	ND	ND
Vanadium	ND	ND	1.9	4.9	SB-MU04-99A	3/3	3.37	3.3
Zinc	ND	ND	34.1	101	SB-MU04-99A	3/3	60.03	45

FREQUENCY OF DETECTIONS IN MUSSEL TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-MU01/02-99A	SB-MU04-99A	SB-MU05-99A
SAMPLE DATE	1/16/99	1/16/99	1/15/99
WET WEIGHT BASIS			
Percent Lipids (%)	1.6	1	2.1
Moisture (%)	85	93	81

FREQUENCY OF DETECTIONS IN OYSTER TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-OY01-99A	SB-OY02-99A	SB-OY03-99A	SB-OY04-99A	SB-OY05-99A
SAMPLE DATE	01/14/99	01/15/99	01/15/99	01/15/99	01/15/99
INORGANICS (mg/kg)					
Aluminum	111	49.3	90.6	69.5	78.9
Antimony	9.39 U	12.42 U	1.69 U	2.65 U	3.9 U
Arsenic	12.5	7.4	10	11.9	4.1
Barium	0.83 J	0.35 J	0.62 J	0.68 J	0.3 J
Beryllium	3.61 U	4.78 U	0.65 U	1.02 U	1.5 U
Cadmium	1.6	1.1	1.7	1.3	0.6
Calcium	2330	2830	4040	7840	5960
Chromium	0.65	0.46	0.66	0.72	0.43
Cobalt	0.37 J	0.34 J	3.51 U	5.51 U	0.21 J
Copper	50.3	45.1	46	21.4	17.1
Iron	225	123	199	228	137
Lead	1.6	0.69	1	0.82	0.4
Magnesium	2740	2450	3960	5110	2620
Manganese	9.8	6.4	11.8	7	5.7
Mercury	0.063	0.069	0.252	0.07	0.053
Nickel	2.4	1.1 J	2.3	1.8 J	1.3
Potassium	8940	8780	9090	11200	5000
Selenium	3.2	2.8	3.1	2.8	1
Silver	0.34 J	3.82 U	0.52 U	0.82 U	1.2 U
Sodium	19700	18600	31700	43800	22400
Thallium	7.22 U	9.55 U	1.3 U	2.04 U	3 U
Vanadium	1.4 J	0.68 J	0.56 J	1.7 J	0.35 J
Zinc	1280	793	722	728	894

FREQUENCY OF DETECTIONS IN OYSTER TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	49.3	111	SB-OY01-99A	5/5	79.86	78.9
Antimony	1.69 U	12.42 U	ND	ND		0/5	ND	ND
Arsenic	ND	ND	4.1	12.5	SB-OY01-99A	5/5	9.18	10
Barium	ND	ND	0.3 J	0.83 J	SB-OY01-99A	5/5	0.56	0.62
Beryllium	0.65 U	4.78 U	ND	ND		0/5	ND	ND
Cadmium	ND	ND	0.6	1.7	SB-OY03-99A	5/5	1.26	1.3
Calcium	ND	ND	2330	7840	SB-OY04-99A	5/5	4600	4040
Chromium	ND	ND	0.43	0.72	SB-OY04-99A	5/5	0.58	0.65
Cobalt	3.51 U	5.51 U	0.21 J	0.37 J	SB-OY01-99A	3/5	0.31	0.34
Copper	ND	ND	17.1	50.3	SB-OY01-99A	5/5	35.98	45.1
Iron	ND	ND	123	228	SB-OY04-99A	5/5	182.4	199
Lead	ND	ND	0.4	1.6	SB-OY01-99A	5/5	0.9	0.82
Magnesium	ND	ND	2450	5110	SB-OY04-99A	5/5	3376	2740
Manganese	ND	ND	5.7	11.8	SB-OY03-99A	5/5	8.14	7
Mercury	ND	ND	0.053	0.252	SB-OY03-99A	5/5	0.1	0.07
Nickel	ND	ND	1.1 J	2.4	SB-OY01-99A	5/5	1.78	1.8
Potassium	ND	ND	5000	11200	SB-OY04-99A	5/5	8602	8940
Selenium	ND	ND	1	3.2	SB-OY01-99A	5/5	2.58	2.8
Silver	0.52 U	3.82 U	0.34 J	0.34 J	SB-OY01-99A	1/5	0.34	0.34
Sodium	ND	ND	18600	43800	SB-OY04-99A	5/5	27240	22400
Thallium	1.3 U	9.55 U	ND	ND		0/5	ND	ND
Vanadium	ND	ND	0.35 J	1.7 J	SB-OY04-99A	5/5	0.94	0.68
Zinc	ND	ND	722	1280	SB-OY01-99A	5/5	883.4	793

FREQUENCY OF DETECTIONS IN OYSTER TISSUE
STONE BAY
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	SB-OY01-99A	SB-OY02-99A	SB-OY03-99A	SB-OY04-99A	SB-OY05-99A
SAMPLE DATE	01/14/99	01/15/99	01/15/99	01/15/99	01/15/99
WET WEIGHT BASIS					
Percent Lipids (%)	0.2	0.3	0.6	0.6	0.4
Moisture (%)	85	84	88	89	80

FREQUENCY OF DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-SD01-99A		RF-SD02-99A	
SAMPLE DATE	1/16/99		1/16/99	
INORGANICS (mg/kg)				
Aluminum	3000		8160	
Antimony	0.59	U	1.01	U
Arsenic	2.4		6	
Barium	3.5	J	8.9	J
Beryllium	0.23	U	0.39	U
Cadmium	0.09	U	0.15	U
Calcium	5320		26900	
Chromium	7.8		19.2	
Cobalt	1.23	U	2.1	J
Copper	2.4	U	4.6	J
Iron	3620		10100	
Lead	4.6		10.5	
Magnesium	1420		4200	
Manganese	17.7		58.7	
Mercury	0.05	U	0.09	U
Nickel	2.28	U	4.7	J
Potassium	605	J	1500	J
Selenium	0.73	U	1.6	J
Silver	1.5	J	3.2	J
Sodium	3470		9470	
Thallium	0.46	U	0.77	U
Vanadium	7.7	J	19.2	J
Zinc	7.9		23.8	

FREQUENCY OF DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	3000	8160	RF-SD02-99A	2/2	5580	5580
Antimony	0.59 U	1.01 U	ND	ND		0/2	ND	ND
Arsenic	ND	ND	2.4	6	RF-SD02-99A	2/2	4.2	4.2
Barium	ND	ND	3.5 J	8.9 J	RF-SD02-99A	2/2	6.2	6.2
Beryllium	0.23 U	0.39 U	ND	ND		0/2	ND	ND
Cadmium	0.09 U	0.15 U	ND	ND		0/2	ND	ND
Calcium	ND	ND	5320	26900	RF-SD02-99A	2/2	16110	16110
Chromium	ND	ND	7.8	19.2	RF-SD02-99A	2/2	13.5	13.5
Cobalt	1.23 U	1.23 U	2.1 J	2.1 J	RF-SD02-99A	1/2	2.1	2.1
Copper	2.4 U	2.4 U	4.6 J	4.6 J	RF-SD02-99A	1/2	4.6	4.6
Iron	ND	ND	3620	10100	RF-SD02-99A	2/2	6860	6860
Lead	ND	ND	4.6	10.5	RF-SD02-99A	2/2	7.55	7.55
Magnesium	ND	ND	1420	4200	RF-SD02-99A	2/2	2810	2810
Manganese	ND	ND	17.7	58.7	RF-SD02-99A	2/2	38.2	38.2
Mercury	0.05 U	0.09 U	ND	ND		0/2	ND	ND
Nickel	2.28 U	2.28 U	4.7 J	4.7 J	RF-SD02-99A	1/2	4.7	4.7
Potassium	ND	ND	605 J	1500 J	RF-SD02-99A	2/2	1052.5	1052.5
Selenium	0.73 U	0.73 U	1.6 J	1.6 J	RF-SD02-99A	1/2	1.6	1.6
Silver	ND	ND	1.5 J	3.2 J	RF-SD02-99A	2/2	2.35	2.35
Sodium	ND	ND	3470	9470	RF-SD02-99A	2/2	6470	6470
Thallium	0.46 U	0.77 U	ND	ND		0/2	ND	ND
Vanadium	ND	ND	7.7 J	19.2 J	RF-SD02-99A	2/2	13.45	13.45
Zinc	ND	ND	7.9	23.8	RF-SD02-99A	2/2	15.85	15.85

FREQUENCY OF DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-SD01-99A	RF-SD02-99A
SAMPLE DATE	1/16/99	1/16/99
TOC (mg/kg)		
Total Organic Carbon	4930	12400

FREQUENCY OF DETECTIONS IN SEDIMENT
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
TOC (mg/kg)								
Total Organic Carbon	ND	ND	4930	12400	RF-SD02-99A	2/2	8665	8665

FREQUENCY OF DETECTIONS IN CLAM TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-CL01-99A	RF-CL02-99A
SAMPLE DATE	1/16/99	1/16/99
INORGANICS (mg/kg)		
Aluminum	64.2	249
Antimony	5.63 U	0.14 U
Arsenic	11.1	16.2
Barium	0.99 J	1.7 J
Beryllium	2.16 U	0.05 U
Cadmium	0.21	0.23 J
Calcium	3840	5720
Chromium	0.62	1.2
Cobalt	1.4 J	2.1 J
Copper	9.5	10.1
Iron	158	370
Lead	1	0.7
Magnesium	4950	6020
Manganese	9	9
Mercury	0.05	0.054
Nickel	3.6	4
Potassium	6240	9740
Selenium	2	3.1
Silver	1.73 U	0.04 U
Sodium	39900	48900
Thallium	4.33 U	0.11 U
Vanadium	2.5	3.1
Zinc	86.1	125

FREQUENCY OF DETECTIONS IN CLAM TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	64.2	249	RF-CL02-99A	2/2	156.6	156.6
Antimony	0.14 U	5.63 U	ND	ND		0/2	ND	ND
Arsenic	ND	ND	11.1	16.2	RF-CL02-99A	2/2	13.65	13.65
Barium	ND	ND	0.99 J	1.7 J	RF-CL02-99A	2/2	1.35	1.35
Beryllium	0.05 U	2.16 U	ND	ND		0/2	ND	ND
Cadmium	ND	ND	0.21	0.23 J	RF-CL02-99A	2/2	0.22	0.22
Calcium	ND	ND	3840	5720	RF-CL02-99A	2/2	4780	4780
Chromium	ND	ND	0.62	1.2	RF-CL02-99A	2/2	0.91	0.91
Cobalt	ND	ND	1.4 J	2.1 J	RF-CL02-99A	2/2	1.75	1.75
Copper	ND	ND	9.5	10.1	RF-CL02-99A	2/2	9.8	9.8
Iron	ND	ND	158	370	RF-CL02-99A	2/2	264	264
Lead	ND	ND	0.7	1	RF-CL01-99A	2/2	0.85	0.85
Magnesium	ND	ND	4950	6020	RF-CL02-99A	2/2	5485	5485
Manganese	ND	ND	9	9	RF-CL01-99A,RF-CL02-99A	2/2	9	9
Mercury	ND	ND	0.05	0.054	RF-CL02-99A	2/2	0.05	0.05
Nickel	ND	ND	3.6	4	RF-CL02-99A	2/2	3.8	3.8
Potassium	ND	ND	6240	9740	RF-CL02-99A	2/2	7990	7990
Selenium	ND	ND	2	3.1	RF-CL02-99A	2/2	2.55	2.55
Silver	0.04 U	1.73 U	ND	ND		0/2	ND	ND
Sodium	ND	ND	39900	48900	RF-CL02-99A	2/2	44400	44400
Thallium	0.11 U	4.33 U	ND	ND		0/2	ND	ND
Vanadium	ND	ND	2.5	3.1	RF-CL02-99A	2/2	2.8	2.8
Zinc	ND	ND	86.1	125	RF-CL02-99A	2/2	105.55	105.55

FREQUENCY OF DETECTIONS IN CLAM TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-CL01-99A	RF-CL02-99A
SAMPLE DATE	1/16/99	1/16/99
WET WEIGHT BASIS		
Percent Lipids (%)	0.2	0.1
Moisture (%)	85	88

FREQUENCY OF DETECTIONS IN MUSSEL TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-MU02-99A
SAMPLE DATE	1/16/99
INORGANICS (mg/kg)	
Aluminum	319
Antimony	17.43 U
Arsenic	15.2
Barium	1.2 J
Beryllium	6.7 U
Cadmium	0.21
Calcium	19800
Chromium	1.1
Cobalt	0.34 J
Copper	4.1
Iron	473
Lead	1
Magnesium	3410
Manganese	22.8
Mercury	0.082
Nickel	1.1 J
Potassium	6390
Selenium	3.5
Silver	5.36 U
Sodium	27200
Thallium	13.41 U
Vanadium	3.1
Zinc	38.3

FREQUENCY OF DETECTIONS IN MUSSEL TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-MU02-99A
SAMPLE DATE	1/16/99
WET WEIGHT BASIS	
Percent Lipids (%)	1.1
Moisture (%)	82

FREQUENCY OF DETECTIONS IN OYSTER TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-OY01-99A	RF-OY02-99A
SAMPLE DATE	1/16/99	1/16/99
INORGANICS (mg/kg)		
Aluminum	104	320
Antimony	0.13 U	3.88 U
Arsenic	18.8	32.2
Barium	1.2 J	1.2 J
Beryllium	0.05 U	1.49 U
Cadmium	0.2 J	1.8
Calcium	4390	18200
Chromium	0.85	1.5
Cobalt	2.6	0.84 J
Copper	8.2	88.2
Iron	243	581
Lead	2	1.2
Magnesium	5900	6150
Manganese	10.3	19.2
Mercury	0.094	0.156
Nickel	4.5	2.1 J
Potassium	7500	15200
Selenium	2.3	5.6
Silver	0.04 U	1.4
Sodium	46800	51000
Thallium	0.1 U	2.99 U
Vanadium	3.3	4.6
Zinc	88.9	2230

FREQUENCY OF DETECTIONS IN OYSTER TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID SAMPLE DATE	Minimum Non-Detect	Maximum Non-Detect	Minimum Detected	Maximum Detected	Location of Maximum Detect	Frequency of Detection	Arithmatic Mean Positive Detects	Median Positive Detects
INORGANICS (mg/kg)								
Aluminum	ND	ND	104	320	RF-OY02-99A	2/2	212	212
Antimony	0.13 U	3.88 U	ND	ND		0/2	ND	ND
Arsenic	ND	ND	18.8	32.2	RF-OY02-99A	2/2	25.5	25.5
Barium	ND	ND	1.2 J	1.2 J	RF-OY01-99A,RF-OY02-99A	2/2	1.2	1.2
Beryllium	0.05 U	1.49 U	ND	ND		0/2	ND	ND
Cadmium	ND	ND	0.2 J	1.8	RF-OY02-99A	2/2	1	1
Calcium	ND	ND	4390	18200	RF-OY02-99A	2/2	11295	11295
Chromium	ND	ND	0.85	1.5	RF-OY02-99A	2/2	1.18	1.18
Cobalt	ND	ND	0.84 J	2.6	RF-OY01-99A	2/2	1.72	1.72
Copper	ND	ND	8.2	88.2	RF-OY02-99A	2/2	48.2	48.2
Iron	ND	ND	243	581	RF-OY02-99A	2/2	412	412
Lead	ND	ND	1.2	2	RF-OY01-99A	2/2	1.6	1.6
Magnesium	ND	ND	5900	6150	RF-OY02-99A	2/2	6025	6025
Manganese	ND	ND	10.3	19.2	RF-OY02-99A	2/2	14.75	14.75
Mercury	ND	ND	0.094	0.156	RF-OY02-99A	2/2	0.13	0.13
Nickel	ND	ND	2.1 J	4.5	RF-OY01-99A	2/2	3.3	3.3
Potassium	ND	ND	7500	15200	RF-OY02-99A	2/2	11350	11350
Selenium	ND	ND	2.3	5.6	RF-OY02-99A	2/2	3.95	3.95
Silver	0.04 U	0.04 U	1.4	1.4	RF-OY02-99A	1/2	1.4	1.4
Sodium	ND	ND	46800	51000	RF-OY02-99A	2/2	48900	48900
Thallium	0.1 U	2.99 U	ND	ND		0/2	ND	ND
Vanadium	ND	ND	3.3	4.6	RF-OY02-99A	2/2	3.95	3.95
Zinc	ND	ND	88.9	2230	RF-OY02-99A	2/2	1159.45	1159.45

FREQUENCY OF DETECTIONS IN OYSTER TISSUE
REFERENCE AREAS
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	RF-OY01-99A	RF-OY02-99A
SAMPLE DATE	1/16/99	1/16/99
WET WEIGHT BASIS		
Percent Lipids (%)	0.1	0.6
Moisture (%)		

FREQUENCY AND RANGE OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING LEVELS AND REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs) SSV/ ER-L (1)	ER-M (2)	Contaminant Frequency/Range No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above SSV ER-L	ER-M	Reference Areas Range	Mean
Inorganics (mg/kg)								
Aluminum	NE	NE	5/5	1,580 - 14,800	NA	NA	3,000 - 8,160	5,580
Arsenic	7.24	70	4/5	0.84J - 6.8	0	0	2.4 - 6	4.2
Barium	500 (3)	NE	5/5	2.1J - 14.4J	0	NA	3.5J - 8.9J	6.2
Calcium	NE	NE	5/5	161J - 4,930	NA	NA	5,320 - 26,900	16,110
Chromium	52.3	370	5/5	3.2 - 29.8	0	0	7.8 - 19.2	13.5
Copper	18.7	270	3/5	2.4J - 16.6	0	0	4.6J	4.6J
Iron	NE	27000 (4)	5/5	1,480 - 17,400	NA	0	3,620 - 10,100	6,860
Lead	30.2	218	5/5	2.5 - 20.7	0	0	4.6 - 10.5	7.55
Magnesium	NE	NE	5/5	475J - 5,280	NA	NA	1,420 - 4,200	2,810
Manganese	460 (5)	1100 (5)	5/5	4.2 - 88	0	0	17.7 - 58.7	38.2
Nickel	15.9	51.6	1/5	5.8J	0	0	4.7J	4.7
Potassium	NE	NE	5/5	273J - 2,510J	NA	NA	605J - 1,500J	1,053
Silver	1	3.7	5/5	0.46J - 4.6J	1	1	1.5J - 3.2J	2.35
Sodium	NE	NE	5/5	1,860 - 15,000	NA	NA	3,470 - 9,470	6,470
Thallium	NE	NE	1/5	1.3J	NA	NA	ND	NA
Vanadium	NE	NE	5/5	3.6J - 25.7J	NA	NA	7.7J - 19.2J	13.45
Zinc	124	410	5/5	2.9J - 38.8	0	0	7.9 - 23.8	15.85

Notes:

J - value reported is estimated
mg/kg - milligrams per kilogram
SSV - Sediment Screening Value
NE - Not Established
ND - Not Detected
NA - Not Applicable

(1) Region IV Sediment Screening Value (USEPA, 1995), unless otherwise noted
(2) Long et al. (1995) value, unless otherwise noted
(3) Sullivan,et al., 1985
(4) Tetra Tech, 1986 (apparent effects threshold)
(5) Canadian Screening Value (CMEE, 1993)

FREQUENCY AND RANGE OF MUSSEL TISSUE DATA COMPARED TO REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range: No. of Positive Detects/No. of Samples	Contaminant Frequency/Range: Range of Positive Detections	Reference Area Detection
Inorganics (mg/kg)			
Aluminum	3/3	317 - 1,010	319
Arsenic	3/3	11 - 37.4	15.2
Barium	3/3	0.83J - 2.3J	1.2J
Beryllium	1/3	0.05J	ND
Cadmium	3/3	0.19 - 0.52	0.21
Calcium	3/3	8,470 - 24,100	19,800
Chromium	3/3	0.82 - 2	1.1
Cobalt	3/3	0.35J - 0.64J	0.34J
Copper	3/3	4.1 - 12.9	4.1
Iron	3/3	366 - 1100	473
Lead	3/3	1.3 - 4.8	1
Magnesium	3/3	3,010 - 7,950	3,410
Manganese	3/3	18.1 - 91.9	22.8
Mercury	3/3	0.086 - 0.157	0.082
Nickel	3/3	0.73J - 3J	1.1J
Potassium	3/3	6,080 - 18,900	6,390
Selenium	3/3	3.3 - 9.4	3.5
Sodium	3/3	24,100 - 69,800	27,200
Vanadium	3/3	1.9 - 4.9	3.1
Zinc	3/3	34.1 - 101	38.3

Notes:

J - value reported is estimated
mg/kg - milligrams per kilogram
Reference is based on one sample: therefore, the mean value is not calculated.

FREQUENCY AND RANGE OF OYSTER TISSUE DATA COMPARED TO REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Reference Areas	
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range	Mean
Inorganics (mg/kg)				
Aluminum	5/5	49.3 - 111	104 - 320	212
Arsenic	5/5	4.1 - 12.5	18.8 - 32.2	25.5
Barium	5/5	0.3J - 0.83J	1.2J	1.2
Cadmium	5/5	0.6 - 1.7	0.2J - 1.8	1
Calcium	5/5	2,330 - 7,840	4,390 - 18,200	11,295
Chromium	5/5	0.43 - 0.72	0.85 - 1.5	1.18
Cobalt	3/5	0.21J - 0.37J	0.84J - 2.6	1.72
Copper	5/5	17.1 - 50.3	8.2 - 88.2	48.2
Iron	5/5	123 - 228	243 - 581	412
Lead	5/5	0.4 - 1.6	1.2 - 2	1.6
Magnesium	5/5	2,450 - 5,110	5,900 - 6,150	6,025
Manganese	5/5	5.7 - 11.8	10.3 - 19.2	14.75
Mercury	5/5	0.053 - 0.252	0.094 - 0.156	0.13
Nickel	5/5	1.1J - 2.4	2.1 - 4.5	3.3
Potassium	5/5	5,000 - 11,200	7,500 - 15,200	11,350
Selenium	5/5	1 - 3.2	2.3 - 5.6	4
Silver	1/5	0.34J	1.4	1.4
Sodium	5/5	18,600 - 43,800	46,800 - 51,000	48,900
Vanadium	5/5	0.35J - 1.7J	3.3 - 4.6	3.95
Zinc	5/5	722 - 1,280	88.9 - 2,230	1,159.50

Notes:

J - value reported is estimated
mg/kg - milligrams per kilogram

FREQUENCY AND RANGE OF CLAM TISSUE DATA COMPARED TO REFERENCE AREAS
STUDY AREA
STONE BAY AQUATIC ASSESSMENT, CTO-0100
MCB, CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Reference Areas	
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range	Mean
Inorganics (mg/kg)				
Aluminum	1/1	275	64.2 - 249	157
Arsenic	1/1	12.4	11.1 - 16.2	13.65
Barium	1/1	1.7J	0.99J - 1.7J	1.35
Cadmium	1/1	0.47	0.21 - 0.23J	0.22
Calcium	1/1	12,400	3,840 - 5,720	4,780
Chromium	1/1	1.2	0.62 - 1.2	0.91
Cobalt	1/1	2.3J	1.4J - 2.1J	1.75
Copper	1/1	12.6	9.5 - 10.1	9.8
Iron	1/1	442	158 - 370	264
Lead	1/1	1.8	0.7 - 1	0.85
Magnesium	1/1	8,370	4,950 - 6,020	5,485
Manganese	1/1	33.5	9	9
Mercury	1/1	0.05	0.05 - 0.054	0.05
Nickel	1/1	4.1	3.6 - 4	3.8
Potassium	1/1	11,600	6,240 - 9,740	7,990
Selenium	1/1	2.8	2 - 3.1	3
Sodium	1/1	71,900	39,990 - 48,900	44,400
Vanadium	1/1	1.9J	2.5 - 3.1	2.8
Zinc	1/1	117	86.1 - 125	105.55

Notes:

Clams were only obtained from one study area sampling station.
J - value reported is estimated
mg/kg - milligrams per kilogram

Baker

Baker Environmental, Inc.

ATTACHMENT C

Form I's

STONE BAY **SEDIMENT - INORGANICS**

TOTAL METALS
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

RF-SD01-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: Y0199A

Matrix (soil/water): SOIL   Lab Sample ID: 990034-19 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 73.0

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	3000		*	P
7440-36-0	Antimony	0.59	U	N	P
7440-38-2	Arsenic	2.4			P
7440-39-3	Barium	3.5	B		P
7440-41-7	Beryllium	0.23	U		P
7440-43-9	Cadmium	0.09	U		P
7440-70-2	Calcium	5320			P
7440-47-3	Chromium	7.8			P
7440-48-4	Cobalt	1.2	U		P
7440-50-8	Copper	2.4	U		P
7439-89-6	Iron	3620		*	P
7439-92-1	Lead	4.6		*	P
7439-95-4	Magnesium	1420			P
7439-96-5	Manganese	17.7			P
7439-97-6	Mercury	0.06	U		AV
7440-02-0	Nickel	2.3	U		P
7440-09-7	Potassium	605	B		P
7782-49-2	Selenium	0.73	U	N	P
7440-22-4	Silver	1.5	B		P
7440-23-5	Sodium	3470			P
7440-28-0	Thallium	0.46	U		P
7440-62-2	Vanadium	7.7	B		P
7440-66-6	Zinc	7.9			P

Color Before: BROWN   Clarity Before: Texture: MEDIUM

Color After: COLORLESS   Clarity After: Artifacts:

Comments:

129

TOTAL METALS
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

RF-SD02-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: Y0199A

Matrix (soil/water): SOIL Lab Sample ID: 990034-20 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 49.2

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	8160		*	P
7440-36-0	Antimony	1.0	U	N	P
7440-38-2	Arsenic	6.0			P
7440-39-3	Barium	8.9	B		P
7440-41-7	Beryllium	0.39	U		P
7440-43-9	Cadmium	0.15	U		P
7440-70-2	Calcium	26900			P
7440-47-3	Chromium	19.2			P
7440-48-4	Cobalt	2.1	B		P
7440-50-8	Copper	4.6	B		P
7439-89-6	Iron	10100		*	P
7439-92-1	Lead	10.5		*	P
7439-95-4	Magnesium	4200			P
7439-96-5	Manganese	58.7			P
7439-97-6	Mercury	0.09	U		AV
7440-02-0	Nickel	4.7	B		P
7440-09-7	Potassium	1500	B		P
7782-49-2	Selenium	1.6	B	N	P
7440-22-4	Silver	3.2	B		P
7440-23-5	Sodium	9470			P
7440-28-0	Thallium	0.77	U		P
7440-62-2	Vanadium	19.2	B		P
7440-66-6	Zinc	23.8			P

Color Before: BROWN Clarity Before: Texture: MEDIUM

Color After: COLORLESS Clarity After: Artifacts:

Comments:

130

TOTAL METALS
1

EPA SAMPLE NO.

INORGANIC ANALYSIS DATA SHEET

SB-SD01-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: Y0199A

Matrix (soil/water): SOIL Lab Sample ID: 990034-14 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 76.4

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	1750		*	P
7440-36-0	Antimony	0.66	U	N	P
7440-38-2	Arsenic	1.1	B		P
7440-39-3	Barium	2.9	B		P
7440-41-7	Beryllium	0.26	U		P
7440-43-9	Cadmium	0.10	U		P
7440-70-2	Calcium	484	B		P
7440-47-3	Chromium	5.6			P
7440-48-4	Cobalt	1.4	U		P
7440-50-8	Copper	2.7	U		P
7439-89-6	Iron	2380		*	P
7439-92-1	Lead	6.0		*	P
7439-95-4	Magnesium	843	B		P
7439-96-5	Manganese	8.9			P
7439-97-6	Mercury	0.05	U		AV
7440-02-0	Nickel	2.5	U		P
7440-09-7	Potassium	430	B		P
7782-49-2	Selenium	0.81	U	N	P
7440-22-4	Silver	0.75	B		P
7440-23-5	Sodium	3980			P
7440-28-0	Thallium	0.51	U		P
7440-62-2	Vanadium	5.3	B		P
7440-66-6	Zinc	5.8			P

Color Before: BROWN Clarity Before: Texture: MEDIUM

Color After: COLORLESS Clarity After: Artifacts:

Comments:

131

FORM I - IN ILM04.0

EPA SAMPLE NO.

INORGANIC ANALYSIS DATA SHEET

SB-SD02-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: Y0199A

Matrix (soil/water): SOIL Lab Sample ID: 990034-15 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 74.6

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	1780		*	P
7440-36-0	Antimony	0.61	U	N	P
7440-38-2	Arsenic	0.85	B		P
7440-39-3	Barium	2.1	B		P
7440-41-7	Beryllium	0.24	U		P
7440-43-9	Cadmium	0.09	U		P
7440-70-2	Calcium	161	B		P
7440-47-3	Chromium	4.2			P
7440-48-4	Cobalt	1.3	U		P
7440-50-8	Copper	16.6			P
7439-89-6	Iron	2120		*	P
7439-92-1	Lead	5.7		*	P
7439-95-4	Magnesium	592	B		P
7439-96-5	Manganese	6.3			P
7439-97-6	Mercury	0.06	U		AV
7440-02-0	Nickel	2.3	U		P
7440-09-7	Potassium	341	B		P
7782-49-2	Selenium	0.75	U	N	P
7440-22-4	Silver	0.90	B		P
7440-23-5	Sodium	2530			P
7440-28-0	Thallium	0.47	U		P
7440-62-2	Vanadium	4.5	B		P
7440-66-6	Zinc	5.6			P

Color Before: BROWN Clarity Before: Texture: MEDIUM

Color After: COLORLESS Clarity After: Artifacts:

Comments:

132

TOTAL METALS
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-SD03-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: Y0199A

Matrix (soil/water): SOIL Lab Sample ID: 990034-16 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 82.9

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	1580		*	P
7440-36-0	Antimony	0.57	U	N	P
7440-38-2	Arsenic	0.68	U		P
7440-39-3	Barium	2.2	B		P
7440-41-7	Beryllium	0.22	U		P
7440-43-9	Cadmium	0.09	U		P
7440-70-2	Calcium	323	B		P
7440-47-3	Chromium	3.2			P
7440-48-4	Cobalt	1.2	U		P
7440-50-8	Copper	2.4	B		P
7439-89-6	Iron	1480		*	P
7439-92-1	Lead	2.5		*	P
7439-95-4	Magnesium	511	B		P
7439-96-5	Manganese	4.2			P
7439-97-6	Mercury	0.06	U		AV
7440-02-0	Nickel	2.2	U		P
7440-09-7	Potassium	285	B		P
7782-49-2	Selenium	0.70	U	N	P
7440-22-4	Silver	0.46	B		P
7440-23-5	Sodium	2080			P
7440-28-0	Thallium	0.44	U		P
7440-62-2	Vanadium	3.7	B		P
7440-66-6	Zinc	2.9	B		P

Color Before: BROWN Clarity Before: Texture: MEDIUM

Color After: COLORLESS Clarity After: Artifacts:

Comments:

133

TOTAL METALS
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-SD04-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: Y0199A

Matrix (soil/water): SOIL   Lab Sample ID: 990034-17 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 35.8

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	14800		*	P
7440-36-0	Antimony	1.4	U	N	P
7440-38-2	Arsenic	6.8			P
7440-39-3	Barium	14.4	B		P
7440-41-7	Beryllium	0.53	U		P
7440-43-9	Cadmium	0.21	U		P
7440-70-2	Calcium	4930			P
7440-47-3	Chromium	29.8			P
7440-48-4	Cobalt	2.8	U		P
7440-50-8	Copper	8.7	B		P
7439-89-6	Iron	17400		*	P
7439-92-1	Lead	20.7		*	P
7439-95-4	Magnesium	5280			P
7439-96-5	Manganese	88.0			P
7439-97-6	Mercury	0.13	U		AV
7440-02-0	Nickel	5.8	B		P
7440-09-7	Potassium	2510	B		P
7782-49-2	Selenium	1.7	U	N	P
7440-22-4	Silver	4.6	B		P
7440-23-5	Sodium	15000			P
7440-28-0	Thallium	1.3	B		P
7440-62-2	Vanadium	25.7	B		P
7440-66-6	Zinc	38.8			P

Color Before: BROWN   Clarity Before: Texture: MEDIUM

Color After: COLORLESS   Clarity After: Artifacts:

Comments:

134

TOTAL METALS
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-SD05-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: Y0199A

Matrix (soil/water): SOIL Lab Sample ID: 990034-18 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 79.1

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	1580		*	P
7440-36-0	Antimony	0.58	U	N	P
7440-38-2	Arsenic	0.84	B		P
7440-39-3	Barium	2.7	B		P
7440-41-7	Beryllium	0.23	U		P
7440-43-9	Cadmium	0.09	U		P
7440-70-2	Calcium	1320			P
7440-47-3	Chromium	3.9			P
7440-48-4	Cobalt	1.2	U		P
7440-50-8	Copper	2.3	U		P
7439-89-6	Iron	1660		*	P
7439-92-1	Lead	3.4		*	P
7439-95-4	Magnesium	475	B		P
7439-96-5	Manganese	8.7			P
7439-97-6	Mercury	0.06	U		AV
7440-02-0	Nickel	2.2	U		P
7440-09-7	Potassium	273	B		P
7782-49-2	Selenium	0.72	U	N	P
7440-22-4	Silver	0.60	B		P
7440-23-5	Sodium	1860			P
7440-28-0	Thallium	0.45	U		P
7440-62-2	Vanadium	3.6	B		P
7440-66-6	Zinc	3.3	B		P

Color Before: BROWN Clarity Before: Texture: MEDIUM

Color After: COLORLESS Clarity After: Artifacts:

Comments:

135

STONE BAY **SEDIMENT - TOTAL ORGANIC CARBON**

CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL ORGANIC CARBON

EPA 415.1/9060

Client: Baker Environmental

Client Sample ID: RF-SD01-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Sediment

Laboratory ID: 990034-19

Percent Solids: 73.0

Target Analyte	Result	Units	Method Reporting Limit	Date Prep'd	Date Analyzed
Total Organic Carbon	4930	mg/Kg+	68.5	01/25/99	01/25/99

. Dry weight basis.

Reported by: Jeffrey D. Maynon

Approved by: Donald Tortorelli

CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL ORGANIC CARBON

EPA 415.1/9060

Client: Baker Environmental

Client Sample ID: RF-SD02-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Sediment

Laboratory ID: 990034-20

Percent Solids: 49.2

Target Analyte	Result	Units	Method Reporting Limit	Date Prep'd	Date Analyzed
Total Organic Carbon	12400	mg/Kg+	102	01/25/99	01/25/99

+ Dry weight basis.

Reported by: Jeffrey D. Mayron

Approved by: Donald Tatoelli

STONE BAY

SEDIMENT - GEOTECHNICAL LABORATORY TEST DATA

GeoTesting Express

1145 MASSACHUSETTS AVE.
BOXBOROUGH, MA 01719
978-635-0424 (FAX) 978-635-0266

January 26, 1999

Ms. Peg Marple
Ceimic Corporation
10 Dean Knauss Drive
South Ferry Industrial Park
Narragansett, RI 02882

RE: Baker Environmental (GTX-2130)

Dear Ms. Marple:

Enclosed are the test results you requested for the above referenced project. We received the following three soil samples from you on January 22, 1999:

RF-SD01-99A
RF-SD02-99A
SB-SD01-99A

A copy of the chain of custody form for these samples is located at the back of this report. GeoTesting Express performed one sieve analysis (ASTM D 422) and one Atterberg limits (ASTM D 4318) on each of these samples. Two of the samples were determined to be non-plastic.

The results presented in this report apply only to the items tested. This report shall not be reproduced except in full, without written approval from GeoTesting Express. The remainder of these samples will be retained for a period of sixty days and will then be discarded unless otherwise notified by you. Please call me directly if you have any questions or require additional information. Thank you for allowing us this opportunity to once again provide your firm with physical properties testing of soils. We look forward to working with you again in the future.

Respectfully yours;

Gary T. Torosian
Laboratory Manager

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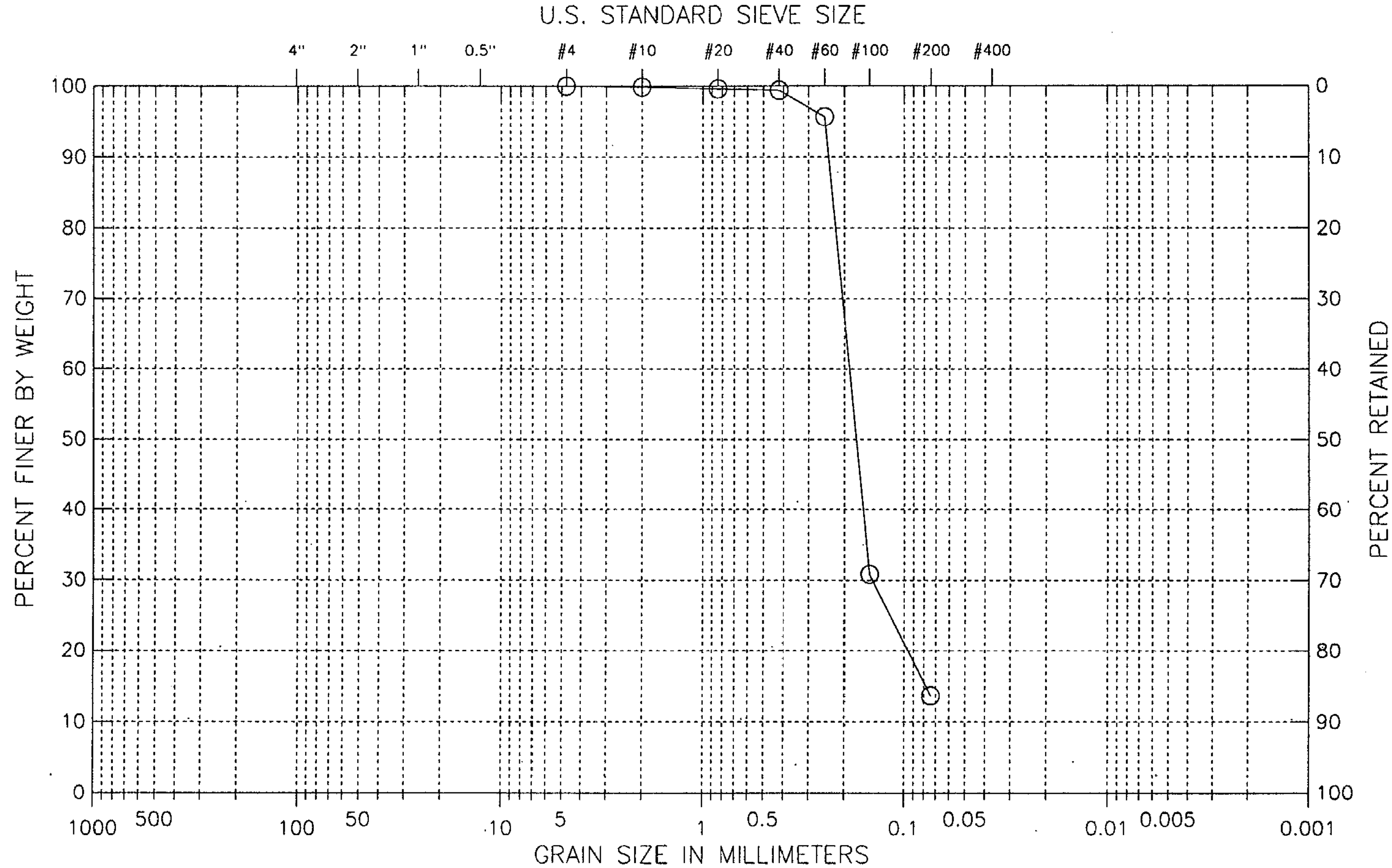
	Boring No. : ---	Project : Baker Environmental
	Sample No.: RF-SD01-99A	Project No.: GTX-2130
	Test Method ASTM D 422	Location: ---
	Filename : RFSD0199	Date : Tue Jan 26 1999



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :
(SM) Silty sand
Visual Description :
Wet, dark greenish gray silty sand

Remarks :
Hydrometer not requested

Figure 1

GEOTECHNICAL LABORATORY TEST DATA

Project : Baker Environmental
Project No. : GTX-2130
Boring No. : ---
Sample No. : RF-SD01-99A
Location : ---
Depth : ---
Test Date : 01/25/99
Test Method : ASTM D 422
Filename : RFSD0199
Elevation : ---
Tested by : tje
Checked by : gtt
Soil Description : Wet, dark greenish gray silty sand
Remarks : Hydrometer not requested

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.17	0.17	100
#20	0.033	0.84	0.31	0.48	100
#40	0.017	0.42	0.25	0.73	99
#60	0.010	0.25	4.59	5.32	96
#100	0.006	0.15	80.33	85.65	31
#200	0.003	0.07	21.24	106.89	14
Pan			16.89	123.78	0

Total Dry Weight of Sample = 133.01

D85 : 0.2295 mm
D60 : 0.1881 mm
D50 : 0.1736 mm
D30 : 0.1442 mm
D15 : 0.0782 mm
D10 : 0.0638 mm

Soil Classification
ASTM Group Symbol : SM
ASTM Group Name : Silty sand
AASHTO Group Symbol : A-2-4(0)
AASHTO Group Name : Silty Gravel and Sand

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Baker Environmental	GTX-2130	tje	---
LOCATION		**CHECKED BY**	**SAMPLE NUMBER**
---		gtt	RF-SD01-99A
SAMPLE DESCRIPTION		**DATE**	**FILENAME**
Wet, dark greenish gray silty sand		Tue Jan 26 1999	RFSD0199

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT, W_N (%)					
NUMBER OF BLOWS, N					
ONE-POINT LIQUID LIMIT, LL					

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT (%)					

SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	34.2
LIQUID LIMIT, LL	
PLASTIC LIMIT, PL	
PLASTICITY INDEX, PI	
LIQUIDITY INDEX, LI*	

*LI = (W − PL)/PI

PLASTICITY CHART

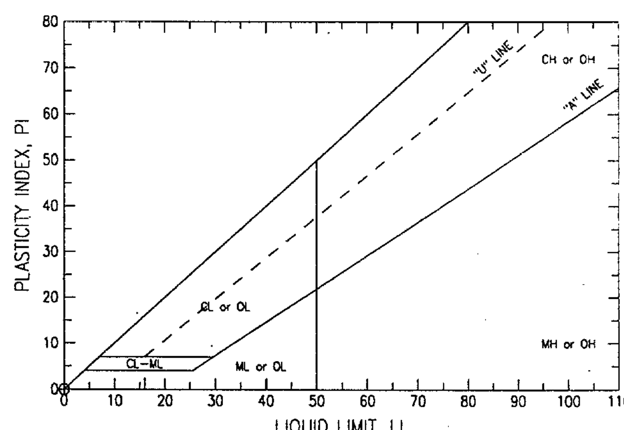


Fig. 1.0

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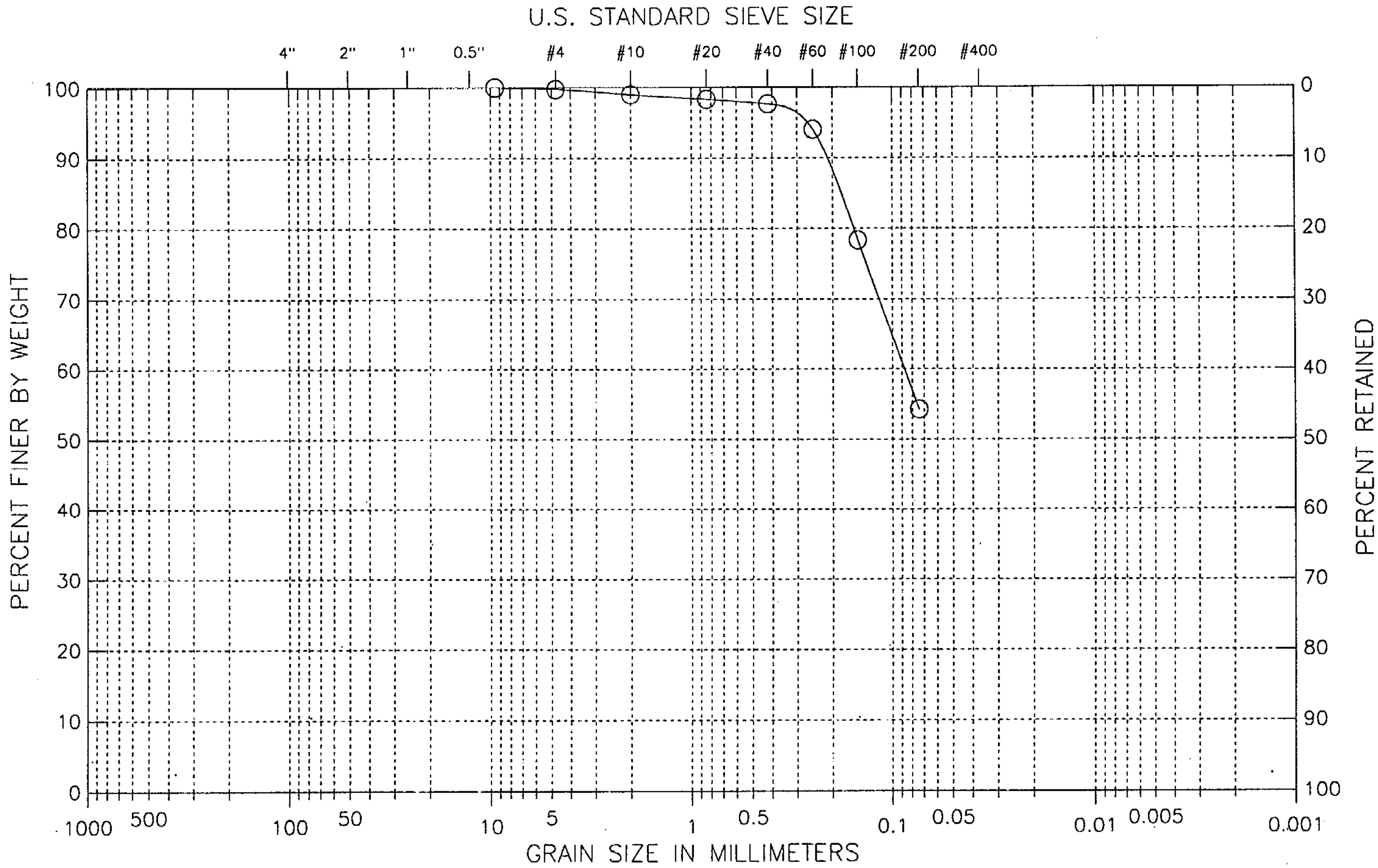
	Boring No. : ---	Project : Baker Environmental
	Sample No.: RF-SD02-99A	Project No.: GTX-2130
	Test Method ASTM D 422	Location: ---
	Filename : RFSD0299	Date : Tue Jan 26 1999



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :
(CH) Sandy fat clay
Visual Description :
Very wet, dark greenish gray sandy clay w/ shells

Remarks :
Hydrometer not requested

Figure 2

GEOTECHNICAL LABORATORY TEST DATA

Project : Baker Environmental
Project No. : GTX-2130
Boring No. : ---
Sample No. : RF-SD02-99A
Location : ---
Depth : ---
Test Date : 01/25/99
Test Method : ASTM D 422
Filename : RFSD0299
Elevation : ---
Tested by : tje
Checked by : gtt
Soil Description : Very wet, dark greenish gray sandy clay w/ shells
Remarks : Hydrometer not requested

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Sieve Openings Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
0.375"	0.374	9.51	0.00	0.00	100
#4	0.187	4.75	0.11	0.11	100
#10	0.079	2.00	0.39	0.50	99
#20	0.033	0.84	0.34	0.84	98
#40	0.017	0.42	0.34	1.18	98
#60	0.010	0.25	1.82	3.00	94
#100	0.006	0.15	7.87	10.87	78
#200	0.003	0.07	12.10	22.97	54
Pan			27.25	50.22	0

Total Dry Weight of Sample = 59.62

D85 : 0.1856 mm
D60 : 0.0874 mm
D50 : N/A
D30 : N/A
D15 : N/A
D10 : N/A

Soil Classification
ASTM Group Symbol : CH
ASTM Group Name : Sandy fat clay
AASHTO Group Symbol : A-7-6(24)
AASHTO Group Name : Clayey Soils

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ATTERBERG LIMITS

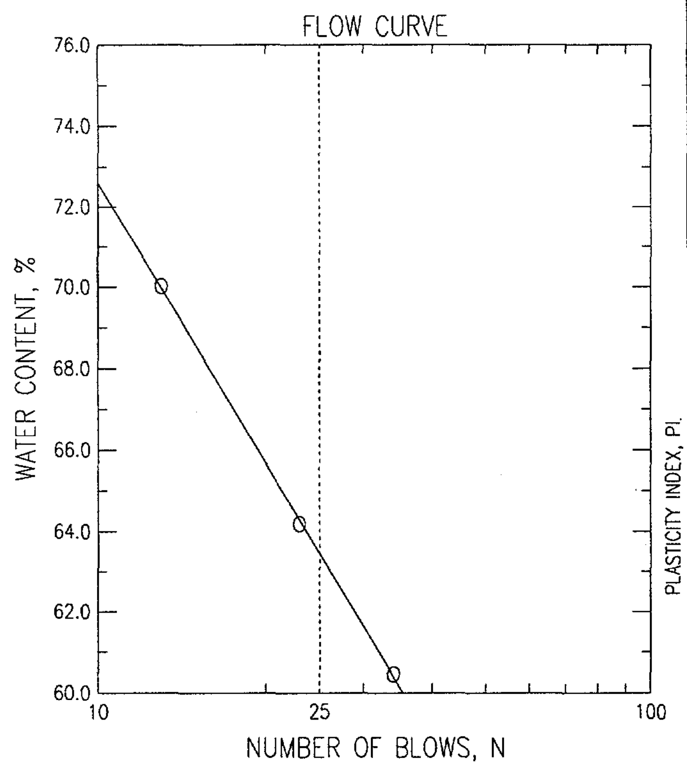
PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Baker Environmental	GTX-2130	tje	---
LOCATION ---		CHECKED BY gtt	SAMPLE NUMBER RF-SD02-99A
SAMPLE DESCRIPTION Very wet, dark greenish gray sandy clay w/ shells		DATE Tue Jan 26 1999	FILENAME RFSD0299

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	bk17	bk33	bk137		
WT. WET SOIL + TARE	37.14	39.16	37.22		
WT. DRY SOIL + TARE	33.94	35.63	34.27		
WT. WATER	3.2	3.53	2.95		
TARE WT.	29.37	30.13	29.39		
WT. DRY SOIL	4.57	5.5	4.88		
WATER CONTENT, W_N (%)	70.02	64.18	60.45		
NUMBER OF BLOWS, N	13	23	34		
ONE-POINT LIQUID LIMIT, LL	64.69	63.54	62.74		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	bk76	bk144			
WT. WET SOIL + TARE	34.24	37.63			
WT. DRY SOIL + TARE	33.37	36.19			
WT. WATER	0.87	1.44			
TARE WT.	29.19	29.61			
WT. DRY SOIL	4.18	6.58			
WATER CONTENT (%)	20.81	21.88			



SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	69.1
LIQUID LIMIT, LL	63.5
PLASTIC LIMIT, PL	21.3
PLASTICITY INDEX, PI	42.1
LIQUIDITY INDEX, LI*	1.13

*LI = (W − PL)/PI

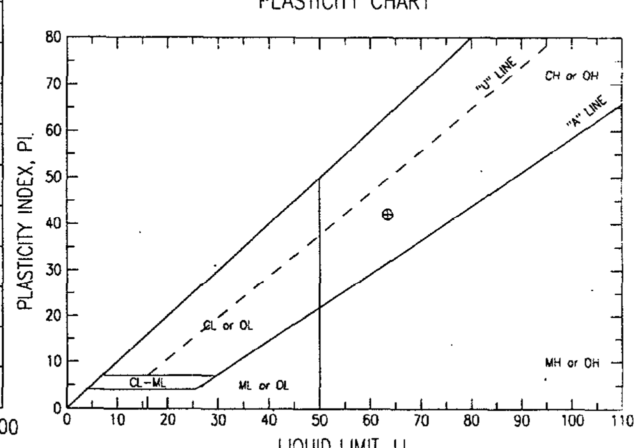


Fig. 2.0

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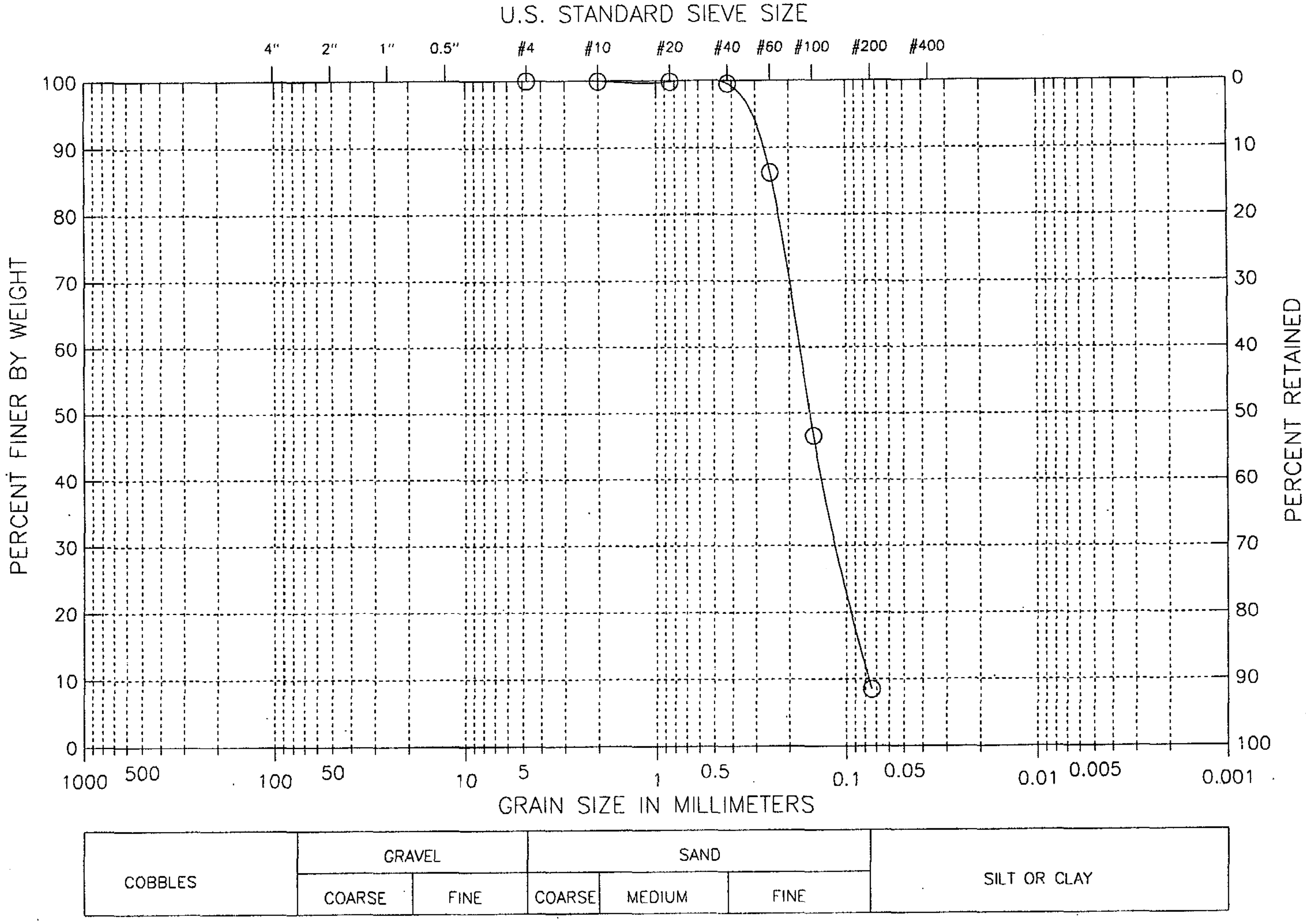
	Boring No. : ---	Project : Baker Environmental
	Sample No.: SB-SD01-99A	Project No.: GTX-2130
	Test Method ASTM D 422	Location: ---
	Filename : SBSD0199	Date : Tue Jan 26 1999



Classification :
(SP-SM) Poorly graded sand with silt

Visual Description :
Wet, dark greenish gray sand with silt

Remarks :

Figure 3

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GEOTECHNICAL LABORATORY TEST DATA

Project : Baker Environmental
Project No. : GTX-2130
Boring No. : ---
Sample No. : SB-SD01-99A
Location : ---
Soil Description : Wet, dark greenish gray sand with silt
Remarks : ---

Depth : ---
Test Date : 01/25/99
Test Method : ASTM D 422

Filename : SBSD0199
Elevation : ---
Tested by : tje
Checked by : gtt

FINE SIEVE SET

Sieve Mesh	Sieve Openings Inches	Millimeters	Weight Retained (gm)	Cumulative Weight Retained (gm)	Percent Finer (%)
#4	0.187	4.75	0.00	0.00	100
#10	0.079	2.00	0.08	0.08	100
#20	0.033	0.84	0.08	0.16	100
#40	0.017	0.42	0.29	0.45	100
#60	0.010	0.25	12.89	13.34	86
#100	0.006	0.15	38.42	51.76	47
#200	0.003	0.07	36.88	88.64	8
Pan			8.22	96.86	0

Total Dry Weight of Sample = 106.28

D85 : 0.2460 mm
D60 : 0.1776 mm
D50 : 0.1558 mm
D30 : 0.1099 mm
D15 : 0.0834 mm
D10 : 0.0761 mm

Soil Classification
ASTM Group Symbol : SP-SM
ASTM Group Name : Poorly graded sand with silt
AASHTO Group Symbol : A-3(0)
AASHTO Group Name : Fine Sand

ATTERBERG LIMITS

PROJECT	PROJECT NUMBER	TESTED BY	BORING NUMBER
Baker Environmental	GTX-2130	tje	---
LOCATION ---		CHECKED BY gtt	SAMPLE NUMBER SB-SD01-99A
SAMPLE DESCRIPTION Wet, dark greenish gray sand with silt		DATE Tue Jan 26 1999	FILENAME SBSD0199

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT, W_N (%)					
NUMBER OF BLOWS, N					
ONE-POINT LIQUID LIMIT, LL					

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER					
WT. WET SOIL + TARE					
WT. DRY SOIL + TARE					
WT. WATER					
TARE WT.					
WT. DRY SOIL					
WATER CONTENT (%)					

SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	27.9
LIQUID LIMIT, LL	
PLASTICITY LIMIT, PL	
PLASTICITY INDEX, PI	
LIQUIDITY INDEX, LI*	

*LI = (W - PL)/PI

PLASTICITY CHART

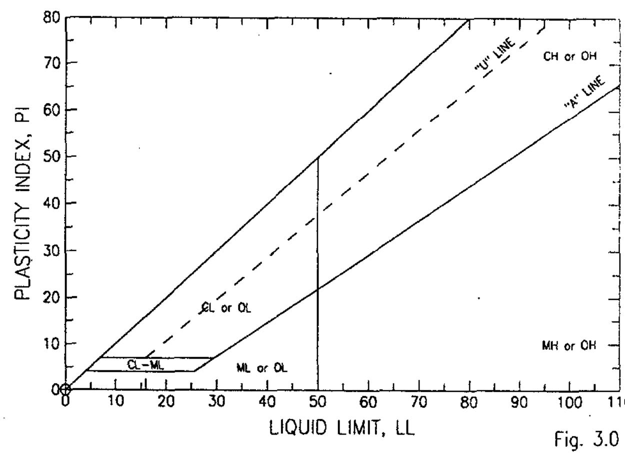

Fig. 3.0

401

STONE BAY

CLAM, MUSSEL, AND OYSTER TISSUE - INORGANICS

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

RF-CL01-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-08 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 15.4

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	64.2			P
7440-36-0	Antimony	0.10	U		P
7440-38-2	Arsenic	11.1		*E	P
7440-39-3	Barium	0.99	B		P
7440-41-7	Beryllium	0.04	U		P
7440-43-9	Cadmium	0.21			P
7440-70-2	Calcium	3840		*E	P
7440-47-3	Chromium	0.62			P
7440-48-4	Cobalt	1.4	B		P
7440-50-8	Copper	9.5			P
7439-89-6	Iron	158		E	P
7439-92-1	Lead	1.0		N	P
7439-95-4	Magnesium	4950		E	P
7439-96-5	Manganese	9.0		N*E	P
7440-02-0	Nickel	3.6			P
7440-09-7	Potassium	6240		E	P
7782-49-2	Selenium	2.0		N	P
7440-22-4	Silver	0.03	U	N	P
7440-23-5	Sodium	39900			P
7440-28-0	Thallium	0.08	U		P
7440-62-2	Vanadium	2.5			P
7440-66-6	Zinc	86.1		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

EPA SAMPLE NO.

RF-CL02-99A

INORGANIC ANALYSIS DATA SHEET

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: TY0199A

Matrix (soil/water): SOIL   Lab Sample ID: T990034-21 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 11.5

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	249			P
7440-36-0	Antimony	0.14	U		P
7440-38-2	Arsenic	16.2		*E	P
7440-39-3	Barium	1.7	B		P
7440-41-7	Beryllium	0.05	U		P
7440-43-9	Cadmium	0.23	B		P
7440-70-2	Calcium	5720		*E	P
7440-47-3	Chromium	1.2			P
7440-48-4	Cobalt	2.1	B		P
7440-50-8	Copper	10.1			P
7439-89-6	Iron	370		E	P
7439-92-1	Lead	0.70		N	P
7439-95-4	Magnesium	6020		E	P
7439-96-5	Manganese	9.0		N*E	P
7440-02-0	Nickel	4.0			P
7440-09-7	Potassium	9740		E	P
7782-49-2	Selenium	3.1		N	P
7440-22-4	Silver	0.04	U	N	P
7440-23-5	Sodium	48900			P
7440-28-0	Thallium	0.11	U		P
7440-62-2	Vanadium	3.1			P
7440-66-6	Zinc	125		NE	P

Color Before: GREY   Clarity Before: Texture: MEDIUM

Color After: YELLOW   Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

EPA SAMPLE NO.

RF-MU02-99A

INORGANIC ANALYSIS DATA SHEET

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: TY0199A

Matrix (soil/water): SOIL   Lab Sample ID: T990034-09 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 17.9

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	319			P
7440-36-0	Antimony	0.09	U		P
7440-38-2	Arsenic	15.2		*E	P
7440-39-3	Barium	1.2	B		P
7440-41-7	Beryllium	0.03	U		P
7440-43-9	Cadmium	0.21			P
7440-70-2	Calcium	19800		*E	P
7440-47-3	Chromium	1.1			P
7440-48-4	Cobalt	0.34	B		P
7440-50-8	Copper	4.1			P
7439-89-6	Iron	473		E	P
7439-92-1	Lead	1.0		N	P
7439-95-4	Magnesium	3410		E	P
7439-96-5	Manganese	22.8		N*E	P
7440-02-0	Nickel	1.1	B		P
7440-09-7	Potassium	6390		E	P
7782-49-2	Selenium	3.5		N	P
7440-22-4	Silver	0.03	U	N	P
7440-23-5	Sodium	27200			P
7440-28-0	Thallium	0.07	U		P
7440-62-2	Vanadium	3.1			P
7440-66-6	Zinc	38.3		NE	P

Color Before: GREY   Clarity Before: Texture: MEDIUM

Color After: YELLOW   Clarity After: Artifacts:

Comments:

219

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

RF-OY01-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: TY0199A

Matrix (soil/water): SOIL   Lab Sample ID: T990034-07 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 11.8

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	104			P
7440-36-0	Antimony	0.13	U		P
7440-38-2	Arsenic	18.8		*E	P
7440-39-3	Barium	1.2	B		P
7440-41-7	Beryllium	0.05	U		P
7440-43-9	Cadmium	0.20	B		P
7440-70-2	Calcium	4390		*E	P
7440-47-3	Chromium	0.85			P
7440-48-4	Cobalt	2.6			P
7440-50-8	Copper	8.2			P
7439-89-6	Iron	243		E	P
7439-92-1	Lead	2.0		N	P
7439-95-4	Magnesium	5900		E	P
7439-96-5	Manganese	10.3		N*E	P
7440-02-0	Nickel	4.5			P
7440-09-7	Potassium	7500		E	P
7782-49-2	Selenium	2.3		N	P
7440-22-4	Silver	0.04	U	N	P
7440-23-5	Sodium	46800			P
7440-28-0	Thallium	0.10	U		P
7440-62-2	Vanadium	3.3			P
7440-66-6	Zinc	88.9		NE	P

Color Before: GREY   Clarity Before: Texture: MEDIUM

Color After: YELLOW   Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

RF-OY02-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-13 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 9.8

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	320			P
7440-36-0	Antimony	0.15	U		P
7440-38-2	Arsenic	32.2		*E	P
7440-39-3	Barium	1.2	B		P
7440-41-7	Beryllium	0.06	U		P
7440-43-9	Cadmium	1.8			P
7440-70-2	Calcium	18200		E	P
7440-47-3	Chromium	1.5			P
7440-48-4	Cobalt	0.84	B		P
7440-50-8	Copper	88.2			P
7439-89-6	Iron	581		E	P
7439-92-1	Lead	1.2		N	P
7439-95-4	Magnesium	6150		E	P
7439-96-5	Manganese	19.2		N*E	P
7440-02-0	Nickel	2.1	B		P
7440-09-7	Potassium	15200		E	P
7782-49-2	Selenium	5.6		N	P
7440-22-4	Silver	1.4		N	P
7440-23-5	Sodium	51000			P
7440-28-0	Thallium	0.12	U		P
7440-62-2	Vanadium	4.6			P
7440-66-6	Zinc	2230		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE

1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-CL04-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-11 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 10.7

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	275			P
7440-36-0	Antimony	0.14	U		P
7440-38-2	Arsenic	12.4		*E	P
7440-39-3	Barium	1.7	B		P
7440-41-7	Beryllium	0.05	U		P
7440-43-9	Cadmium	0.47			P
7440-70-2	Calcium	12400		*E	P
7440-47-3	Chromium	1.2			P
7440-48-4	Cobalt	2.3	B		P
7440-50-8	Copper	12.6			P
7439-89-6	Iron	442		E	P
7439-92-1	Lead	1.8		N	P
7439-95-4	Magnesium	8370		E	P
7439-96-5	Manganese	33.5		N*E	P
7440-02-0	Nickel	4.1			P
7440-09-7	Potassium	11600		E	P
7782-49-2	Selenium	2.8		N	P
7440-22-4	Silver	0.04	U	N	P
7440-23-5	Sodium	71900			P
7440-28-0	Thallium	0.10	U		P
7440-62-2	Vanadium	1.9	B		P
7440-66-6	Zinc	117		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-MU01/02-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: TY0199A

Matrix (soil/water): SOIL   Lab Sample ID: T990034-02 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 15.4

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	1010			P
7440-36-0	Antimony	0.09	U		P
7440-38-2	Arsenic	11.0		*E	P
7440-39-3	Barium	1.5	B		P
7440-41-7	Beryllium	0.05	B		P
7440-43-9	Cadmium	0.24			P
7440-70-2	Calcium	19500		*E	P
7440-47-3	Chromium	1.9			P
7440-48-4	Cobalt	0.55	B		P
7440-50-8	Copper	12.5			P
7439-89-6	Iron	1100		E	P
7439-92-1	Lead	4.8		N	P
7439-95-4	Magnesium	3080		E	P
7439-96-5	Manganese	26.3		N*E	P
7440-02-0	Nickel	3.0			P
7440-09-7	Potassium	7130		E	P
7782-49-2	Selenium	3.4		N	P
7440-22-4	Silver	0.03	U	N	P
7440-23-5	Sodium	24100			P
7440-28-0	Thallium	0.07	U		P
7440-62-2	Vanadium	3.3			P
7440-66-6	Zinc	45.0		NE	P

Color Before: GREY   Clarity Before: Texture: MEDIUM

Color After: YELLOW   Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-MU04-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-12 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 6.7

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	455			P
7440-36-0	Antimony	0.23	U		P
7440-38-2	Arsenic	37.4		*E	P
7440-39-3	Barium	2.3	B		P
7440-41-7	Beryllium	0.09	U		P
7440-43-9	Cadmium	0.52			P
7440-70-2	Calcium	24100		*E	P
7440-47-3	Chromium	2.0			P
7440-48-4	Cobalt	0.64	B		P
7440-50-8	Copper	12.9			P
7439-89-6	Iron	643		E	P
7439-92-1	Lead	1.6		N	P
7439-95-4	Magnesium	7950		E	P
7439-96-5	Manganese	91.9		N*E	P
7440-02-0	Nickel	3.0	B		P
7440-09-7	Potassium	18900		E	P
7782-49-2	Selenium	9.4		N	P
7440-22-4	Silver	0.07	U	N	P
7440-23-5	Sodium	69800			P
7440-28-0	Thallium	0.18	U		P
7440-62-2	Vanadium	4.9			P
7440-66-6	Zinc	101		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-MU05-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: TY0199A

Matrix (soil/water): SOIL   Lab Sample ID: T990034-05 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 18.6

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	317			P
7440-36-0	Antimony	0.09	U		P
7440-38-2	Arsenic	11.3		*E	P
7440-39-3	Barium	0.83	B		P
7440-41-7	Beryllium	0.03	U		P
7440-43-9	Cadmium	0.19			P
7440-70-2	Calcium	8470		*E	P
7440-47-3	Chromium	0.82			P
7440-48-4	Cobalt	0.35	B		P
7440-50-8	Copper	4.1			P
7439-89-6	Iron	366		E	P
7439-92-1	Lead	1.3		N	P
7439-95-4	Magnesium	3010		E	P
7439-96-5	Manganese	18.1		N*E	P
7440-02-0	Nickel	0.73	B		P
7440-09-7	Potassium	6080		E	P
7782-49-2	Selenium	3.3		N	P
7440-22-4	Silver	0.03	U	N	P
7440-23-5	Sodium	27600			P
7440-28-0	Thallium	0.07	U		P
7440-62-2	Vanadium	1.9			P
7440-66-6	Zinc	34.1		NE	P

Color Before: GREY   Clarity Before: Texture: MEDIUM

Color After: YELLOW   Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

EPA SAMPLE NO.

INORGANIC ANALYSIS DATA SHEET

SB-OY01-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-01 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 15.1

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	111			P
7440-36-0	Antimony	0.10	U		P
7440-38-2	Arsenic	12.5		*E	P
7440-39-3	Barium	0.83	B		P
7440-41-7	Beryllium	0.04	U		P
7440-43-9	Cadmium	1.6			P
7440-70-2	Calcium	2330		E	P
7440-47-3	Chromium	0.65			P
7440-48-4	Cobalt	0.37	B		P
7440-50-8	Copper	50.3			P
7439-89-6	Iron	225		E	P
7439-92-1	Lead	1.6		N	P
7439-95-4	Magnesium	2740		E	P
7439-96-5	Manganese	9.8		N*E	P
7440-02-0	Nickel	2.4			P
7440-09-7	Potassium	8940		E	P
7782-49-2	Selenium	3.2		N	P
7440-22-4	Silver	0.34	B	N	P
7440-23-5	Sodium	19700			P
7440-28-0	Thallium	0.08	U		P
7440-62-2	Vanadium	1.4	B		P
7440-66-6	Zinc	1280		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

226

TOTAL METALS TISSUE
1

EPA SAMPLE NO.

INORGANIC ANALYSIS DATA SHEET

SB-OY02-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-06 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 15.7

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	49.3			P
7440-36-0	Antimony	0.10	U		P
7440-38-2	Arsenic	7.4		*E	P
7440-39-3	Barium	0.35	B		P
7440-41-7	Beryllium	0.04	U		P
7440-43-9	Cadmium	1.1			P
7440-70-2	Calcium	2830		*E	P
7440-47-3	Chromium	0.46			P
7440-48-4	Cobalt	0.34	B		P
7440-50-8	Copper	45.1			P
7439-89-6	Iron	123		E	P
7439-92-1	Lead	0.69		N	P
7439-95-4	Magnesium	2450		E	P
7439-96-5	Manganese	6.4		N*E	P
7440-02-0	Nickel	1.1	B		P
7440-09-7	Potassium	8780		E	P
7782-49-2	Selenium	2.8		N	P
7440-22-4	Silver	0.03	U	N	P
7440-23-5	Sodium	18600			P
7440-28-0	Thallium	0.08	U		P
7440-62-2	Vanadium	0.68	B		P
7440-66-6	Zinc	793		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-OY03-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-03 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 12.0

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	90.6			P
7440-36-0	Antimony	0.12	U		P
7440-38-2	Arsenic	10.0		*E	P
7440-39-3	Barium	0.62	B		P
7440-41-7	Beryllium	0.05	U		P
7440-43-9	Cadmium	1.7			P
7440-70-2	Calcium	4040		*E	P
7440-47-3	Chromium	0.66			P
7440-48-4	Cobalt	0.25	U		P
7440-50-8	Copper	46.0			P
7439-89-6	Iron	199		E	P
7439-92-1	Lead	1.0		N	P
7439-95-4	Magnesium	3960		E	P
7439-96-5	Manganese	11.8		N*E	P
7440-02-0	Nickel	2.3			P
7440-09-7	Potassium	9090		E	P
7782-49-2	Selenium	3.1		N	P
7440-22-4	Silver	0.04	U	N	P
7440-23-5	Sodium	31700			P
7440-28-0	Thallium	0.09	U		P
7440-62-2	Vanadium	0.56	B		P
7440-66-6	Zinc	722		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-OY04-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC   Case No.: CTO 100   SAS No.:   SDG No.: TY0199A

Matrix (soil/water): SOIL   Lab Sample ID: T990034-10 S

Level (low/med): LOW   Date Received: 01/19/99

% Solids: 11.3

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	69.5			P
7440-36-0	Antimony	0.13	U		P
7440-38-2	Arsenic	11.9		*E	P
7440-39-3	Barium	0.68	B		P
7440-41-7	Beryllium	0.05	U		P
7440-43-9	Cadmium	1.3			P
7440-70-2	Calcium	7840		*E	P
7440-47-3	Chromium	0.72			P
7440-48-4	Cobalt	0.27	U		P
7440-50-8	Copper	21.4			P
7439-89-6	Iron	228		E	P
7439-92-1	Lead	0.82		N	P
7439-95-4	Magnesium	5110		E	P
7439-96-5	Manganese	7.0		N*E	P
7440-02-0	Nickel	1.8	B		P
7440-09-7	Potassium	11200		E	P
7782-49-2	Selenium	2.8		N	P
7440-22-4	Silver	0.04	U	N	P
7440-23-5	Sodium	43800			P
7440-28-0	Thallium	0.10	U		P
7440-62-2	Vanadium	1.7	B		P
7440-66-6	Zinc	728		NE	P

Color Before: GREY   Clarity Before: Texture: MEDIUM

Color After: YELLOW   Clarity After: Artifacts:

Comments:

TOTAL METALS TISSUE
1

INORGANIC ANALYSIS DATA SHEET

EPA SAMPLE NO.

SB-OY05-99A

Lab Name: CEIMIC CORPORATION

Contract: BAKER ENV.

Lab Code: CEIMIC Case No.: CTO 100 SAS No.: SDG No.: TY0199A

Matrix (soil/water): SOIL Lab Sample ID: T990034-04 S

Level (low/med): LOW Date Received: 01/19/99

% Solids: 20.0

Concentration Units (ug/L or mg/Kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	78.9			P
7440-36-0	Antimony	0.08	U		P
7440-38-2	Arsenic	4.1		*E	P
7440-39-3	Barium	0.30	B		P
7440-41-7	Beryllium	0.03	U		P
7440-43-9	Cadmium	0.60			P
7440-70-2	Calcium	5960		E	P
7440-47-3	Chromium	0.43			P
7440-48-4	Cobalt	0.21	B		P
7440-50-8	Copper	17.1			P
7439-89-6	Iron	137		E	P
7439-92-1	Lead	0.40		N	P
7439-95-4	Magnesium	2620		E	P
7439-96-5	Manganese	5.7		N*E	P
7440-02-0	Nickel	1.3			P
7440-09-7	Potassium	5000		E	P
7782-49-2	Selenium	1.0		N	P
7440-22-4	Silver	0.02	U	N	P
7440-23-5	Sodium	22400			P
7440-28-0	Thallium	0.06	U		P
7440-62-2	Vanadium	0.35	B		P
7440-66-6	Zinc	894		NE	P

Color Before: GREY Clarity Before: Texture: MEDIUM

Color After: YELLOW Clarity After: Artifacts:

Comments:

STONE BAY

CLAM, MUSSEL, AND OYSTER TISSUE - MERCURY

CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: PBO

Date Sampled:

Date Sample Received: 01/19/99

Matrix: Soil

Laboratory ID: PBO

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	ND	0.003

ND = Not Detected

Reported by: *[signature]*

Approved by: *[signature]*

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

LABORATORY CONTROL SAMPLE SUMMARY
TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Ceimic Project: 990034

Laboratory Control Spike ID: SRM-2

Date Analysis Completed: 02/01/99

Matrix: Soil

Concentration in: mg/Kg (ppm)

Target Analyte	Preparation Batch	True Value	Lab Control Spike Result	Lab Control Spike Recovery(%)	QC Limits(%)
Mercury	0201	0.064	0.0570	89.1	80 - 120

Reported by: Donald Totorelli

Approved by: NP

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CEIMIC
Corporation
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TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-CL01-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 15

Laboratory ID: 990034-08

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.050	0.003

+ Dry weight basis.

Reported by: Donald Tatorelli

Approved by: NP

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CEIMIC
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"Analytical Chemistry for Environmental Management"

DUPLICATE SAMPLE SUMMARY
TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-CL01-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Tissue

Duplicate Percent Solids: 15

Laboratory ID: 990034-08Dup

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Sample Result	Duplicate Result	RPD(%)	QC Limit(%)
Mercury	0.0500	0.0620	21	20

+ Dry weight basis.
RPD = Relative Percent Difference

Reported by: Donald Tortorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

SPIKE SAMPLE SUMMARY
TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-CL01-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Tissue

Percent Solids: 15

Laboratory ID: 990034-08Spk

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Sample Result	Predigest Spike Added	Spiked Sample Result	Recovery(%) Predigest Spike	Recovery(%) QC Limits	Recovery(%) Post Digest Spike
Mercury	0.0500	0.150	0.167	78	75 - 125	NR

NR = Not Required
\+ Dry weight basis.

Reported by: Donald Tatoulli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-CL02-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 12

Laboratory ID: 990034-21

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.054	0.003

+ Dry weight basis.

Reported by: Donald Vatorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-CL04-99A

Date Sampled: 01/15/99

Laboratory ID: 990034-11

Date Sample Received: 01/19/99

Date Analysis Completed: 02/01/99

Matrix: Soil

Concentration in: mg/Kg (ppm)+

Percent Solids: 11

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.048	0.003

+ Dry weight basis.

Reported by: Donald Tortorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-MU01/02-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 15

Laboratory ID: 990034-02

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.088	0.003

+ Dry weight basis.

Reported by: Donald Tatorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-MU02-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 18

Laboratory ID: 990034-09

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.082	0.003

+ Dry weight basis.

Reported by: Donald Tatorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-MU04-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 7

Laboratory ID: 990034-12

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.157	0.003

\+ Dry weight basis.

Reported by: ______

Approved by: ______

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-MU05-99A

Date Sampled: 01/15/99

Laboratory ID: 990034-05

Date Sample Received: 01/19/99

Date Analysis Completed: 02/01/99

Matrix: Soil

Concentration in: mg/Kg (ppm)+

Percent Solids: 19

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.086	0.003

+ Dry weight basis.

Reported by: [signature]

Approved by: [signature]

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-OY01-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 12

Laboratory ID: 990034-07

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.094	0.003

+ Dry weight basis.

Reported by: Donald Totoelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-OY01-99A

Date Sampled: 01/14/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 15

Laboratory ID: 990034-01

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.063	0.003

+ Dry weight basis.

Reported by: Donald Tatoulli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-OY02-99A

Date Sampled: 01/15/99

Laboratory ID: 990034-06

Date Sample Received: 01/19/99

Date Analysis Completed: 02/01/99

Matrix: Soil

Concentration in: mg/Kg (ppm)+

Percent Solids: 16

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.069	0.003

+ Dry weight basis.

Reported by: Donald Tortorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: RF-OY02-99A

Date Sampled: 01/16/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 10

Laboratory ID: 990034-13

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.156	0.003

+ Dry weight basis.

Reported by: Donald Tortorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-OY03-99A

Date Sampled: 01/15/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 12

Laboratory ID: 990034-03

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.252	0.003

+ Dry weight basis.

Reported by: Donald Tortorelli

Approved by: NP

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-OY04-99A

Date Sampled: 01/15/99

Laboratory ID: 990034-10

Date Sample Received: 01/19/99

Date Analysis Completed: 02/01/99

Matrix: Soil

Concentration in: mg/Kg (ppm)+

Percent Solids: 11

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.070	0.003

\+ Dry weight basis.

Reported by: [signature]

Approved by: [signature]

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CEIMIC
Corporation
"Analytical Chemistry for Environmental Management"

TOTAL METALS
CLP METHOD ILM04.0

Client: Baker Environmental

Client Sample ID: SB-OY05-99A

Date Sampled: 01/15/99

Date Sample Received: 01/19/99

Matrix: Soil

Percent Solids: 20

Laboratory ID: 990034-04

Date Analysis Completed: 02/01/99

Concentration in: mg/Kg (ppm)+

Target Analyte	Preparation Batch	Sample Concentration	Reporting Limit
Mercury	0201	0.053	0.003

+ Dry weight basis.

Reported by: Donald Vatorelli

Approved by: NP

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Baker

Baker Environmental, Inc.

ATTACHMENT D

Analytical Quality Assurance

ENVIRONMENTAL RESOURCE ASSOCIATES
Arvada, Colorado 80002 1-800-ERA-0122

9306021C → 930621F

Certification

F21 → F24

Lot 216

PriorityPollutnT™/CLP Quality Control Standards

Inorganics in Soil

Parameter	Lot Number 216 Certified Value mg/kg	Advisory Range mg/kg	
TRACE METALS			
aluminum	6000	3600 - 8400	60–140%
antimony	27.8	14 - 117	50 – 150
arsenic	67.7	41 - 105	61 – 150
barium	187	131 - 243	70 – 130
beryllium	57.5	35 - 81	61 – 141
cadmium	110	55 - 166	50 – 160
calcium	2040	1220 - 2860	60 – 140
chromium	169	95 - 265	50 – 140
cobalt	87.0	43 - 130	~~50~~ 49 – 149
copper	141	84 - 200	60 – 142
iron	10800	7020 - 15100	65 – 140
lead	100	55 - 140	55 – 140
magnesium	2050	1200 - 3080	59 – 150
manganese	294	206 - 383	70 – 130
mercury	2.36	1.3 - 3.8	55 – 161
molybdenum	124	93 - 167	75 – 135
nickel	79.6	40 - 112	50 – 140
potassium	2130	1260 - 2770	60 – 130
selenium	99.1	54 - 149	54 – 150
silver	124	62 - 186	50 – 150
sodium	527	316 - 738	60 – 140
thallium	67.9	34 - 102	50 – 150
vanadium	84.8	59 - 115	70 – 135
zinc	197	98 - 280	50 – 142

1. The Trace Metals Certified Values are equal to the mean recoveries for each parameter as determined in an interlaboratory round robin study (3 laboratories, 10 to 24 data points per parameter). The standard was digested using Method 3050, SW-846 and the digest analyzed by ICP and atomic absorption spectroscopy.

2. The Advisory Ranges are listed as guidelines for acceptable recoveries given the limitations of the EPA methodologies commonly used to determine these parameters. The range closely approximates the 95% confidence interval for these parameters based upon experimental data from this lot, previous ERA lots and published USEPA data.

F80
9463231

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material 1566a

Oyster Tissue

This Standard Reference Material (SRM) is intended primarily for use in calibrating instrumentation and validating methodology for the chemical analysis of marine bivalve tissue. A unit of SRM 1566a contains approximately 25 grams of oyster tissue.

Certified Concentrations of Constituent Elements: The certified elemental concentrations are shown in Table 1. Certified values are based on results obtained by reference methods of known accuracy; or alternatively, from results obtained by two or more independent and reliable analytical methods. Noncertified values are given, for information only, in Table 2. All values are based on minimum sample size of 250 mg of the dried material.

NOTICE AND WARNINGS TO USERS

Expiration of Certification: This certification is invalid after 5 years from the date of shipping. Please return the attached registration card to register your SRM.

Storage: The material should be kept in its tightly closed, original bottle and stored in a desiccator over $Mg(ClO_4)_2$ at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation, including ultraviolet lamps or sunlight.

Use: A minimum sample weight of 250 mg of the dried material (see Instructions for Drying) is necessary for any certified value in Table 1 to be valid within the stated uncertainty. The bottle should be shaken well before each use, closed tightly immediately after use, and stored as described above.

The statistical analysis of the data was performed by S.B. Schiller and K.R. Eberhardt of the Statistical Engineering Division.

The overall direction and coordination of the analytical chemistry measurements leading to this certificate were performed in the NIST Center for Analytical Chemistry by R. Zeisler.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Gaithersburg, MD 20899
October 2, 1989

Stanley D. Rasberry, Chief
Office of Standard Reference Materials

(over)

Instructions for Drying: Before weighing, samples of SRM 1566a should be dried to constant weight by one of the following procedures:

1. Reduced-pressure drying at room temperature for 48 hours over $Mg(ClO_4)_2$ in a vacuum desiccator at approximately 1.3×10^4 Pa (100 mm Hg).

2. Vacuum drying at room temperature for 24 hours at a pressure of approximately 30 Pa (0.2 mm Hg) using a cold trap.

3. Freeze drying for 20 hours at a pressure of approximately 3 Pa (0.02 mm Hg).

Source and Preparation of Material: The oysters for this reference material were obtained from a commercial source. They had been shucked, frozen, and packaged in sealed plastic bags. The oyster material was ground, freeze-dried, and powdered at Leon Laboratories, Fort Lauderdale, FL. At NIST, the oyster tissue was jet-milled to pass a 355-µm screen, radiation-sterilized, and bottled.

Homogeneity Assessment: Samples from randomly selected bottles of SRM 1566a were analyzed for homogeneity by x-ray fluorescence and neutron activation methods. In addition, results by other analytical methods were examined for evidence of inhomogeneity. The uncertainties in Table 1 include estimates of inhomogeneity.

Table 1. Certified Concentrations of Constituent Elements

Element[1]	Concentration,[2] Wt. Percent	Element[1]	Concentration,[2] Wt. Percent
Calcium[d,e,o]	0.196 ± 0.019	Potassium[f,k]	0.790 ± 0.047
Chlorine[g,k,o]	0.829 ± 0.014	Sodium[d,k]	0.417 ± 0.013
Magnesium[d,e,k]	0.118 ± 0.017	Sulfur[g,l]	0.862 ± 0.019
Phosphorus[d,o]	0.623 ± 0.018		

Element[1]	Concentration,[2] µg/g	Element[1]	Concentration,[2] µg/g
Aluminum[f,k]	202.5 ± 12.5	Manganese[d,e,k,o]	12.3 ± 1.5
Arsenic[c,k,l]	14.0 ± 1.2	Mercury[a,l]	0.0642 ± .0067
Cadmium[b,h,k,l,m]	4.15 ± 0.38	Nickel[b,h,l,o]	2.25 ± 0.44
Chromium[h,k,l]	1.43 ± 0.46	Selenium[k,l,o]	2.21 ± 0.24
Cobalt[k,l]	0.57 ± 0.11	Silver[h,k,l]	1.68 ± 0.15
Copper[b,e,h,k,l,m,o]	66.3 ± 4.3	Strontium[e,h,o]	11.1 ± 1.0
Iodine[i,k,l]	4.46 ± 0.42	Uranium[i,j]	0.132 ± 0.012
Iron[d,k,o]	539 ± 15	Vanadium[j,k,l]	4.68 ± 0.15
*Lead[h]	0.371 ± 0.014	Zinc[d,e,k,l,m,o]	830 ± 57

* Lead was determined by isotope dilution mass spectrometry, inductively coupled plasma, at NIST and at another laboratory.

1. Analytical Methods:
[a]Atomic absorption spectrometry, cold vapor
[b]Atomic absorption spectrometry, electrothermal
[c]Atomic absorption spectrometry, hydride generation
[d]Atomic emission spectrometry, direct current plasma
[e]Atomic emission spectrometry, inductively coupled plasma
[f]Atomic emission spectroscopy, flame
[g]Ion chromatography
[h]Isotope dilution mass spectrometry, inductively coupled plasma
[i]Isotope dilution mass spectrometry, resonance ionization
[j]Isotope dilution mass spectrometry, thermal ionization
[k]Neutron activation, instrumental
[l]Neutron activation, radiochemical
[m]Polarography
[n]Spectrophotometry
[o]X-ray fluorescence spectrometry

2. Based on dry weight. (For drying instructions, please refer to the section of this certificate on Instructions for rying.)

The certified concentrations are weighted means of results from two or more analytical techniques. The weights for the weighted means were computed according to the iterative procedure of Paule and Mandel [1]. Each uncertainty is obtained from a 95% prediction interval plus an allowance for systematic error among the methods used. The allowance for systematic error is equal to the greatest difference between the weighted mean (certified value) and the component means for the analytical methods used. In the absence of systematic error, the resulting uncertainty limits will cover the concentration of approximately 95% of samples of this SRM having a minimum sample size of 250 mg.

Table 2. Noncertified Concentrations of Constituent Elements

Element	Concentration, Percent by Weight
Nitrogen (Kjeldahl)	(6.81)

Method Reference. Official Methods of Analysis of the Association of Official Analytical Chemists, Arlington, VA, 14th Ed., 1984, p. 16, Nitrogen (Total) in Fertilizers, Kjeldahl Method (Final Action): Method 2.057, Improved Method for Nitrate Free Samples. Mercuric Oxide was used as a catalyst. Samples were dried as described in procedure 2 under "Instructions for Drying".

Element	Concentration, µg/g	Element	Concentration, µg/g
Antimony	(0.01)	Rubidium	(3)
Cerium	(0.4)	Samarium	(0.06)
Cesium	(0.02)	Scandium	(0.06)
Europium	(0.01)	Tantalum	(0.003)
Fluorine	(240)	Terbium	(0.007)
Gold	(0.01)	Thorium	(0.04)
Hafnium	(0.04)	*Tin	(3)
Lanthanum	(0.3)		

Note: There is evidence that tin is inhomogeneously distributed in the SRM.

Analysts:
Inorganic Analytical Research Division, National Institute of Standards & Technology.

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3. T.A. Butler
4. Z. Chun**
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13. H.M. Kingston
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16. T.J. Murphy
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18. P.A. Pella*
19. K.W. Pratt
20. T.C. Rains
21. T.A. Rush
22. D.S. Simons*
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30. X. Yingkai**
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* Gas and Particulate Science Division
** Guest Scientists

Cooperating Analysts & Organizations

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Reference

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Baker

Baker Environmental, Inc.

ATTACHMENT E

Ecological Information

E.1
Life History Information

LIFE HISTORY OF THE GREAT BLUE HERON (*Ardea herodias*)

The great blue heron is the largest and most widely distributed American heron, inhabiting lakes, ponds, rivers, and marshes but is occasionally found in newly-plowed fields and meadows (Bull and Farrand 1977; Eckert 1987). With the exception of the breeding season, this species is mostly solitary in its habits. This heron feeds either by standing motionless in the water waiting for prey, or searching in a stealthy manner with a very slow and careful walk. The primary food item is fish, although frogs, small turtles, crustaceans, mice, voles, shrews, snakes, and ground-nesting birds are also taken. Almost without exception, the great blue heron will shake its bill in the water immediately after swallowing prey, perhaps to wash debris off. Although the digestive fluids of the heron are acidic enough to dissolve bone rapidly, occasionally an undigested pellet of feathers and fur is regurgitated (Eckert 1987).

Courtship occurs soon after the spring migration, with copulation usually occurring on the ground. Colonial nests are placed on the uppermost branches of trees or shrubs. Occasionally a ground nest will be built if it can be placed in a secluded area. Successful nesting areas are usually returned to year after year. Three to four eggs are incubated equally by both sexes for about twenty-eight days (Eckert 1987).

The great blue heron is migratory in the northernmost portion of its range. Lingering birds usually fall prey to severe weather (Bull and Farrand 1977). Southward migration in autumn begins in early October; northward migration in spring begins in March or early April (Eckert 1987).

EXPOSURE PROFILE OF THE GREAT BLUE HERON (*Ardea herodias*)

Adult great blue heron (*Ardea herodias*) range in weight from 2,204 to 2,576 g (U.S. EPA 1993). A food ingestion rate of 0.18 g/g BW/day and a water ingestion rate of 0.045 g/g BW/day are reported for this species (U.S. EPA 1993). Based on these values a 2,204 g heron will consume 396.7 g food/day and 99.2 g water/day. Fall feeding territory size is reported as 1.5 acres, with summer foraging distances from nesting colonies ranging from 2 to 5 miles (U.S. EPA 1993).

An incidental sediment ingestion rate could not be identified for the great blue heron. Therefore, in order to evaluate this exposure pathway, a model was developed which predicted the amount of sediment which may be entrained in the digestive system of a fish, the bluegill (*Lepomis machrochirus*) and crayfish (*Orconectes* sp.). Fish and crayfish are assumed to be the only food source for the great blue heron in order to complete this derivation.

Bluegills commonly reach a size of 12 ounces (Pflieger 1975). From this, the amount of sediment entrained in fish 12 ounces (340 g) in weight was predicted. A study evaluating the stomach contents of 153 bluegills reported an average content of detritus and sediment to be 9.6 percent of the total diet (Kolehmainen 1974). A daily food ingestion rate of 1.75 percent of the body weight per day has been reported for the bluegill (Kolehmainen 1974). This provides a predicted intake rate of 5.95 g of food per day for a 340 g fish. If a conservative assumption is made that 9.6 percent of the food ingested is entirely sediment, it can be predicted that a fish of this size may contain 0.5712 g of sediment in its digestive system.

For the purpose of this model, it was assumed that the level of sediment contained in the digestive system of a fish remains constant over time. This value (0.5712 g) was divided by the predicted fish body weight (340 g) in order to express sediment entrained in fish digestive systems in units of grams of sediment per gram of fish body weight. This provided a value of 0.00168 g sediment/g body weight. When this value is multiplied by the food ingestion rate of the great blue heron (396.7 g/day), the predicted sediment ingestion rate for the heron via consumption of fish is approximately 0.7 g/day.

As with the bluegill, life history information for the crayfish *Orconectes* sp. was used in predicting the incidental sediment ingestion rate for the great blue heron via consumption of freshwater invertebrates. Adult *O. virilis* weigh from 5 to over 20 g and consume 0.3 to 1 percent of its total body weight per day (Kim 1994; Tack 1941; Vannote 1963). In order to express the food ingestion rate in units of g/day, the highest reported food ingestion rate of 1 percent of the total body weight per day was multiplied by the lowest reported body weight of 5 g to yield a food ingestion rate of 0.05 g/day. *Orconectes* spp. detritus ingestion rates range from 10 percent of the total diet per day in young-of-the-year *Orconectes immunis* (Vannote 1963) to 11 percent of the total diet per day in *O. virilis* (Tack 1941). For this risk assessment, it will be assumed that these values represent the percentage of sediment in the diet of a crayfish. The food ingestion rate of 0.05 g/day was multiplied by the incidental sediment ingestion rate of 11 percent of the total diet per day to yield an incidental sediment ingestion rate of 0.0055 g/day. For the purpose of this model, it was assumed that the level of sediment contained in the digestive system of crayfish remains constant over time. Therefore, in order to express the amount of sediment entrained in a crayfish's digestive system in units of gram of sediment per gram of crayfish body weight, the sediment ingestion rate of 0.0055 g/day was divided by the lowest adult crayfish body weight of 5 g to yield a sediment ingestion rate of 0.0011 g sediment/g BW of crayfish/day. When this value is multiplied by the food ingestion rate of the great blue heron (396.7 g/day), the predicted incidental sediment ingestion rate for the great blue heron via consumption of crayfish is 0.44 g/day.

[The user of this file should then decide what the percent composition of fish versus crayfish the diet is assumed to be for the particular risk assessment, then apply the percentages to these calculated sediment ingestion rates]

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LIFE HISTORY INFORMATION FOR GREAT BLUE HERON
(*Ardea herodias*)

Body Weight:	3.0 kg (Newell et al. 1987)
Ingestion Rate:	0.6 kg/day (Newell et al. 1987)
Home Range:	Based on a 10 km radius feeding range, the home range of great blue heron is 30,000 ha (Erwin and Spendelow 1991). This equates to 74,130 acres.
Water Ingestion Rate:	0.12 L/day estimated based on the allometric equation (Water Ingestion Rate $= 0.059\ Wt^{0.67}$, where Wt is the average body weight of the species in kg)
Diet:	Almost all aquatic (Erwin and Spendelow 1991)
Sediment Ingestion Rate	54 g/day (based on 9% of the dietary ingestion rate) calculated based on soil ingestion rates reported for shore birds and Canada gees (Beyer et al. 1991)

LIFE HISTORY OF THE MINK (*Mustela vison*)

Adult mink (*Mustela vison*) weigh from 520 to 1,730 g (Merritt 1987; U.S. EPA 1993). Home ranges vary from 19 to 1,900 acres (U.S. EPA 1993). The lowest reported body weight of 520 g and the smallest reported home range of 19 acres was assumed for this risk assessment.

Mink are opportunistic carnviores that hunt principally along shorelines and emergent vegetation (U.S. EPA 1993). Seasonal availability and regional preferences govern the primary constituent of the mink's diet. Mammals and crayfish usually result as the most most abundant prey items, but fish, amphibians, and young birds are also taken (Merritt 1987; Linscombe *et al.* 1982; U.S. EPA 1993). A year-round food ingestion rate of 0.22 g/g BW/day has been estimated for both male and female mink (U.S. EPA 1993). In order to express this value in units of g/day, the food ingestion rate was multiplied by the lowest reported body weight (550 g) to yield a food ingestion rate of 121 g/day. The highest reported estimated water ingestion rate of 0.11 g/g BW/day for farm-raised females was used in this risk assessment (U.S. EPA 1993). In order to express this value in units of g/day, this water ingestion rate was multiplied by the lowest reported body weight of 550 g to yield a water ingestion rate of 60.5 g/day (60.5 ml/day).

An incidental soil or sediment ingestion rate was not available from the literature, therefore, a predicted incidental ingestion rate for soil and sediment rate that may be entrained in the digestive system of prey items (fish, aquatic invertebrates, and small mammals) was used for this risk assessment. Consumption of these prey items was assumed to be the primary mechanism by which a carnivorous mammal such as the mink may incidentally ingest soil or sediment. The derivation of these predicted levels of incidental soil and sediment ingestion via consumption of fish, aquatic invertebrates, and small mammals is described below.

Life history information for the bluegill (*Lepomis machrochirus*) was used to predict the amount of sediment that may be ingested by mink via consumption of fish. Adult bluegills range in size from 100 to 230 mm (Pflieger 1975; Smith 1985). In keeping with the conservative approach of this risk assessment, the amount of sediment entrained in the lowest body size of 100 mm in length was predicted. The weight of a 100 mm bluegill was calculated to be 18.11 g based on the following algorithm relating length to weight (Hillman 1982):

$$\log \text{Weight (g)} = -5.374 + 3.316 \log \text{Length (mm)}$$

A daily food ingestion rate of 1.75 percent of the body weight per day has been reported for the bluegill (Kolehmainen 1974). This provides a predicted intake rate of 0.32 g of food per day for a 18.11 g fish. A study evaluating the stomach contents of 153 bluegills reported an average content of detritus and sediment to be 9.6 percent of the total diet (Kolehmainen 1974). If a conservative assumption is made that 9.6 percent of the food ingested is entirely sediment, it can be predicted that a fish of this size may contain 0.03 g of sediment in its digestive system.

For the purpose of this model, it was assumed that the level of sediment contained in the digestive system of a fish remains constant over time. This value (0.03 g) was divided by the predicted fish body weight (18.11 g) in order to express sediment entrained in fish digestive systems in units of grams of sediment per gram of fish body weight. This provided a value of 0.0017 g sediment/g body weight. When this value is multiplied by the food ingestion rate of the mink (121 g/day), the predicted sediment ingestion rate for the mink via consumption of fish is 0.2 g/day.

Life history information for the crayfish *Orconectes* sp. was used in predicting the incidental sediment ingestion rate for the mink via consumption of freshwater invertebrates. Adult *O. virilis* weigh from 5 to 20+ g and consume 0.3 to 1 percent of its total body weight per day (Kim 1994; Tack 1941; Vannote 1963). In order to express the food ingestion rate in units of g/day, the highest reported food ingestion rate of 1 percent of the total body weight per day was multiplied by the lowest reported body weight of 5 g to yield a food ingestion rate of 0.05 g/day.

Orconectes spp. detritus ingestion rates range from 10 percent of the total diet per day in young-of-the-year *Orconectes immunis* (Vannote 1963) to 11 percent of the total diet per day in *O. virilis* (Tack 1941). For this risk assessment, it will be assumed that these values represent the percentage of sediment in the diet of a crayfish. The food ingestion rate of 0.05 g/day was multplied by the incidental sediment ingestion rate of 11 percent of the total diet per day to yield an incidental sediment ingestion rate of 0.0055 g/day.

For the purpose of this model, it was assumed that the level of sediment contained in the digestive system of crayfish remains constant over time. Therefore, in order to express the amount of sediment entrained in a crayfish's digestive system in units of gram of sediment per gram of crayfish body weight, the sediment ingestion rate of 0.0055 g/day was divided by the lowest adult crayfish body weight of 5 g to yield a sediment ingestion rate of 0.0011 g sediment/g BW of crayfish. When this value is multiplied by the food ingestion rate of the mink (121 g/day), the predicted incidental sediment ingestion rate for the mink via consumption of crayfish is 0.133 g/day.

Life history information for the white-footed mouse was used in predicting the incidental soil ingestion rate for the mink via consumption of small mammals. A soil ingestion rate of less than 2 percent of the total diet has been reported for the white-footed mouse (Beyer *et al.* 1994) . A conservative soil ingestion rate of 1.9 percent of the total diet was assumed for this risk assessment. In order to express this value in units of g/day, this soil ingestion rate was multiplied by the food ingestion rate of the white footed mouse (4.50 g/day; U.S. EPA 1993) to yield a soil ingestion rate of 0.0855 g/day.

For this risk assessment, it was assumed that the level of soil contained in the digestive system of a white-footed mouse remains constant over time. In order to express this value in units of g soil/g mouse BW, this value of 0.0855 g was divided by the lowest reported body weight of the white-footed mouse (13 g; Merritt 1987) to yield a value of 0.0065 g soil/g BW. When this value is multiplied by the food ingestion rate for the mink (121 g/day; U.S. EPA 1993), the predicted incidental soil ingestion rate for the mink via consumption of white-footed mice is 0.795 g/day.

Assuming that fish, crayfish, and mice comprise equal proportions of the mink's diet, the incidental soil and sediment ingestion rate via consumption of these prey items is approximately 0.4 g/day.

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E.2
Toxicity Benchmarks

TOXICITY BENCHMARK VALUES

Copper

One study (OHMD, 1987) conducted showed that an oral dose of 100 mg/kg/day fed to a dog caused death. For this report, a NOAEL value of 1 mg/kg/day (100mg/kg/day divided by 10) was used in the mink model.

A dose of 350 mg/kg (61.3 mg/kg/day) caused a significant decrease in the growth and consumption by chickens (Smith, 1969). Another study on chickens, found a dose of 326 mg/kg (23.5 mg/kg/day) caused respiratory problems (Hatch, 1978). Assuming that respiratory problems are acute effects, a NOAEL (23.5 mg/kg/day divided by 100) of 0.235 mg/kg/day was developed for the heron model (Hatch, 1978).

Lead

A study conducted on mice determined that 1.5 mg/kg/day of lead caused a reduction in success of implanted ova (Clark, 1979). Another study (Clark, 1979) found that 2.2 mg/kg/day of lead produced a reduction in the frequency of pregnancy when the dose was administered for 3 to 5 days. For this report, a value of 0.15 mg/kg/day was used as a NOAEL (1.5 mg/kg/day divided by 10) was used in the mink model.

In a single dose study (Lawler et al., 1991), the gastric motility of adult male and female red-tailed hawks (*Buteo jamaicensis*) fed 0.82 and 1.64 mg/kg BW/day of lead was evaluated through the use of surgically implanted tranducers for a period of 3 weeks. Neither concentration had any effect on the gastric contractions of egestion of undigested material pellets.

Another study conducted on red-tailed hawks (Reiser and Temple, 1981) found that 3 mg/kg/day of lead caused the clinical symptoms of lead poisoning. A similar study (Osborne et al., 1983) found that 3 mg/kg/day fed to starlings caused a reduction in muscle condition and altered their feeding activity. For this assessment, a value of 0.3 mg/kg/day NOAEL developed from red-tailed hawk and sterling studies was used in the heron model.

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E.3
Receptor Models

Stone Bay - Study Area
Aquatic Receptor Models
MCB, Camp Lejeune

Ecological Contaminant of Concern	Sediment Mean (mg/kg)	Sediment Maximum (mg/kg)	Surface Water Mean (mg/L)	Surface Water Maximum (mg/L)	Tissue Mean (mg/L)	Tissue Maximum (mg/L)	Species with the Maxi. Concentration
Copper	9.23	16.6	0.000996	0.00153	35.98	50.3	oyster
Lead	7.66	20.7	0.0005278	0.000926	2.57	4.8	mussel

Stone Bay Aquatic Assessment
MCB, Camp Lejeune

Great Blue Heron

Body Weight	3.0000000 kg
Food Ingestion Rate	0.6000000 kg/day
Water Ingestion Rate	0.1200000 L/day
Sediment Ingestion Rate	0.0540000 kg/day

Maximum Concentrations - Conservative Model

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	16.6	0.00153	50.3	10.3588612	0.235	2.35	4.41E+01	4.41E+00
Lead	20.7	0.000926	4.8	1.33263704	0.3	3	4.44E+00	4.44E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay Aquatic Assessment
MCB, Camp Lejeune

Great Blue Heron

Body Weight	3.0000000 kg
Food Ingestion Rate	0.6000000 kg/day
Water Ingestion Rate	0.1200000 L/day
Sediment Ingestion Rate	0.0540000 kg/day

Mean Concentrations - Less Conservative Model

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	9.23	0.000996	35.98	7.36217984	0.235	2.35	3.13E+01	3.13E+00
Lead	7.66	0.0005278	2.57	0.651901112	0.3	3	2.17E+00	2.17E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay Aquatic Assessment
MCB, Camp Lejeune

Mink

Body Weight	0.5200000 kg
Food Ingestion Rate	0.1210000 kg/day
Water Ingestion Rate	0.0605000 L/day
Soil Ingestion Rate	0.0003330 kg/day

Maximum Concentrations - Conservative Model

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Vegetation Concentration (mg/kg)	Invetebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	16.6	0.00153	6.64	50.3	13.2603084	1	10	1.33E+01	1.33E+00
Lead	20.7	0.000926	8.28	4.8	3.05697908	0.15	1.5	2.04E+01	2.04E+00

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay Aquatic Assessment
MCB, Camp Lejeune

Mink

Body Weight	0.5200000 kg
Food Ingestion Rate	0.1210000 kg/day
Water Ingestion Rate	0.0605000 L/day
Soil Ingestion Rate	0.0003330 kg/day

Mean Concentrations - Less Conservative Model

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Vegetation Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	9.23	0.000996	3.692	35.98	9.23739586	1	10	9.24E+00	9.24E-01
Lead	7.66	0.0005278	3.064	2.57	1.31595522	0.15	1.5	8.77E+00	8.77E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL
NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay - Reference Areas
Aquatic Receptor Models
MCB, Camp Lejeune

Ecological Contaminant of Concern	Sediment Mean (mg/kg)	Sediment Maximum (mg/kg)	Surface Water Mean (mg/L)	Surface Water Maximum (mg/L)	Tissue Mean (mg/kg)	Tissue Maximum (mg/kg)	Species with the Maxi. Concentration
Copper	4.6	4.6			48.2	88.2	oyster
Lead	7.55	10.5			1.6	2	oyster

Stone Bay Aquatic Assessment - Reference Areas
MCB, Camp Lejeune

Mink

Body Weight	0.5200000 kg
Food Ingestion Rate	0.1210000 kg/day
Water Ingestion Rate	0.0605000 L/day
Soil Ingestion Rate	0.0003330 kg/day

Maximum Concentrations - Conservative Model

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Vegetation Concentration (mg/kg)	Invetebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	4.6	0	1.84	88.2	20.9545612	1	10	2.10E+01	2.10E+00
Lead	10.5	0	4.2	2	1.44941635	0.15	1.5	9.66E+00	9.66E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay Aquatic Assessment - Reference Areas
MCB, Camp Lejeune

Mink

Body Weight	0.5200000 kg
Food Ingestion Rate	0.1210000 kg/day
Water Ingestion Rate	0.0605000 L/day
Soil Ingestion Rate	0.0003330 kg/day

Mean Concentrations - Less Conservative Model

ECOC	Soil Concentration (mg/kg)	Water Concentration (mg/L)	Vegetation Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	4.6	0	1.84	48.2	11.6468688	1	10	1.16E+01	1.16E+00
Lead	7.55	0	3.02	1.6	1.07987337	0.15	1.5	7.20E+00	7.20E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay Aquatic Assessment - Reference Areas
MCB, Camp Lejeune

Great Blue Heron

Body Weight	3.0000000 kg
Food Ingestion Rate	0.6000000 kg/day
Water Ingestion Rate	0.1200000 L/day
Sediment Ingestion Rate	0.0540000 kg/day

Mean Concentrations - Less Conservative Model

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	4.6	0	48.2	9.7228	0.235	2.35	4.14E+01	4.14E+00
Lead	7.55	0	1.6	0.4559	0.3	3	1.52E+00	1.52E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Stone Bay Aquatic Assessment - Reference Areas
MCB, Camp Lejeune

Great Blue Heron

Body Weight	3.0000000 kg
Food Ingestion Rate	0.6000000 kg/day
Water Ingestion Rate	0.1200000 L/day
Sediment Ingestion Rate	0.0540000 kg/day

Maximum Concentrations - Conservative Model

ECOC	Sediment Concentration (mg/kg)	Water Concentration (mg/L)	Fish Concentration (mg/kg)	Dose (mg/kg/day)	NOAEL (mg/kg/day)	LOAEL (mg/kg/day)	NOAEL HQ_n	LOAEL HQ_l
Copper	4.6	0	88.2	17.7228	0.235	2.35	7.54E+01	7.54E+00
Lead	10.5	0	2	0.589	0.3	3	1.96E+00	1.96E-01

NA - Not Available
HQ_n - Hazard Quotient based on the NOAEL
HQ_l - Hazard Quotient based on the LOAEL

NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

Baker

Baker Environmental, Inc.

ATTACHMENT F

Memorandum to the Final Aquatic Assessment for Stone Bay

MEMORANDUM
TO THE
FINAL AQUATIC ASSESSMENT
FOR STONE BAY

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

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LIST OF ACRONYMS AND ABBREVIATIONS

FAA	Final Aquatic Assessment
HQ	Hazard quotient
LOAEL	Lowest-observed-adverse-effect level
MCB	Marine Corps Base, Camp Lejeune, North Carolina
NOAEL	No-observed-adverse-effect level
USEPA	United States Environmental Protection Agency

INTRODUCTION

The purpose of this memorandum is to provide a nontechnical discussion of the ecological receptor models presented in the Final Aquatic Assessment for Stone Bay (FAA) (Baker, 1999) and to provide the results of a site-specific receptor model. Ecological receptor models are recommended in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997) to be used as a tool for assessing potential risk to ecological species from exposure to contaminated media. Ecological receptor models were included in the FAA as an additional means of analyzing the collected data and estimating potential risks to higher trophic levels in the aquatic food chain. The results of the ecological receptor modeling effort are one component to the overall ecological risk assessment process.

The receptor species modeled for Stone Bay were selected based upon the following criteria: 1) species expected to inhabit the area, 2) input parameters available for that species or a similar species, and 3) comparative toxicity reference values for copper and lead that are available for that receptor species or a similar species. The ecological receptor models presented in the FAA represent primary feeders of surface water, sediment, and benthic species within Stone Bay. The models used in the assessment included the great blue heron, the red drum, and the mink. In addition to the receptor models calculated for the study area in Stone Bay (within the safety fan of the rifle range), receptor models were calculated for reference areas in Stone Bay (outside of the safety fan of the rifle range). The chosen reference areas represent ecologically-similar aquatic habitats to the study area that are not impacted by rifle range activities.

Based on the conclusions of the FAA and the ecological receptor models included therein, the great blue heron was the only receptor species that indicated a potential risk. The estimated risk was due to copper concentrations in surface water, sediment, and benthic tissue. The heron model calculated for the reference area also indicated risk caused by copper concentrations. Although the ecological receptor models used in the FAA are a USEPA-accepted methodology for assessing risk, they are recognized as a conservative estimation of risk which includes some inherent uncertainty. Therefore, an additional great blue heron model is provided herein. This additional great blue heron model represents a site-specific version of the model.

This memorandum is divided into five sections that clarify the role, operation, and interpretation of ecological receptor models, specifically for the great blue heron. Section 1 (Ecological Receptor Model Terminology) defines the various terms used in discussing ecological models. Section 2 (Calculation of the Ecological Receptor Models) discusses the calculation of the models and variations of conservativeness made within the models, Section 3 (Uncertainty of the Ecological Receptor Models) recognizes the components of the model that contribute to uncertainty, Section 4 (Results of the Ecological Receptor Models) presents the findings of each version of the heron model, and Section 5 (Conclusions) incorporates the conclusions of the FAA with the results of this memorandum.

1.0 ECOLOGICAL RECEPTOR MODEL TERMINOLOGY

An understanding of the terms used in the ecological receptor models is a necessary part of comprehending the entire process. The following glossary is provided to assist in defining the terms used in discussing the ecological receptor models.

Benthic Tissue - Meat (non-shell) portion of shellfish (oysters, clams, and mussels) used in aquatic assessment.

Biota - Animal and plant life of a particular region.

Dosage - A measured quantity of ingestion or dermal exposure at one time.

Exposure Point Concentration - Concentration selected to estimate the exposure of a species to a particular contaminant in an environmental medium.

Hazard Quotient (HQ) - The ratio of estimated site-specific exposure to a single chemical from a site over a specified period divided by a toxicity reference value obtained from the literature (See Toxicity Reference Value) for a particular species.

Lowest-Observed-Adverse-Effect Level (LOAEL) - The lowest level of a stressor evaluated in a test that causes statistically significant differences from the control.

No-Observed-Adverse-Effect Level (NOAEL) - The highest level of a stressor evaluated in a test that does not cause statistically significant differences from the control.

Receptor - The ecological entity exposed to the stressor (e.g., great blue heron, red drum, and mink).

Trophic Level - A functional classification of taxa within a community that is based on feeding relationships.

Toxicity Reference Value - A dosage obtained from the literature derived from scientific experiments.

2.0 CALCULATION OF THE ECOLOGICAL RECEPTOR MODELS

Ecological receptor models are simple, conservative, mathematical expressions of potential risk to specific receptor species. The models operate by first calculating an estimated dose that the species inhabiting the site will be exposed to from ingestion of surface water, sediment, and benthic tissue. The calculated study area dose is compared with experimental doses (toxicity reference values) obtained from the literature shown to cause no or low adverse impact to a particular species. The HQ method was used to estimate potential risks in the ecological receptor models. The following equation was used to calculate HQs:

$$Hazard\ Quotient = \frac{Exposure\ Point\ Concentration}{NOAEL\ /\ LOAEL}$$

Where:

Exposure Point Concentration = Maximum detected or arithmetic mean concentration
NOAEL = No Observed Adverse Effect Level
LOAEL = Lowest Observed Adverse Effect Level (effects on growth, respiration, reproduction, etc.)

An HQ equal to or greater than one indicates that exposure to the particular contaminant has the potential to cause adverse effects to the species. An HQ less than one indicates that the contaminant is not expected to cause adverse effects to the species. The greater the HQ, the greater the magnitude of potential risk to the species; however, for this assessment, any HQ greater than one was recognized as a potential risk.

2.1 Conservativeness of the Models

The receptor models operate on the basis of various conservative assumptions. Many different variables are used in the models, each having various degrees of effect on the model results. The first step in calculating a receptor model is to establish what exposure point concentration will be used in the model (maximum detected concentration, 95% upper confidence level, or mean concentration). USEPA federal guidance (USEPA, 1997) recommends calculating several versions of the receptor models. Each version representing various degrees of conservativeness. Typically, as within this assessment, a very conservative, "worst-case" version is calculated first and each subsequent version of the model becomes less conservative.

Varying degrees of conservativeness in the receptor models allows the risk assessor to begin at a "worst case" scenario and if no risks are indicated by this model (HQ values below one), than no additional versions of the model need to be generated. However, if risks are demonstrated in the "worst case," conservative model, as per USEPA guidance, less conservative models are calculated.

Variations in conservativeness can be achieved by adjusting input parameters and exposure point concentrations. Three levels of conservativeness have been created for the great blue heron ecological receptor model. These different versions of the heron model calculated for the study area at Stone Bay are highlighted below. The first two versions of the heron model were originally presented in the FAA (Most Conservative and Less Conservative models). Because risk to the heron was demonstrated in these models, a focused examination of expected site-specific risk to the heron was made in this memorandum. Further examination of potential risks to the great blue heron were made by developing a site-specific model for the study area at Stone Bay. The assumptions made in this additional heron model are also presented below.

2.1.1 The Most Conservative Great Blue Heron Model

The following bullets present the highlighted features of the most conservative ("worst case" scenario) version of the model.

- This model assumes the heron will obtain 100% of its diet from the study area.
- The maximum detected concentrations of copper and lead in surface water, sediment, and benthic tissue were used to represent site-wide concentrations. The maximum detected tissue concentration was selected among the three benthic species (clams, mussels, or oyster).
- Copper and lead were assumed to be 100 percent bioavailable.
- Because toxicity values could not be found for the specific receptor species, values reported for closely related species were used.

- The highest ingestion rates (drinking water, food, and incidental sediment ingestion) were used in the model.
- A low body weight was used in the model.
- A NOAEL toxicity reference value was used in the model.

2.1.2 The Less Conservative Great Blue Heron Model

The less conservative heron model assumes less conservative inputs to the receptor model. The following bullets present the highlighted features of the less conservative version of the model.

- This model assumes the heron will obtain 100% of its diet from the study area.
- The mean values of the detected concentrations of copper and lead were used to represent site-wide concentrations of surface water, sediment, and benthic tissue. The mean value for the species selected in the most conservative models.
- Copper and lead were assumed to be 100 percent bioavailable.
- Because toxicity values could not be found for the specific receptor species, values reported for closely related species were used.
- Average ingestion rates (drinking water, food, and incidental sediment ingestion) were used in the model.
- An average or higher body weight was used in the model.
- A LOAEL toxicity reference value was used in the model.

2.1.3 The Site-Specific Great Blue Heron Model

The site-specific heron model was calculated in an attempt to present a more site-related scenario specific to the study area within Stone Bay. The following bullets present the highlighted features of the site-specific version of the model.

- This model assumes the heron will obtain a fraction of its diet from the study area. The surface area of the study area is compared with the home range of the heron to provide a realistic percent of the diet obtained from the study area.

- The mean values of the detected concentrations of copper and lead were used to represent site-wide concentrations of surface water, sediment, and benthic tissue. The mean value for the species selected in the most conservative models.
- Copper and lead were assumed to be 100 percent bioavailable.
- Because toxicity values could not be found for the specific receptor species, values reported for closely related species were used.
- Average ingestion rates (drinking water, food, and incidental sediment ingestion) were used in the model.
- An average or higher body weight was used in the model.
- A LOAEL toxicity reference value was used in the model.

2.2 Derivation of Toxicity Reference Value

Toxicity reference values are experimentally-based doses developed in scientific experiments. Toxicity reference values represent doses at which no (NOAEL) or low (LOAEL) adverse effects are noted to the test species. Potential risk to the receptor within the study area exists if the HQs (site calculated dose divided by toxicity reference value doses) exceed one.

Toxicity reference values used in the great blue heron model were based on chicken studies for copper and red-tailed hawk studies for lead. One study found a significant adverse effect to the growth of the chicken at a dosage of 61.3 mg/kg/day of copper (Smith, 1969). A second chicken study calculated a LOAEL value of 23.5 mg/kg/day of copper (Hatch, 1978). At this concentration, acute respiratory problems were noted in the chickens. The LOAEL from the second study (23.5 mg/kg/day) was used in this assessment. As per USEPA guidance, a NOAEL value was derived from the LOAEL value by dividing by 10 to provide a conservative estimation of a concentration at which no adverse effects would be expected to occur.

In a single dose study (Lawler et al., 1991), the gastric motility of adult male and female red-tailed hawks fed 0.82 and 1.64 mg/kg BW/day of lead was evaluated through the use of surgically implanted transducers for a period of three weeks. Neither concentration had any effect on the gastric contractions of egestion of undigested material pellets. Another study conducted on red-tailed hawks found that 3 mg/kg/day of lead caused the clinical symptoms of lead poisoning. A similar study (Osborne et al., 1983) found that 3 mg/kg/day fed to starlings caused a reduction in muscle condition and altered their feeding activity. A LOAEL of 3 mg/kg/day was used in this assessment. As per USEPA guidance, a NOAEL value was derived from the LOAEL value by dividing by 10 to provide a conservative estimation of a concentration at which no adverse effects would be expected to occur.

3.0 UNCERTAINTY OF THE ECOLOGICAL RECEPTOR MODELS

As with any modeling effort, inherent uncertainties exist within the ecological receptor models. The following factors are the primary contributors to the uncertainty of the models: 1) receptors are exposed to multiple media, 2) receptors are exposed to contaminants via multiple food pathways, and 3) there are temporal variables of the receptor (e.g., differ life stages, and sexual differences) that influence the response of the species. In addition, there is uncertainty associated with using surrogate species for comparative purposes. For example, the heron model for Stone Bay was compared to studies conducted on the chicken and red-tailed hawk.

For this assessment, NOAEL values were not found in the literature. Therefore, LOAEL values were used to calculate a NOAEL. A LOAEL was divided by a factor of 10 to obtain a NOAEL value (USEPA, 1997). There is uncertainty in this calculation of NOAELs; however, the uncertainty most likely errs on the conservative side.

There is uncertainty associated with some of the toxicity values derived from a single species. Prediction of ecosystem effects from laboratory studies is difficult. Laboratory studies cannot take into account the effects of environmental factors which may add to the effects of contaminant stress. NOAELs and LOAELs were generally selected from studies using single contaminant exposure scenarios.

There is uncertainty in the total daily intake models used to evaluate a reduction of receptor populations or sub-populations. Many input parameters are based on default values (i.e., ingestion rates) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the level to which the indicator species will represent other species potentially exposed to copper and lead concentrations at the site.

There are some differences of opinion found in the literature as to the effectiveness of using ecological receptor models to predict concentrations of contaminants found in ecological species. The food chain models currently used incorporate simplistic assumptions that may not represent conditions at the site, bioavailability of contaminants, or site-specific behavior of the receptors. The modeling process and results serve as an additional tool to evaluate site conditions and estimate potential risk. The results of the models are only one component to determining overall site risk.

4.0 ECOLOGICAL RECEPTOR MODEL RESULTS

The results of the three versions of models calculated for the great blue heron are presented in the following sections. The models are presented beginning with the most conservative version and ending with the site-specific version generated for herons inhabiting the study area. In addition, the great blue heron models calculated for the reference areas are also presented and compared to the study area models.

4.1 Most Conservative Great Blue Heron Model

As demonstrated on Table 1, an HQ of 44 was calculated for the great blue heron in the most conservative receptor model due to concentrations of copper. The HQ calculated for lead in the heron was slightly greater than one (HQ = 4.44). The most conservative heron model calculated for the reference area (Table 2) demonstrated similar risk due to copper and lead (copper HQ = 75.40 and lead HQ = 1.96).

4.2 Less Conservative Great Blue Heron Model

As displayed on Table 3, the results of the less conservative heron model indicate a risk to the great blue heron from concentrations of copper. This risk is demonstrated by an HQ slightly greater than one (HQ = 3.13). Potential risk to the heron due to lead is not evident in this model. The less conservative heron model calculated for the reference area (Table 4) demonstrated a similar risk to the heron due to copper (HQ = 4.14).

4.3 Site-Specific Great Blue Heron Model

The site-specific heron model provides a more realistic scenario of how much surface water, sediment, and biota a heron will actually obtain from the study area based on the home range of this species compared with the surface area of the study area. As indicated on Table 5, no risk is demonstrated in the site-specific heron model (HQs were calculated below one). Because no risk was demonstrated in the study area heron model, no comparisons to the reference areas were necessary. Therefore, a site-specific reference model was not calculated.

5.0 CONCLUSIONS

The ecological receptor models provide an additional means of analyzing the collected data and estimating potential risks to higher trophic levels in the aquatic food chain. The results of the ecological receptor modeling effort serve as one factor in assessing the overall ecological condition of the study area. It should be noted that any risks identified through the modeling process are potential risks, and do not confirm harmful effects to the aquatic environment.

Because risk to the heron was demonstrated in the ecological receptor models presented in the FAA, a focused examination of actual risk to the heron was made in this memorandum. The conclusions presented within the FAA, along with the results of the additional site-specific heron model presented in this memorandum, indicate that the great blue heron is not likely to be adversely impacted by rifle range activities.

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