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FINAL

SITE INVESTIGATION WORK PLAN

**SITE 10 - ORIGINAL BASE LANDFILL
MCB CAMP LEJEUNE, NORTH CAROLINA**

CONTRACT TASK ORDER 0369

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Prepared for:

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EXECUTIVE SUMMARY

Site 10 is referred to as the Original Base Landfill and is located on the western side of Holcomb Boulevard, approximately 1,600 feet south of Wallace Creek and 1,750 feet north of Bearhead Creek. The Original Base Landfill was approximately five to ten acres in size when it was in full operation. The Initial Assessment Study (IAS)(Water and Air Research, 1993) indicates that the area was used as a disposal site for construction debris and as a burn dump. It is believed the landfill was operated prior to 1950 during construction of the base. Records indicating the type of debris and /or wastes disposed at the site were unavailable.

During the IAS, it was decided that the site did not need further investigation and was removed from the list of sites warranting further investigation at the base. In 1994, two marines were conducting night maneuvers and fell into an "open trench" and received a rash from an "oily substance" that they had contacted in the bottom. They were treated at the base hospital and released. Site 10 was one of two sites that the marines may have been crossing while on maneuvers. The other site has not been located. It is not known if the reference to the other site referred to a potential IR site, or just another base location. Because Site 10 was identified as one of the locations where the marines may have contacted the "oily substance", it was determined that the site should be investigated further to determine if contamination exists.

An expedited site characterization and evaluation of Site 10 was conducted in September 1995 by the Department of the Navy (DoN) in the western portion of the landfill. At the time of the investigation, it was believed that the landfill existed within the boundaries of the study area. Subsequent information such as aerial photographs indicated that the landfill was much larger than originally believed, consequently creating a need to investigate the remaining portion.

Five (5) soil borings (10-SB01 through 10-SB05) were drilled on site and advanced to the water table. A single surface and two subsurface soil samples were collected from each of the five locations using a Geoprobe. All soil samples were analyzed for full TCL organics and TAL metals. Results of the surface and subsurface soils were compared to Region III Risk-Based Concentrations (RBCs) for residential and industrial soil. In addition, the detected inorganics were compared to base background results.

Acetone was detected in surface samples collected at the site. However, not in excess of industrial or residential RBCs. Numerous SVOCs were detected in the samples collected during the expedited site characterization. The following semivolatile organics (SVOCs) exceeded residential and/or industrial RBCs: benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene. Pesticides such as aldrin, 4,4'-DDE, Endosulfan II and 4,4'-DDT were detected in samples. The concentrations of these compounds were not in excess of the RBCs. PCBs were not detected in any of the samples. Arsenic, barium, beryllium, potassium, manganese, lead, and zinc were detected at concentrations exceeding the residential or industrial RBCs, and/or base background concentrations.

No VOCs were detected in subsurface soils collected at the site. Benzo(a)pyrene was the only detected SVOC whose concentration exceeded residential RBCs. A pesticide was detected in the subsurface soils, however the concentration was below the RBCs. No PCBs were detected. Arsenic, barium, calcium, copper, manganese, lead, and zinc were detected at concentrations exceeding the residential and industrial RBCs, and/or base background concentrations.

Three (3) temporary monitoring wells (10-TW01, 10-TW02, and 10-TW03) were installed, and a single round of groundwater samples were collected. Groundwater samples were analyzed for full TCL organics and TAL Inorganics (total and dissolved fractions). Results of the groundwater samples were compared to Federal Maximum Contaminant Levels (MCLs) and the North Carolina Water Quality Standards (NCWQS).

VOCs, SVOCs, and pesticides/PCBs were detected at low levels. However, the detected concentrations were well below the MCLs and NCWQS. The following inorganics were detected at levels above the MCLs and/or NCWQS: aluminum, arsenic, chromium, iron (total and dissolved samples), manganese, nickel, lead, and vanadium.

A Site Investigation (SI) is proposed at Site 10 to determine if contamination is present at the site, to determine if additional work is warranted in the form of a remedial investigation (RI), and to provide enough information to minimize the number of soil borings and groundwater monitoring wells needed for a RI (if needed). It is not the focus of the SI to determine the extent (if any) of contamination detected at the site, however enough data will be collected to establish groundwater flow in the shallow aquifer, to provide a quantitative Risk Assessment (RA) using conservative receptors, and to qualitatively assess all data against applicable criteria.

The objective of these project plans are to evaluate background information along with the location and setting of the site, to identify site-specific SI data quality and sampling objectives, to describe the tasks and field investigation activities that will be conducted at the site, and to ensure that all data collection methods are carried out in accordance with U.S. Environmental Protection Agency (USEPA) Region IV and Naval Facilities Engineering Service Center (NFESC) procedures.

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (DEHNR), the United States Department of the Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB are thoroughly investigated, and that appropriate CERCLA response and Resource Conservation Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect the public health and welfare, and the environment (MCB Camp Lejeune FFA, 1989).

Under the scope of the FFA, a Site Investigation (SI) can be implemented at Site 10 to determine if contamination is present at a site and to collect data to determine if additional work is warranted in the form of a remedial investigation (RI). In addition, data is collected to establish groundwater flow in the shallow aquifer, to provide a quantitative Risk Assessment (RA) using conservative receptors, and to qualitatively assess all data against applicable criteria. It is not the focus of the SI to determine the extent (if any) of contamination detected at the site; therefore, the number of samples collected at the site is based on the dimensions of the site and observations made during a site visit.

Site 10 is referred to as the original Base landfill and is located west of Holcomb Boulevard, approximately 1,600 feet south of Wallace Creek. During full operation, the landfill was approximately 5-10 acres in size and was reportedly used for disposal of construction debris and a burn dump. The landfill ceased operations prior to 1950.

1.1 Objective of SI Work Plan

The objective of this SI Work Plan is to identify the tasks required to implement an SI for Site 10 at MCB Camp Lejeune. The various studies or investigations required to collect appropriate data are described in this Work Plan. In addition, the Work Plan documents the scope and objectives of the individual SI activities. It serves as a tool for assigning responsibilities and establishing the project schedule and cost. The preparation and contents of the SI Work Plan are based on the scoping process, which is described below.

1.2 SI Scoping

Scoping is the initial planning stage of the SI. The result or outcome of the scoping process is documented in the SI Work Plan. Scoping begins once the background information is reviewed and evaluated and consists of the following activities:

- Preliminary assessment of human health risks, based on existing information.
- Identifying any potential interim actions which may need to be undertaken early in the program to mitigate potential threats to the public health.
- Identifying potential contaminant migration pathways and receptors.

- Identifying contaminants of potential concern.
- Identifying potential Federal and State Applicable or Relevant and Appropriate Requirements (ARARs).
- Define the optimum sequence of investigation activities.
- Identifying the sampling strategies for the collection of data.
- Determining the type, amount, and data quality objectives (DQOs) to assess human health risks.

The background information available to this process included several existing environmental assessment reports, which are identified in Section 7.0 (References), and information collected during the site visit.

As part of the scoping process, a project meeting was conducted with the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), USEPA Region IV, and the North Carolina DEHNR to discuss the proposed SI scope and to obtain technical and administrative input from LANTDIV.

1.3 SI Work Plan Format

The following elements are presented in this SI Work Plan.

- Section 2 - Background and Setting
- Section 3 - SI Data Quality and Sampling Objectives
- Section 4 - SI Tasks
- Section 5 - Project Staffing
- Section 6 - Project Schedule
- Section 7 - References

Section 2 documents the evaluation of background information, along with the location and setting of the site. The purpose of this section is to define the physical and known environmental characteristics of the site. This section focuses on identifying potential and/or confirmed contaminant migration pathways, identifying potential (or known) impacts to public health and environment and identifying Federal or State standards and criteria.

Section 3 defines site-specific SI data quality and sampling objectives. Data or information deemed necessary to identify migration pathways and assess human health risks are presented in this section. This data may consist of chemical analyses, hydrogeologic information, or engineering analyses. The collection methods for obtaining this information are also identified and described in general terms [more detailed descriptions of the field investigation activities are documented in the Sampling and Analysis Plan (SAP)].

Section 4 identifies and describes the tasks and field investigation activities that will be implemented to complete the SI in terms of meeting the site-specific objectives. These tasks generally follow the description of tasks identified in EPA's SI Guidance Document (OSWER Directive 9345.1-05). Section 5 discusses project staffing for implementing the SI. The SI schedule is provided in Section 6. References used in developing the SI Work Plan are provided in Section 7.

2.0 BACKGROUND AND SETTING

The purpose of this section is to summarize and evaluate existing information pertaining to MCB, Camp Lejeune, Site 10. The current understanding of the physical setting of the site, the history of the site, and the existing information related to previous environmental investigative activities are described herein.

This section specifically addresses the location and setting of the site, historical events associated with past usage or disposal activities, topography and surface drainage, regional geology and hydrogeology, site-specific geology and Hydrogeology, surface water hydrology, climatology, natural resources, ecological features, and land use.

Additional background information is presented in the following documents:

- Initial Assessment Study (IAS) of Marine Corps Base Camp Lejeune, North Carolina (Water and Air Research, 1983)
- Final Site Summary Report, Marine Corps Base, Camp Lejeune (Environmental Science and Engineering, Inc. 1990)
- Hydrogeology of Aquifers in Cretaceous and Younger Rocks in the Vicinity of Onslow and Southern Jones Counties, North Carolina (U.S. Geological Survey, 1990)
- Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina (U.S. Geological Survey, 1989)
- Final Site Characterization and Evaluation Report, Sites 10 and 85 - MCB, Camp Lejeune and Sites 11 and 17 - Naval Station Roosevelt Roads (Baker, 1995)

2.1 MCB, Camp Lejeune, North Carolina

This section provides an overview of the physical features associated with MCB, Camp Lejeune, North Carolina (which also includes Marine Corps Air Station New River).

2.1.1 Location and Setting

MCB, Camp Lejeune is located within the Coastal Plain Physiographic Province. It is located in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. This includes the recent acquisition of approximately 64 square miles west of the facility within the Greater Sandy Run Area of the county. The military reservation is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean.

The eastern border of MCB, Camp Lejeune is the Atlantic shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB, Camp Lejeune to the north. MCB, Camp Lejeune is depicted in Figure 2-1.

The Greater Sandy Run Area (GSRA) is located in the southeast portion of Onslow County, North Carolina, near the Pender-Onslow County border. The GSRA is approximately 31 miles northeast of Wilmington, North Carolina; 15 miles south of Jacksonville, North Carolina; and 5 miles northwest of the Atlantic Ocean. The GSRA is located south and west of MCB, Camp Lejeune, sharing a common boundary along Route 17 between Dixon and Verona.

The following overview of the Complex was taken from the document "Master Plan, Camp Lejeune Complex, North Carolina." The Complex consists of 12 identifiable developed areas. Of the developed areas, Hadnot Point comprises the most concentrated area of development. This area includes the organizational offices for the Host Activity and for the Headquarters, 26th Marine Expeditionary Unit, as well as the Headquarters and regimental areas for the 2nd Marine Division, Marine Expeditionary Force, 22nd Marine Expeditionary Unit, 24th Marine Expeditionary Unit, the Central Exchange & Commissary and the Naval Dental Clinic Headquarters. Directly north of Hadnot Point are the family housing areas concentrated throughout the wooded areas of the central Complex and along the shores of the New River. Also located in this north central area are major personnel support land uses, including the newly-constructed Naval Hospital, school sites, recreational areas, as well as additional family housing areas (quarters developments, Midway Park and Tarawa Terrace I and II).

The Air Station and Camp Geiger are considered as a single urban area possessing two separate missions and supported by two unrelated groups of personnel. The Marine Corps Air Station (MCAS), New River encompasses 2,772 acres and is located in the northwestern section of the Complex and lies approximately five miles south of Jacksonville. The MCAS includes air support activities, troop housing and personnel support facilities, all of which immediately surround the aircraft operations and maintenance areas.

Camp Geiger, located directly north of MCAS, New River, contains a mixture of troop housing, personnel support and training uses. Currently, the area is utilized by a number of groups which have no direct relationship to one another. The majority of the land surrounding this area is comprised of buffer zones and unbuildable marshland.

The Camp Lejeune Complex contains five other areas of concentrated development, all of which are much smaller in size and population than either Hadnot Point, MCAS New River, or the Camp Geiger area. The oldest of these is the Montford Point area, which is bounded by the New River to the south and west and by Route 24 on the north. New development in Montford Point has been limited, with most of the facilities for troop housing, maintenance, supply and personnel support having been converted from their intended uses. A majority of the MCB training schools requiring classroom instruction are located here and use surrounding undeveloped areas for training operations when required. The French Creek area located directly south of Hadnot Point is occupied by the 2nd Force Service Support Group (2nd FSSG). Its activities are directed toward providing combat service and technical support as required by Headquarters, II Marine Expeditionary Force. Expansion of the French Creek Complex is constrained by the Ordnance Storage Depot explosives safety arc on the south and by the regimental area of Hadnot Point. Onslow Beach, located along the Onslow Bay, east of the New River Inlet, presents assets for expeditionary training as well as recreational use. Courthouse Bay is located on one of a series of small bays which are formed by the New River. This area is used for maintenance, storage and training associated with expeditionary vehicles and heavy engineering equipment. The Engineering School, also located here, conducts training activities in the large open area located to the southeast of the Courthouse Bay. Another concentrated area of development is the Rifle Range. This area is located on the southwest side of the New River, is

singular in purpose and has only a small number of assigned personnel. It was constructed in the early stages of Base development and is used solely for rifle qualification training. The small group of barracks, located at the Rifle Range, are used for two-week periods by troops assigned to range training.

2.1.2 History and Mission of Camp Lejeune

Construction of MCB, Camp Lejeune began in 1941 with the objective of developing the "World's Most Complete Amphibious Training Base." Construction of the base started at Hadnot Point, where the major functions of the base are centered. Development at the Camp Lejeune Complex is primarily in five geographical locations under the jurisdiction of the Base Command. These areas include Camp Geiger, Montford Point, Courthouse Bay, Mainside, and the Rifle Range Area.

The MCB organization functions as the host command to the two Fleet Marine Force Atlantic (FMFLANT) tenant activities including Headquarters Marine Forces Atlantic/Marine Expeditionary Force and the 2nd FSSG/2nd Marine Division. The MCB host organization mission is to provide housing, training facilities, logistical support and certain administrative support for tenant units and for other units assigned to MCB, Camp Lejeune and to conduct specialized schools and other training maneuvers, as directed.

The mission of the 2nd Marine Division is to execute amphibious assault operations, and other operations as may be directed, which are supported by Marine aviation and force service support units. With the aircraft wing, the Marine division provides combined arms for service with the Fleet in the seizure or defense of advanced naval bases and for the conduct of land operations essential to the prosecution of a naval campaign.

The mission of the 2nd FSSG is to command, administer and train assigned units in order to provide combat service and technical support as required by Headquarters FMFLANT and its subordinate command in accomplishment of the overall FMFLANT mission.

2.1.3 Previous Investigations

In response to the passage of CERCLA, the DoN initiated the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, investigate, and clean up past hazardous waste disposal sites at Navy installations. The NACIP investigations were conducted by the Navy Energy and Environmental Support Activity (NEESA) and consisted of Initial Assessment Studies (IAS) and Confirmation Studies. IAS are similar to the USEPA's Preliminary Assessments/Site Investigations (PAs/SIs). Confirmation Studies are similar to USEPA's RI/FS. When the Superfund Amendment and Reauthorization Act (SARA) was passed in 1986, the DoN dissolved the NACIP in favor of the Installation Restoration Program (IRP), which adopted USEPA Superfund terminology and procedures.

The IAS for MCB, Camp Lejeune was conducted by Water and Air Research, Inc., (WAR) in 1983. The IAS identified a number of sites at MCB, Camp Lejeune as potential sources of contamination. Based on historical records, aerial photographs, field inspections, and personnel interviews, the IAS identified 76 sites at MCB, Camp Lejeune as potential sources of contamination. Of these 76 sites, 27 sites warranted further investigation to assess potential long-term impacts based on contamination characteristics, migration pathways, and pollutant receptors. Site 10 was not one of the 27 sites needing further investigation. In 1994, two marines conducting night maneuvers fell into an open

trench and received a rash from an "oily substance" that they had contacted in the bottom. They were treated at the base hospital and released. Site 10 was one of two sites that the marines may have been crossing while on maneuvers. Therefore, it was determined that the site should be investigated further to determine if contamination exists at the site.

2.1.4 Topography and Surface Drainage

The generally flat topography of MCB, Camp Lejeune is typical of the seaward portions of the North Carolina Coastal Plain. Elevations on the base vary from sea level to 72 feet above mean sea level (msl); however, the elevation of most of MCB, Camp Lejeune is between 20 and 40 feet above msl.

Drainage at MCB, Camp Lejeune is generally toward the New River, except in areas near the coast, which drain through the Intracoastal Waterway. In developed areas, natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of MCB, Camp Lejeune is in broad, flat interstream areas. Drainage is poor in these areas (Water and Air Research, 1983).

The U.S. Army Corps of Engineers has mapped the limits of 100-year floodplain at MCB, Camp Lejeune at 7.0 feet above msl in the upper reaches of the New River (Water and Air Research, 1983); this increases downstream to 11 feet above msl near the coastal area (Water and Air Research, 1983). Inspection of 100-year flood plain (FEMA National Flood Insurance Program) maps indicate that Site 10 does not lie within the 100-year floodplain.

2.1.5 Regional Geology

MCB, Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the province consist predominantly of sand, silt, and clay. Other sediments may be present, including peat, shell beds and gravel. Sediments may be of marine or continental origin (Back, 1966). These sediments lay in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1991). These sediments range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic rocks of pre-Cretaceous age. Table 2-1 presents a generalized stratigraphic column for this area (ESE 1991).

United States Geological Survey (USGS) studies at MCB, Camp Lejeune indicate that the Base is underlain by sand, silt, clay, calcareous clay and partially consolidated limestone. Aquifers that occur beneath the Base include the surficial, Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The combined thickness of these sediments beneath the base is approximately 1,500 feet. A generalized hydrogeologic cross-section illustrating the relationship between the aquifers in this area is presented in the USGS Report 93-4049, Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina.

2.1.6 Regional Hydrogeology

The aquifers of primary interest are the surficial aquifer and the aquifer immediately below it, the Castle Hayne. The following summary is a compilation of information, including Harned et al. (1989), and Cardinell et al. (1993).

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. These beds are thin and discontinuous, and have limited lateral continuity. This aquifer is not currently used as a potable water supply at MCB, Camp Lejeune.

The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB, Camp Lejeune area. It is generally thickest in the interstream divide areas and presumed absent where it is cut by the New River and its tributaries.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of good vertical conductivity within the aquifer. Data compiled by Cardinell estimate the lateral hydraulic conductivity of the surficial aquifer in the MCB, Camp Lejeune area 50 feet/day, and is based on a general composition of fine sand mixed with some silt and clay. However, data from slug tests on Baker wells indicate much lower lateral hydraulic conductivity values, ranging from 0.12 to 9.00 feet/day.

Between the surficial and the Castle Hayne aquifers lies the Castle Hayne confining unit. This unit consists of clay, silt, and sandy clay beds. In general, the Castle Hayne confining unit may be characterized as a group of less permeable beds at the top of the Castle Hayne aquifer that have been partly eroded or incised in places.

The Castle Hayne confining unit is discontinuous, and has a thickness ranging from 0 to 26 feet, averaging about 9 feet where present. There is no discernable trend in the thickness of the confining unit. There is no information in the USGS literature regarding any trend of the depth of the confining unit.

The data compiled by Cardinell, et. al., indicate that the vertical hydraulic conductivity of the confining unit ranged from 0.0014 to 0.41 feet/day. Based on the moderate conductivity values and the thin, discontinuous nature of the confining unit, this unit may only be partly effective in retarding the vertical movement of groundwater between the surficial aquifer.

The Castle Hayne aquifer lies below the surficial aquifer and consists primarily of unconsolidated sand, shell fragments, and fossiliferous limestone. Clay, silt, silty and sandy clay, and indurated limestone also occur within the aquifer. The upper part of the aquifer consists primarily of calcareous sand with some continuous and discontinuous thin clay and silt beds. The calcareous sand becomes more limey with depth. The lower part of the aquifer consists of consolidated or poorly consolidated limestone and sandy limestone interbedded with clay and sand.

The Castle Hayne aquifer is about 150 to 350 feet thick in the area, and thickens eastward across the base. The top of the aquifer lies approximately 20 to 65 feet below the ground surface. The top of the aquifer dips southward, and is deepest at the Atlantic coast, east of the New River. The top of the aquifer also forms a basin in the vicinity of Paradise Point. Estimates of hydraulic conductivity indicate a wide variation in range, from 14 to 91 feet/day.

Onslow County and MCB, Camp Lejeune lie in an area where the Castle Hayne aquifer generally contains freshwater. However, the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Over-pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per kilogram (mg/L) chloride throughout the base, except for one well

(USGS-8) in the southern portion of the base that is screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a single sample collected in 1989.

Rainfall in the Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the surficial aquifer. Recharge areas at Camp Lejeune include the interstream areas. In the aquifer, groundwater flows in the direction of lower hydraulic head until it reaches discharge points or fronts. These discharge areas include the New River and its tributaries, and the ocean. Though most of the rainfall entering the surficial aquifer discharges to local streams, a relatively small amount infiltrates to the Castle Hayne. The surficial aquifer supplies the primary recharge to the Castle Hayne aquifer. Like the surficial aquifer, the Castle Hayne naturally discharges to the New River and major tributaries. However, pumping of the Castle Hayne may locally influence discharge directions.

The potentiometric surface of the surficial aquifer varies seasonally. The potentiometric surface is determined by the water levels in monitoring wells. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the potentiometric surface is generally highest in the winter months and lowest in the summer or early fall.

Water levels in well in deeper aquifers, such as the Castle Hayne were also used to establish potentiometric surfaces. Because the Castle Hayne is at least partially confined from the surficial aquifer and is not influenced by rainfall as strongly as the surficial aquifer, the seasonal variations tend to be slower and smaller than in surficial aquifer.

2.1.7 Surface Water Hydrology

The following summary of surface water hydrology was originally presented in the IAS report (WAR, 1983).

The dominant surface water feature at MCB, Camp Lejeune is the New River. It receives drainage from most of the base. The New River is short, with a course of approximately 50 miles on the central Coastal Plain of North Carolina. Over most of its course, the New River is confined to a relatively narrow channel entrenched in Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays, and marls. At MCB, Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB, Camp Lejeune not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet (WAR, 1983). The New River, the Intracoastal Waterway, and the Atlantic Ocean meet at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body-contact sports or commercial shellfishing) and SA (estuarine waters suited for commercial shellfishing). The SC classification applies to three areas of the New River at MCB, Camp Lejeune, including the Rifle Range area; the rest of the New River at MCB, Camp Lejeune falls into the SA classification (ESE, 1991).

2.1.8 Climatology

Although coastal North Carolina lacks distinct wet and dry seasons, there is some seasonal variation in average precipitation. July tends to receive the most precipitation and rainfall amounts during summer are generally the greatest. Daily showers during the summer are not uncommon, nor are periods of one or two weeks without rain. Convective showers and thunderstorms contribute to the variability of precipitation during the summer months. October tends to receive the least amount of precipitation, on average. Throughout the winter and spring months precipitation occurs primarily in the form of migratory low pressure storms. MCB, Camp Lejeune's average yearly rainfall is approximately 52 inches.

Coastal plain temperatures are moderated by the proximity of the Atlantic Ocean. The ocean effectively reduces the average daily fluctuation of temperature. Lying 50 miles offshore at its nearest point, the Gulf Stream tends to have little direct effect on coastal temperatures. The southern reaches of the cold Labrador Current offsets any warming effect the Gulf Stream might otherwise provide.

MCB, Camp Lejeune experiences hot and humid summers; however, ocean breezes frequently produce a cooling effect. The winter months tend to be mild, with occasional brief cold spells. Average daily temperatures range from 38°F to 58°F in January and 72°F to 86°F in July. The average relative humidity, between 75 and 85 percent, does not vary greatly from season to season.

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occur 120 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year, and from the north-northwest during September and October at an average speed of 6.9 miles per hour.

2.1.9 Natural Resources and Ecological Features

The following summary of natural resources and ecological features was obtained from the IAS Report (Water and Air Research, 1983).

The MCB, Camp Lejeune is predominantly tree-covered with large amounts of softwood including shortleaf, longleaf, pond, and pines (primarily loblolly), and substantial stands of hardwood species. Approximately 60,000 of the 112,000 acres of MCB, Camp Lejeune are under forestry management. Timber producing areas are under even-aged management with the exception of those areas along streams and swamps. These areas are managed to provide both wildlife habitat and erosion control. Forest management provides wood production, increased wildlife populations, enhancement of natural beauty, soil protection, prevention of stream pollution, and protection of endangered species.

Upland game species including black bear, whitetail deer, gray squirrel, fox squirrel, quail, turkey, and migratory waterfowl are abundant and are considered in the wildlife management programs.

Aquatic ecosystems on MCB, Camp Lejeune consist of small lakes, the New River estuary, numerous tributaries, creeks, and part of the Intracoastal Waterway. A wide variety of freshwater and saltwater fish species exist here. Freshwater ponds are under management to produce optimum yields and ensure continued harvest of desirable fish species (Water and Air Research, 1983). Freshwater fish in the streams and ponds include largemouth bass, redbreast sunfish, bluegill, chain pickerel, yellow perch, and catfish. Reptiles include alligators, turtles, and snakes, including venomous species. Both

recreational and commercial fishing are practiced in the waterways of the New River and its tributaries.

Wetland ecosystems at MCB, Camp Lejeune can be categorized into five habitat types: (1) pond pine or pocosin; (2) sweet gum, water oak, cypress, and tupelo; (3) sweet bay, swamp black gum, and red maple; (4) tidal marshes; and, (5) coastal beaches. Pocosins provide excellent habitat for bear and deer because these areas are seldom disturbed by humans. The presence of pocosin-type habitat at MCB, Camp Lejeune is primarily responsible for the continued existence of black bear in the area. Many of the pocosins are overgrown with brush and pine species that would not be profitable to harvest. Sweet gum, water oak, cypress, and tupelo habitat is found in the rich, moist bottomlands along streams and rivers. This habitat extends to the marine shorelines. Deer, bear, turkey, and waterfowl are commonly found in this type of habitat. Sweet bay, swamp black gum, and red maple habitat exist in the floodplain areas of MCB, Camp Lejeune. Fauna including waterfowl, mink, otter, raccoon, deer, bear, and gray squirrel frequent this habitat. The tidal marsh at the mouth of the New River is one of the few remaining North Carolina coastal areas relatively free from filling or other manmade changes. This habitat, which consists of marsh and aquatic plants such as algae, cattails, saltgrass, cordgrass, bulrush, and spikerush, provides wildlife with food and cover. Migratory waterfowl, alligators, raccoons, and river otter exist in this habitat. Coastal beaches along the Intracoastal Waterway and along the outer banks of MCB, Camp Lejeune are used for recreation and to house a small military command unit. Basic assault training maneuvers are also conducted along these beaches. Training regulations presently restrict activities that would impact ecologically sensitive coastal barrier dunes. The coastal beaches provides habitat for many shorebirds (Water and Air Research, 1983).

The Environmental Management Department (EMD) of MCB, Camp Lejeune, the U.S. Fish and Wildlife Service, and the North Carolina Wildlife Resource Commission have entered into an agreement for the protection of endangered and threatened species that might inhabit MCB, Camp Lejeune. Habitats are maintained at MCB, Camp Lejeune for the preservation and protection of rare and endangered species through the Base's forest and wildlife management programs. Full protection is provided to such species, and critical habitat is designated in management plans to prevent or mitigate adverse effects of Base activities. Special emphasis is placed on habitat and sightings of alligators, osprey, bald eagles, cougars, dusky seaside sparrows, and red-cockaded woodpeckers (Water and Air Research, 1983).

Within 15 miles of MCB, Camp Lejeune are three publicly owned forests: Croatan National Forest; Hofmann Forest; and Camp Davis Forest. The remaining land surrounding MCB, Camp Lejeune is primarily used for agriculture. Typical crops include soybeans, small grains, and tobacco (Water and Air Research, 1983).

2.1.10 Land Use and Demographics

MCB, Camp Lejeune presently covers an area of approximately 236 square miles. Military and civilian population is approximately 60,000. During World War II, MCB, Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the recent Gulf War (i.e., Desert Storm). Toward the end of World War II, the camp was designated as a home base for the Second Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands.

The following information was extracted from the document "Master Plan, Camp Lejeune Complex, North Carolina." The existing land use patterns in the various geographic areas within the Marine Corps Base are described in this section and listed, per geographic area, on Table 2-2. The areas described below are depicted on Figure 2-1. In addition, the number of acres comprising each land use category has been estimated and provided on the table.

Military population of Camp Lejeune is approximately 40,928 active duty personnel. The military dependent community is in excess of 32,081. About 36,086 of these personnel and dependents reside in base housing units. The remaining personnel and dependents live off base. An additional 4,412 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,739 in 1940, prior to the formation of the base, to its present population of 121,350.

2.1.11 Water Supply

Potable water for MCB, Camp Lejeune is supplied entirely by groundwater. The base has no formally established groundwater preservation areas; however, because the base controls more than 110,000 acres of land, and because much of this land has remained undeveloped, the undeveloped areas serve the function of groundwater preserves. Groundwater usage is roughly seven million gallons per day (Cardinell, et al., 1993). Groundwater is pumped from approximately 75 of 90 water supply wells located within the boundaries of MCB, Camp Lejeune. Water is treated at eight plants which have a total capacity of 15.8 million gallons per day.

All of the water supply wells utilize the Castle Hayne aquifer. The Castle Hayne aquifer is highly permeable, semi-confined aquifer that is capable of yielding several hundred to 1,000 gpm in municipal and industrial wells in the MCB, Camp Lejeune area. The water supply wells at the base average 162 feet in depth; eight inches in diameter (casing); and yield 174 gpm (Harned, et al., 1989). The water is typically a hard, calcium bicarbonate type.

Two sources were reviewed to locate water supply wells within a 1-mile radius of Site 10. These sources were the USGS hydrogeologic assessment at Camp Lejeune (Harned, et. al., 1989) and the Wellhead Management Program Study report of 1991 (Geophex, 1991). Based on a review of these sources, there is a supply well (HP-610) located within a one-mile radius of Site 10.

The supply well was sampled in 1992 during the Wellhead Monitoring Study conducted by Greenhorne and O'Mara, Inc. and was found to contain TCE at concentrations exceeding North Carolina Water Quality Standards (NCWQS) and Federal Maximum Contaminant Levels (MCLs). The well was subsequently deactivated.

2.2 Site 10 - Original Base Landfill

This section addresses the setting, site topography and drainage features, site history, site geology and hydrogeology for Site 10 - Original Base Landfill.

2.2.1 Site Location and Setting

Site 10 is referred to as the Original Base Landfill and is located on the western side of Holcomb Boulevard approximately 1,600 feet south of Wallace Creek and 1,750 feet north of Bearhead Creek. Sites 6 and 82 (RI sites investigated in 1992) are located adjacent to the eastern edge of

Holcomb Boulevard, directly east of the site. Site 10 is located about one and one-half miles northeast of Hadnot Point, as shown on Figure 2-1. The Original Base Landfill was approximately five to ten acres in size when it was in full operation. The proposed study area is populated with trees varying in age from saplings to trees that are 30-40 years in age. A thick underbrush is also present throughout much of the area. Figure 2-4 is a site map illustrating the general layout of the Original Base Landfill.

During the site visit it was noted that many swamps exist south, west and north of the site. However, it is not certain if the swamps were present because of the increased precipitation that the area received due to the recent hurricanes or if they are a genuine feature. Nevertheless, it demonstrates that the soils drain poorly.

The site visit in September 1996 confirmed the presence of construction debris including concrete, bricks, scrap metal, metal piping and asphalt within boundaries of the site. The area is currently unrestricted with respect to site access. Military maneuvers are conducted in the area.

2.2.2 Site Topography and Drainage

Site 10 is situated in a topographical high area sloping north, west, and south. Surface water that does not infiltrate will travel in the direction of slope to the swamps surrounding the site. Wallace Creek (north of Site 10) and Bearhead Creek (south of Site 10) both flow east to west and eventually drain into the New River. Swampy areas exist south, west and north of the site location.

The NC DEHNR stream classifications for Wallace and Bearhead Creeks are SB (primary recreation, aquatic life, propagation and survival, fishing, wildlife, and secondary recreation) and NSW (Nutrient Sensitive Waters).

2.2.3 Site History

There is very little information regarding the history of this site. The Initial Assessment Study (Water and Air Research, 1993) indicates that the area was used as a disposal site for construction debris and as a burn dump. It is believed the landfill was operated prior to 1950 during construction of the base. Records documenting the type of debris and/or wastes disposed at the site were unavailable. During the IAS, it was decided that the site did not need to be investigated further and was removed from the list of sites warranting further investigation at the base. As discussed previously in Section 2.1.3, in 1994, two marines conducting night maneuvers fell into an open trench and received a rash from an "oily substance" that they had contacted. Site 10 was one of two sites that the marines may have been crossing while on maneuvers. Once this incident was reported, the site was added to the list of sites warranting investigation. An aerial photograph depicting the site as it existed in 1949 is provided on Figure 2-5.

2.2.4 Site Geology and Hydrogeology

A remedial investigation (RI) was conducted in August 1992 at Sites 6 and 82 located east of Site 10, directly across Holcomb Boulevard. Although the soils (less than 20 feet) may differ due to landfilling operations conducted at Site 10, the soils outside the boundary of the former landfill and below the depth of landfilling should be similar. The following geologic and hydrogeologic descriptions are an excerpt from the RI report for Sites 6 and 82 (CTO-0133).

The surface soils (0 to 25 feet, bgs) were described as silty sands with thin interbedded layers of silt and clay. Thin, discontinuous layers of silt are present near the northern and southern boundaries of the investigation. Descriptions of the soils encountered during the expedited site characterization are similar to the previously described soils.

Subsurface soils (below 25 feet, bgs) consist of fine to medium grained silty sand, silt, silty and sandy clays and limestone fragments. The appearance of the deeper sands are similar to that described for the surficial. Below 50 to 60 feet the sands become very dense to hard. Large amounts of shell fragments were noted and thin lenses of clay are interbedded within the sands. The clays contain trace amounts of silt and sand and are non to slightly plastic. The limestone beds contain mixtures of sand and marl.

Shallow groundwater in the northern portion of the site is flowing northwest toward Wallace Creek while groundwater in the southern portion flows toward Bearhead Creek indicating that a divide occurs in the central portion of the site.

2.2.5 Previous Investigations

An expedited site characterization and evaluation of Site 10 was conducted in September 1995 by DoN. However, it should be noted that the investigation was conducted in the western portion of the landfill. At the time of the investigation, it was believed that the landfill existed within the boundaries of the study area. Subsequent information such as the aerial photograph from 1949 (Figure 2-5) indicated that the landfill was much larger than originally believed, consequently creating a need to investigate the remaining portion. A summary of the findings of the investigation is presented below.

2.2.5.1 Soil Investigation

Five (5) soil borings (10-SB01 through 10-SB05) were drilled on site and advanced to the water table. A single surface and two subsurface soil samples were collected from each of the five locations using a GeoProbe (see Figure 2-6). Surface soil samples were collected from 0 to 6 inches below ground surface (bgs). The subsurface samples were collected from just above the water table and from a depth midway between the surface and the water table. All soil samples were analyzed for full TCL organics and TAL metals. Results of the surface and subsurface soils were compared to Region III Risk-Based Concentrations (RBCs) for residential and industrial soil and North Carolina Risk Analysis Framework Method I Target Concentrations. In addition, the detected inorganics were compared to base background results. Contaminant concentrations exceeding Region III RBCs are summarized in Table 2-3 through 2-6, and discussed below.

Surface Soil:

- Acetone was detected in surface samples collected at the site. However, not in excess of industrial or residential RBCs. The presence of acetone may not be site related.
- Numerous SVOCs were detected in the samples collected during the expedited site characterization. The following semivolatile organics (SVOCs) exceeded residential and/or industrial RBCs: benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene. Benzo(a)anthracene was the only semivolatile which exceeded North Carolina Risk Framework Method I Target Concentrations protective of groundwater.

- Pesticides such as aldrin 4,4'-DDE, Endosulfan II and 4,4'-DDT were detected in samples. The concentrations of these compounds were not in excess of the RBCs. PCBs were not detected in any of the samples.
- Arsenic, barium, beryllium, potassium, manganese, lead, and zinc were detected at concentrations exceeding the residential or industrial RBCs, North Carolina Risk Framework Method I Target concentrations protective of groundwater and/or base background concentrations.

Subsurface Soil:

- No VOCs were detected in subsurface soils collected at the site.
- Benzo(a)pyrene was the only detected SVOC whose concentration exceeded residential RBCs only.
- A single pesticide compound was detected in the subsurface soils, however the concentration was below the RBCs. No PCBs were detected.
- Arsenic, barium, calcium, copper, manganese, lead, and zinc were detected at concentrations exceeding the residential and industrial RBCs, North Carolina Risk Framework Method I Target concentration protective of groundwater and/or base background concentrations.

2.2.5.2 Groundwater Investigation

Three (3) temporary monitoring wells (10-TW01, 10-TW02, and 10-TW03) were installed, and one round of groundwater samples was collected. Groundwater samples were analyzed for full TCL organics and TAL Inorganics (total and dissolved fractions). Results of the groundwater samples were compared to Federal Maximum Contaminant Levels (MCLs) and the North Carolina Water Quality Standards (NCWQS). Analytical findings are summarized in Table 2-7 and highlighted below.

- VOCs, SVOCs, and pesticides/PCBs were detected at low levels. However, the detected concentrations were well below the MCLs and NCWQS.
- The following inorganics were detected at levels above the MCLs and/or NCWQS: aluminum, arsenic, chromium, iron (total and dissolved samples), manganese, nickel, lead, and vanadium.

3.0 DATA QUALITY AND SAMPLING OBJECTIVES

The purpose of this section is to define the site-specific SI data quality and sampling objectives in order to determine if contamination is present at the site, to collect data to determine if additional work is warranted in the form of a Remedial Investigation (RI) or removal action, to establish the direction of groundwater flow in the shallow aquifer, to provide a limited quantitative Risk Assessment (RA) using conservative receptors, and to qualitatively assess all data against applicable criteria. The site-specific SI objectives presented in this section have been identified based on review and evaluation of existing background information.

3.1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that ensure data of known and appropriate quality are obtained during the SI. The DQOs associated with each field sampling and analysis program are discussed and presented in this section. The DQOs were developed using the following three stages:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses/needs
- Stage 3 - Design data collection program

Stage 1 of the DQO process takes place during the scoping of the SI. This stage involves the evaluation of existing information and the development of objectives for field data collection efforts.

Stage 2 of the DQO process involves definition of the quality and quantity of data that will be required to meet the objectives established in Stage 1.

Stage 3 involves the design of a data collection program to meet the requirements identified in Stage 2.

3.1.1 Stage 1 - Identification of Decision Types

As part of the Stage 1 DQO process, available information from previous site investigations and other sources (e.g., USGS) were reviewed in order to describe current site conditions, evaluate existing data, and assess the adequacy of the data. This information was documented in Section 2.0 of this Work Plan. From this review and evaluation, SI objectives have been developed to assess the nature of the threat posed by the release or potential release of hazardous substances and characterize the site with respect to the environmental setting. These objectives are presented in Section 3.2.

3.1.2 Stage 2 - Identification of Data Uses/Needs

In Stage 2 of the DQO process, the data quality and quantity required to support the SI objectives developed during Stage 1 are identified. With respect to the SI objectives, data will be required to address specific environmental media at each site. Data uses for each environmental media are presented in Section 3.1.2.1. Site-specific data needs are discussed in Section 3.1.2.2.

3.1.2.1 Data Uses for Environmental Media

SI data uses can be described in general purpose categories. These categories include the following:

- Site Investigation - Data are used to determine the nature of contamination at a site. Site investigation data are generated through the sampling and analysis of waste sources and environmental media.
- Health and Safety - Data are typically used to establish the level of protection needed for investigators or workers at a site, and if there should be an immediate concern for the population living within the site vicinity.
- Risk Assessment - Data are used to evaluate the threat posed by a site to public health and the environment. Risk assessment data are generated through the sampling and analysis of environmental media.

With respect to the above data uses, an understanding of the site background, site history, and contaminant migration and exposure pathways are required in order to define the data needs (or data limitations). This "background" information was presented in Section 2.0 for each site. The site-specific data needs are presented in Section 3.1.2.2. SI objectives, which have been formed to meet the data needs, are presented in Section 3.2.

3.1.2.2 Site-Specific Data Needs

Data needs for Site 10 are as follows:

- Verify the presence or absence of shallow groundwater contamination.
- Verify the presence or absence of site-related contaminants in the surface and subsurface soil in order to conduct a limited human health risk assessment.
- Provide hydrogeologic parameters of the upper portion of the shallow aquifer.
- Provide information to support the assessment of risks to human health presented by potential exposure to the shallow groundwater and surface soil.

The type and quality of data required to meet the criteria listed above are presented in Section 4.0. The data quality levels differ with respect to the end use of the data. Level IV data quality are generally required in risk assessments, characterizing the nature and extent of contamination, and to support subsequent investigations. Level III data quality is appropriate for risk assessments, site characterization, and evaluating treatment alternatives. Level II data quality is appropriate for field screening (eg., ENSYS Screening). Level I data is appropriate for field measurements such as static water level, specific conductance, and pH. The analytical methods also differ with respect to the end use of the data. For this SI, USEPA methods and Contract Laboratory Program (CLP) methods will be used when applicable.

This field investigation will employ the use of Level III data. Although Level III data allows for the use of analytical methods other than CLP, the samples collected during this field investigation will be analyzed in accordance with CLP. However, the CLP requirements for documentation will not be

required. Like Level IV data, Level III data is conformational and used for determining the presence or absence of contaminants.

3.1.3 Stage 3 - Design Data Collection Program

The data collection program for Site 10 has been designed to meet the objectives outlined in the following sections. Section 4.0 of the SI Work Plan identifies the tasks required to perform the SI, including the risk assessment. Sections 3.0 through 5.0 of the FSAP provide the specific details of this sampling program.

3.2 Study Objectives

For each site-specific study objective, the criteria necessary to meet each objective along with a general description of the study or investigation required to obtain the information is found in Table 3-1.

4.0 SITE INVESTIGATION

This section identifies the tasks and field investigations required to complete SI activities at Site 10.

4.1 Task 1 - Project Management

Project Management activities involve such activities as daily technical support and guidance, budget and schedule review and tracking, preparation and review of invoices, personnel resources planning and allocation, preparation of monthly progress reports, and communication with LANTDIV and the Activity.

4.2 Task 2 - Subcontract Procurement

Task 2 involves the procurement of services such as drilling, surveying, laboratory analysis, and data validation. Procurement of these services will be performed in accordance with the Navy Clean Contract Procurement Manual.

4.3 Task 3 - Field Investigations

The field investigations will be conducted under Task 3. An overview of the field investigation to be conducted at the site is presented in the following subsections. Specific details with respect to the sampling procedures, locations and number of samples, and analytical methods are provided in the Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP). The field investigations described below will provide data to meet the overall SI objectives presented in Section 3.0 of this SI Work Plan. Table 4-1 summarizes the sampling and analytical requirements.

4.3.1 Soil Investigation

An overview of the soil investigation to be conducted at Site 10 is provided herein.

- A 250 by 250 foot sampling grid will be established over the central and eastern portions of the site. A soil boring will be advanced at each grid point (23 total) across the site (Figure 4-1). Additionally, two borings will be installed on the west and south of the area investigated during the expedited site characterization. A utility clearance will be conducted at the site prior to boring and well installation.
- One soil boring will be installed west of the site and used as a “control” sample point. Control samples are samples which may not represent background conditions, but represent the current state of soil/groundwater quality unaffected by site activities. Since two RI sites exist directly east of the site (upgradient), a control point will be established west of the site in an undisturbed area.
- Soil borings are expected to extend less than 10 feet below ground surface (bgs). Borings which will be converted into temporary wells are expected to extend approximately 7 feet below the water table.
- Two soil samples will be collected from each boring, one at 0 to 1 foot bgs., and one immediately above the saturated zone. An additional sample will be collected as

necessary, from any soils appearing to be visibly contaminated, or if the depth to the saturated zone is greater than 10 feet.

- All samples will be submitted for laboratory analysis including Target Compound List (TCL) organics (volatiles, semivolatiles, pesticides, and polychlorinated biphenyls) and Target Analyte List (TAL) metals.
- All samples will be analyzed on a routine turnaround time of 28 days.

4.3.2 Groundwater Investigation

A summary of the groundwater investigation is provided below.

- Eight (8) shallow, temporary wells are proposed to characterize groundwater conditions (Figure 4-1).
- Eight of the soil borings will be converted to temporary wells. The wells will be installed to an approximate depth of 15 feet bgs. One well, located west of the suspected location of the site will be used as a control point.
- The temporary wells will be installed by a GeoProbe rig and will not require development, because (1) no sand filter pack will be placed around the well section, (2) compared to augering, direct push methods causes less soil disturbance, and (3) drilling mud or water will not be introduced into the well boring.
- The temporary monitoring wells will be used to assess shallow groundwater flow direction.
- One round of groundwater samples will be collected from the wells. Low-flow purge and sampling techniques will be used in the collection of samples. All samples will be submitted to the laboratory for analysis (routine turnaround) of TCL organics and TAL metals.

4.3.3 Surface Water Sample Collection

The following procedures will be used for the collection of surface water samples at the site. At each of the six stations, samples will be collected at the approximate mid-vertical point or near the bank of the surface water body. Care will be taken to ensure that the sampler does not contact and/or stir up the sediments, while still being relatively close to the sediment-water interface.

The surface water samples will be collected by dipping the laboratory-supplied sample bottles directly into the water. Clean nitrile gloves will be worn by sampling personnel at each sampling station.

The water samples will be collected from near mid-stream at each station, where applicable. Water samples at the furthest downstream station will be collected first, with subsequent samples taken at the next upstream station(s). Sediment samples will be collected after the water samples to minimize sediment disturbance and suspension. Sampling personnel shall stand downstream at each station in order to minimize sediment disturbance.

All sample containers not containing preservative will be rinsed at least once with the sample water prior to final sample collection. In addition, the sampling container used to transfer the water into sample bottles containing preservatives will be rinsed once with sample water.

Care will be taken when collecting samples for analysis for VOCs to avoid excessive agitation that could result in loss of VOCs. VOC samples will be collected prior to the collection of the samples for analysis of the other parameters. Sample bottles will be filled in the same order at all sampling stations.

The following information will be recorded in the field log book:

- Project location, date and time
- Weather
- Sample location, number, and identification number
- Flow conditions (i.e., high, low, in flood, etc.)
- Visual description of water (i.e., clear, cloudy, muddy, etc.)
- Sketch of sampling location including boundaries of the water body, sample location and depth, and relative position with respect to the site
- Names of sampling personnel
- Sampling technique, procedure, and equipment used

4.3.4 Sediment Sample Collection

The following procedures will be used for the collection of sediment samples. At each of the six stations, surface and near surface sediment samples will be collected at a depth of 0 to 6 inches, and 6 to 12 inches. These intervals of sediment will be collected using a stainless steel hand-held coring instrument. A new or decontaminated stainless steel liner tube, fitted with an eggshell catcher to prevent sample loss, will be used at each station.

The coring device will be pushed into the sediments to a minimum depth of 15 inches, or until refusal, whichever is encountered first. The sediments in the 0 to 6-inch interval and 6 to 12-inch interval will be extruded with a decontaminated extruder into the appropriate sample containers. If less than 12 inches of sediments are obtained, the first 6 inches will be placed in the 0 to 6-inch container and the remaining sediment will be placed into the 6 to 12-inch container.

The sampling procedures for using the hand-held coring instrument (i.e., stainless-steel core sampler) are outlined below:

1. Inspect and prepare the corer:
 - a. Inspect the core tube and, if one is being used, the core liner. Core tube and core liner must be firmly in place, free of obstruction throughout its length. Bottom edge of core tube, or of the nose piece, should be sharp and free of nicks or dents.
 - b. Check the flutter valve for ease of movement.
 - c. Check the flutter valve seat to make sure it is clear of any obstruction that could prevent a tight closure.

- d. Attach a line securely to the core sampler. The line should be free of any frayed or worn sections, and sufficiently long to reach bottom.
2. Get in position for the sampling operation -- keeping in mind that disturbance of the bottom area to be sampled should be avoided.
3. Line up the sampler, aiming it vertically for the point where the sample is to be taken.
4. Push the core sampler, in a smooth and continuous movement, through the water and into the sediments -- increasing the thresh as necessary to obtain the penetration desired.
5. If the corer has not been completely submerged, close the flutter valve by hand and press it shut while the sample is retrieved. Warning: the flutter valve must be kept very wet if it is to seal properly.
6. Lift the core sampler clear of the water, keeping it as nearly vertical as possible, and handle the sample according to the type of the core tube.
7. Secure and identify the new sample. Unscrew the nose cone. Pull the liner out. Push out any extra sediments (greater than 12 inches). Push out the sediments within the 6 to 12-inch interval, then push out the 0 to 6-inch sediment interval. Samples (with the exception of VOAs) will first be homogenized prior to being transferred to their containers.
8. Seal all sample jars tightly.
9. Label all samples.

4.3.5 Surveying

All new soil boring locations, temporary well locations, current site features, estimated extent of the landfill, tree line, access roads and any areas where debris was discovered outside of the landfill boundary will be surveyed.

4.3.6 Investigation Derived Waste Handling

Drill cuttings or excavated soils will be collected and contained in drums if they are determined in the field to be potentially contaminated based on visual observations and HNu readings. A single storage tank with a capacity of 1,000 gallons will be stationed at the site for containing groundwater. A composite soil sample from the drums will be collected and analyzed for TCL organics and TAL inorganics and RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability). One sample will be collected from the tank and analyzed for full TCL organics and TAL total metals. Additional details regarding IDW handling and disposal are provided in Section 6.7 of the FSAP.

4.4 Task 4 - Sample Analysis and Validation

This task involves efforts relating to the following post-field sampling activities:

- Sample Management
- Laboratory Analysis
- Data Validation

Sample management activities involve: coordination with laboratories; tracking of samples submitted for analysis; tracking of analyses received; and tracking of information related to samples submitted and received from a third party validator. Sample management also involves resolving technical or administrative problems (e.g., reanalysis, resubmission of information).

Laboratory analysis begins when the samples are shipped from the field and received by the laboratory. Validation begins when the "raw" laboratory data is received by the validator from Baker. Baker will first receive the data from the laboratory, log it into a database for tracking purposes, and then forward it to the validator. A validation report will be expected within three weeks following receipt of laboratory data packages by the validator. CLP data will be validated per the CLP criteria as outlined in the following documents:

- USEPA, Hazardous Site Control Division, Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, 1991.
- USEPA, Hazardous Site Evaluation Division, Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses, 1988.

All other data will be validated in accordance with the method of analysis using the National Functional Guidelines as a reference.

4.5 Task 5 - Data Evaluation

This task involves efforts related to the data once it is received from the laboratory and is validated. It also involves the evaluation of any field-generated data including: water level measurements, test boring logs, and other field notes. Efforts under this task will include the tabulation of validated data and field data, generation of test boring logs and monitoring well construction logs, generation of geologic cross-section diagrams, and the generation of other diagrams associated with field notes or data received from the laboratory (e.g., sampling location maps).

4.6 Task 6 - Risk Assessment

This section of the Work Plan describes the scope for conducting a site inspection (SI) risk assessment (RA). A risk assessment will be performed as part of this SI to evaluate the potential human health impacts that would occur in the absence of any remedial action. The risk assessment will provide support for determining whether or not an RI or a removal action is necessary.

The SI risk assessment will be performed in accordance with USEPA guidelines. The primary documents that will be utilized include:

- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part A), EPA 1989.
- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), EPA 1991.
- Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives), EPA 1991.
- Risk Assessment Guidance for Superfund: Volume II, Environmental Evaluation Manual, EPA 1989.
- Supplemental Guidance to RAGS: Standard Default Values, EPA 1991a.
- Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992.
- Superfund Exposure Assessment Manual, EPA 1988.
- Exposure Factors Handbook, EPA 1989b.
- Guidance for Data Usability in Risk Assessment, EPA 1990.
- Supplemental USEPA Region IV Risk Assessment Guidance, EPA Region IV, 1991.
- Supplemental Guidance to RAGS: Region IV Bulletins, EPA Region IV, 1995.

USEPA Region IV will be consulted for Federal guidance, and the North Carolina DEHNR will be consulted for guidance in the State of North Carolina.

The technical components of the SI RA are contaminant identification, exposure assessment, toxicity assessment, and risk characterization. The objectives of the risk assessment process can be accomplished by:

- Characterizing the toxicity and levels of contaminants in relevant media (e.g., groundwater and soil).
- Characterizing the environmental fate and transport mechanisms within specific environmental media.
- Identifying potential current and future human receptors.
- Identifying potential exposure routes and the extent of the actual or expected exposure.
- Defining the extent of the expected impact or threat.
- Identifying the levels of uncertainty associated with the above items.

The RA will utilize all available data to date that has been properly validated in accordance with USEPA guidelines plus all data to be collected from additional sampling during this SI.

4.6.1 Human Health Evaluation Process

4.6.1.1 Site Location and Characterization

A background section will be presented at the beginning of the risk assessment to provide an overview of the site characteristics. This section will provide a site location, a general site description, and the site-specific chemicals as discussed in past reports. The physical characteristics of the site and the geographical areas of concern will be discussed. This site description will help to characterize the exposure setting.

4.6.1.2 Data Summary

Because decisions regarding data use may influence the resultant risk assessment, careful consideration must be given to the treatment of those data. For purposes of risk evaluation, chemical concentrations will be characterized and risks will be evaluated for soil and groundwater at Site 10. In selecting data to include in the risk assessment, the objective is to characterize, as accurately as possible, the distribution and concentration of chemicals in each medium.

Data summary tables will be developed for the soil and groundwater results. Each data summary table will indicate the frequency of detection, observed range of concentrations, average background concentrations (inorganics), and the means and upper 95 percent confidence limit (UCL) value for each contaminant detected in each medium. The arithmetic or geometric mean and the 95 percent UCL of that mean will be used in the summary of potential chemical data. The selection of arithmetic or geometric means will depend on whether the sample data are normally or log-normally distributed. In the calculation of the 95 percent UCL mean, concentrations presented as "ND" (nondetect) will be incorporated. In cases where there is a question about the distribution of the data set, a statistical test will be used to determine the best distributional assumption for the data set. The W-test will be employed to determine if the data set is consistent with normal or lognormal distribution. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent UCL can be greater than the maximum detected concentration. In such cases, the maximum detected concentration is used instead.

4.6.1.3 Identifying Chemicals of Potential Concern

The criteria to be used in selecting the Contaminants of Potential Concern (COPCs) from the constituents detected during the sampling and analytical phase of the investigation are: historical information, comparison of the applicable, relevant, and appropriate requirements (ARARs), prevalence, comparison to blank data or base-specific naturally occurring levels (i.e., background), mobility, persistence, toxicity, and comparison to anthropogenic levels. The criteria chosen to establish the COPC are derived from the USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989) as well as USEPA's Region IV Bulletins (USEPA, 1995).

All of the available sample data will undergo review upon initiation of the risk assessment. Common laboratory contaminants such as acetone, methylene chloride, phthalate esters, toluene, and methyl ethyl ketone will be addressed only if concentrations are 10 times greater than the corresponding blanks. In addition, chemicals that are not common laboratory contaminants will be evaluated if they

are greater than five times the laboratory blank. The number of chemicals analyzed in the risk assessment will be a subset of the total number of chemicals detected at a site based on the elimination criteria discussed previously.

Tables will be prepared that list chemical concentrations for all media by site. Data will be further grouped according to organic and inorganic species within each table.

4.6.1.4 Exposure Assessment

The objectives of the exposure assessment at MCB, Camp Lejeune will be to characterize the exposure setting, identify exposure pathways, and quantify the exposure. When characterizing the exposure setting, the potentially exposed populations will be described. The exposure pathway will identify the release source (e.g., soil) for the contaminant, the release mechanism of a medium (e.g., leaching), the point of potential human contact with the contaminated medium, and the exposure route(s) (e.g., ingestion). The magnitude, frequency, and duration for each exposure pathway identified will be quantified during this process.

The identification of potential exposure pathways at the site will include the activities described in the subsections that follow.

Analysis of the Probable Fate and Transport of Site-Specific Chemicals

To determine the environmental fate and transport of the chemicals of concern at the site, the physical/chemical and environmental fate properties of the chemicals will be reviewed. Some of these properties include volatility, photolysis, hydrolysis, oxidation, reduction, biodegradation, accumulation, persistence, and migration potential. This information will assist in predicting potential current and future exposures. It will help in determining those media that are currently receiving site-related chemicals or may receive site-related chemicals in the future. Sources that may be consulted in obtaining this information include computer databases (e.g., AQUIRE, ENVIROFATE), as well as the open literature.

The evaluation of fate and transport may be necessary where the potential for changes in future chemical characteristics is likely and for those media where site-specific data on the chemical distribution is lacking.

Identification of Potentially Exposed Human Populations

Human populations, that may be potentially exposed to chemicals at the MCB, Camp Lejeune include base personnel and their families, base visitors, and on-site workers and recreational fishermen. The Base Master Plan will be consulted to confirm or modify these potential exposures. Current military personnel and future residents could be exposed to chemicals as they carry out activities at the site located at MCB, Camp Lejeune. The list of potential receptors and pathways to be evaluated will be refined during discussions with regulators prior to performing the RA.

Identification of Potential Exposure Scenarios Under Current and Future Land Uses

The exposure scenarios specific to Site 10 will be finalized after consulting with the Base Master Plan, USEPA and the State of North Carolina. Generally, current and future exposure pathways will be considered preliminarily as follows:

- Soil Pathway
 - ▶ Direct ingestion (current military personnel, current trespassers, future residents, future construction workers)
 - ▶ Inhalation of dust (current military personnel, current trespassers, future residents, future construction workers)
 - ▶ Dermal contact (current military personnel, current trespassers, future residents, future construction workers)

- Groundwater
 - ▶ Direct ingestion (future residents/future construction workers)
 - ▶ Inhalation (future residents/future construction workers)
 - ▶ Dermal contact (future residents/future construction workers)

Exposure Point Concentrations

After the potential exposure points and potential receptors have been defined, exposure point concentrations must be calculated. The chemical concentrations at these contact points are critical in determining intake and, consequently, risk to the receptor. The data from site investigations will be used to estimate exposure point concentrations.

The upper 95 percent confidence limits of the means will be used throughout the risk assessment. In cases where maximum concentrations are exceeded by upper 95 percent confidence limit, the maximum concentrations will be used.

Exposure doses will be estimated for each exposure scenario from chemical concentrations at the point of contact by applying factors that account for contact frequency, contact duration, average body weight, and other route-specific factors such as breathing rate (e.g., inhalation). These factors will be incorporated into exposure algorithms that convert the environmental concentrations into exposure doses. Intakes will be reported in milligrams of chemical taken in by the receptor (i.e., ingested, inhaled, etc.) per kilogram body weight per day (mg/kg-day). Intakes for potentially exposed populations will be calculated separately for the appropriate exposure routes and chemicals.

4.6.1.5 Toxicity Assessment

Toxicity values (i.e., numerical values derived from dose-response toxicity data for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity values may be taken or derived from the following sources (note that the most up-to-date toxicity information obtained from IRIS and/or HEAST will be used in the exposure assessments):

- Integrated Risk Information System (IRIS) - The principal toxicology database, which provides updated information from USEPA on cancer slope factors, reference doses, and other standards and criteria for numerous chemicals.

- Health Effects Assessment Summary Tables (HEAST) - A tabular summary of noncarcinogenic and carcinogenic information contained in IRIS.

For some chemicals, toxicity values (i.e., reference doses) may have to be derived if the principal references previously mentioned do not contain the required information. These derivations will be provided in the risk assessment for review by USEPA Region IV. The toxicity assessment will

include a brief description of the studies on which selected toxicity values were based, the uncertainty factors used to calculate noncarcinogenic reference doses (RfDs), the USEPA weight-of-evidence (WOE) classification for carcinogens, and their respective slope factors.

4.6.1.6 Risk Characterization

Risk characterization involves the integration of exposure doses and toxicity information to quantitatively estimate the risk of adverse health effects. Quantitative risk estimates based on the reasonable maximum exposures to the site contaminants will be calculated based on available information. For each exposure scenario, the potential risk for each chemical will be based on intakes from all appropriate exposure routes. Carcinogenic risk and noncarcinogenic hazard indices are assumed to be additive across all exposure pathways and across all of the chemicals of concern for each exposure scenario. Potential carcinogenic risks will be evaluated separately from potential noncarcinogenic effects, as discussed in the following subsections.

Carcinogenic Risk

For the potential carcinogens that are present at the site, the carcinogenic slope factor (CSF) will be used to estimate cancer risks at low dose levels. Risk will be directly related to intake at low levels of exposure. Expressed as an equation, the model for a particular exposure route is:

$$\text{Excess lifetime cancer risk} = \text{Estimated dose} \times \text{carcinogenic slope factor}; \\ \text{or CDI} \times \text{CSF}$$

Where: CDI = Chronic daily intake

This equation is valid only for risk less than 10^{-2} (1 in 100) because of the assumption of low dose linearity. For sites where this model estimates carcinogenic risks of 10^{-2} or higher, an alternative model will be used to estimate cancer risks as shown in the following equation:

$$\text{Excess lifetime cancer risk} = 1 - \exp(-\text{CDI} \times \text{CSF})$$

Where: exp = the exponential

For quantitative estimation of risk, it will be assumed that cancer risks from various exposure routes are additive. Since there are no mathematical models that adequately describe antagonism or synergism, these issues will be discussed in narrative fashion in the uncertainty analysis.

Noncarcinogenic Risk

To assess noncarcinogenic risk, estimated daily intakes will be compared with reference doses (RfD) for each chemical of concern. The potential hazard for individual chemicals will be presented as a hazard quotient (HQ). A hazard quotient for a particular chemical through a given exposure route is the ratio of the estimated daily intake and the applicable RfD, as shown in the following equation:

$$\text{HQ} = \text{CDI}/\text{RfD}$$

Where: HQ = Hazard quotient
 CDI = Chronic daily intake or exposure (mg/kg-day)
 RfD = Reference dose (mg/kg-day)

To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals through a variety of exposure routes, a hazard index (HI), which is the sum of all the hazard quotients, will be calculated. Ratios greater than one, or unity, indicate the potential for adverse effects to occur. Ratios less than one indicate that adverse effects are unlikely. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect. In some cases when the HI exceeds unity it may be appropriate to segregate effects (as expressed by the HI) by target organ since those effects would not be additive. As previously mentioned, where information is available about the antagonism or synergism of chemical mixtures, it will be appropriately discussed in the uncertainty analysis.

4.6.1.7 Uncertainty Analysis

There is uncertainty associated with any risk assessment. The exposure modeling can produce very divergent results unless standardized assumptions are used and the possible variation in others are clearly understood. Similarly, toxicological assumptions, such as extrapolating from chronic animal studies to human populations, also introduce a great deal of uncertainty into the risk assessment. Uncertainty in a risk assessment may arise from many sources including but not limited to:

- Environmental chemistry sampling and analysis.
- Misidentification or failure to be all-inclusive in chemical identification.
- Choice of models and input parameters in exposure assessment and fate and transport modeling.
- Choice of models or evaluation of toxicological data in dose-response quantification.
- Assumptions concerning exposure scenarios and population distributions.

The variation of any factor used in the calculation of the exposure concentration will have an impact on the total carcinogenic and noncarcinogenic risk. The uncertainty analysis will qualitatively discuss non-site and site-specific factors that may product uncertainty in the risk assessment. These factors may include key modeling assumptions, exposure factors, assumptions inherent in the development of toxicological end points, and spatio-temporal variance in sampling.

4.7 Task 7 - SI Reports

Draft, Draft Final and Final Site Investigation reports will be prepared to document the SI findings, the results of the SI risk assessment, and provide conclusions and recommendations. These documents will be prepared using applicable USEPA guidance documents, and will follow the format used previously for other MCB, Camp Lejeune SIs.

4.8 Task 8 - Meetings

This task involves providing technical support to LANTDIV during the SI. It is anticipated that the following meetings will be required:

- Meeting between Baker and LANTDIV/EMD to discuss the SI conclusions prior to the submission of the Draft SI report.
- A remedial project management (RPM) meeting with LANTDIV/EMD, USEPA Region IV, and the North Carolina DEHNR following the submission of the Draft SI report.
- A Restoration Advisory Board (RAB) meeting to present the findings of the SI.

The meetings will be attended by the Baker Project Manager, and Project Engineer or Risk Assessment Specialist.

5.0 PROJECT MANAGEMENT AND STAFFING

The Baker Project Team will be managed by Mr. James S. Culp. The primary responsibilities of the Project Manager will be to monitor the technical performance, cost, and schedule, and to maintain close communication with the Navy Technical Representative, Ms. Katherine Landman. The Project Manager will report to Mr. Matthew D. Bartman (Activity Coordinator) who will be responsible for overall quality assurance/quality control. Mr. John W. Mentz and Mr. Raymond P. Wattras will provide program support.

The Project Team will consist of a Risk Assessment Specialist, Project Engineer, Project Geologist, Health and Safety Specialist, Ecological Scientist, and technical support staff as shown in Figure 5-1.

6.0 SCHEDULE

The proposed project schedule for Site 10 has been prepared in accordance with review periods identified in the Federal Facilities Agreement (FFA), and is presented as Figure 6-1.

7.0 REFERENCES

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TABLES

TABLE 2-1

**GEOLOGIC AND HYDROGEOLOGIC UNITS IN
THE COASTAL PLAIN OF NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0369
MCB CAMP LEJEUNE, NORTH CAROLINA**

Geologic Units			Hydrogeologic Units	
System	Series	Formation	Aquifer and Confining Unit	
Quaternary	Holocene/Pleistocene	Undifferentiated	Surficial aquifer	
Tertiary	Pliocene	Yorktown Formation ⁽¹⁾	Yorktown confining unit	
		Eastover Formation ⁽¹⁾	Yorktown Aquifer	
	Miocene	Pungo River Formation ⁽¹⁾	Pungo River confining unit	
		Belgrade Formation ⁽²⁾	Pungo River Aquifer	
		River Bend Formation	Castle Hayne confining unit	
	Oligocene	Castle Hayne Formation	Castle Hayne Aquifer	
	Eocene	Beaufort Formation	Beaufort confining unit ⁽³⁾	
Paleocene		Beaufort Aquifer		
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee confining unit	
			Peedee Aquifer	
		Black Creek and Middendorf Formations	Black Creek confining unit	
			Black Creek Aquifer	
	Lower Cretaceous ⁽¹⁾	Cape Fear Formation		Upper Cape Fear confining unit
				Upper Cape Fear Aquifer
				Lower Cape Fear confining unit
				Lower Cape Fear Aquifer
	Unnamed deposits ⁽¹⁾	Lower Cretaceous confining unit		
		Lower Cretaceous Aquifer ⁽¹⁾		
Pre-Cretaceous basement rocks		--	--	

⁽¹⁾ Geologic and hydrologic units probably not present beneath MCB, Camp Lejeune.

⁽²⁾ Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.

⁽³⁾ Estimated to be confined to deposits of Paleocene age in the study area.

Source: Harned et al., 1989.

TABLE 2-2

**LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
MCB, CAMP LEJEUNE, NORTH CAROLINA**

Geographic Area	Oper.	Training (Instruc.)	Maint.	Supply/ Storage	Medical	Admin.	Family Housing	Troop Housing	CM	CO	Recreat.	Utility	Total
Hadnot Point	31 (2.9)	15 (1.4)	154 (14.3)	157 (14.4)	10 (0.9)	122 (11.3)	22 (2.0)	196 (18.1)	115 (10.7)	36 (3.3)	182 (16.9)	40 (3.7)	1,080 (100)
Paradise Point	1 (0)		3 (0.4)	1 (0)			343 (34)	19 (1.9)	31 (3.1)		610 (60.4)	2 (0.2)	1,010 (100)
Berkeley Manor/ Watkins Village							406 (80)		41 (8.1)	1 (0.2)	57 (11.2)	2 (0.5)	507 (100)
Midway Park		1 (0.4)		2 (0.7)		2 (0.7)	248 (92.2)		8 (3.0)	3 (1.1)	4 (1.5)	1 (0.4)	269 (100)
Tarawa Terrace I and II			3 (0.5)			1 (0.3)	428 (77.4)		55 (9.9)	11 (2.0)	47 (8.5)	8 (1.4)	553 (100)
Knox Trailer							57 (100)						57 (100)
French Creek	8 (1.4)	1 (0.2)	74 (12.7)	266 (45.6)	3 (0.5)	7 (1.2)		122 (20.9)	22 (3.8)	6 (1.0)	74 (12.7)		583 (100)
Courthouse Bay		73 (28.6)	28 (10.9)	14 (5.5)		12 (4.7)	12 (4.7)	43 (16.9)	15 (5.9)	4 (1.6)	43 (16.9)	11 (4.3)	255 (100)
Onslow Beach	6 (9.8)	1 (1.6)	3 (4.8)	2 (3.2)	1 (1.6)	2 (3.2)		2 (3.2)	12 (19.3)		25 (40.3)	8 (13.0)	62 (100)
Rifle Range		1 (1.3)	1 (1.3)	7 (8.8)	1 (1.3)	5 (6.3)	7 (8.8)	30 (37.5)	5 (6.3)	1 (1.3)	9 (11.3)	13 (16.3)	80 (100)
Camp Geiger (including the MCAS)	4 (1.9)	15 (6.9)	19 (8.8)	50 (23.1)		23 (10.6)		54 (25.0)	27 (12.5)	2 (1.0)	16 (7.4)	6 (2.8)	216 (100)
Montford Point	6 (2.6)	48 (20.5)	2 (0.9)	4 (1.7)	2 (0.9)	9 (3.9)		82 (35.2)	20 (8.6)	1 (0.4)	49 (21.0)	10 (4.3)	233 (100)
Base-Wide Misc.	1 (0.8)			87 (68.0)		3 (2.3)			19 (14.8)			18 (14.1)	128 (100)
TOTAL	57 (1.1)	155 (3.1)	287 (5.7)	590 (11.7)	17 (0.38)	186 (3.7)	1,523 (30.2)	548 (10.8)	370 (7.4)	65 (1.3)	1,116 (22.2)	119 (2.4)	5,033 (100)

TABLE 2-3

ORGANIC COMPOUNDS EXCEEDING CRITERIA - SURFACE SOIL
EXPEDITED SITE CHARACTERIZATION AND EVALUATION
SITE 10
MCB, CAMP LEJEUNE, JACKSONVILLE, NC

Constituent	Risk-Based Concentrations		North Carolina Risk Analysis Framework Method I Target Concentrations	Soil Results				
	Industrial Soils (µg/kg)	Residential Soils (µg/kg)	S3:G1 (µg/kg)	10-SB01-00 Soil	10-SB02-00 Soil	10-SB03-00 Soil	10-SB04-00 Soil	10-SB05-00 Soil
Semivolatiles (µg/kg):								
Benzo(a)anthracene	7,800	880	343	170J	390U	<i>4,500E</i>	440U	450U
Benzo(b)fluoranthene	7,800	880	--	260J	390U	<i>4,600E</i>	440U	450U
Benzo(a)pyrene	780	88	--	<i>190J</i>	390U	3,500E	440U	450U
Indeno(1,2,3-cd)pyrene	7,800	880	--	120J	390U	<i>2,800</i>	440U	450U
Dibenzo(a,h)anthracene	780	88	--	410U	390U	<i>630</i>	440U	450U

Notes:

- µg/kg = Micrograms per kilogram
- U = Analyzed, not detected
- J = Present below detection limit
- E = Exceeds linear range of calibration

Industrial/Residential - Industrial and Residential Risk Based Concentrations (March 1995)

Shading indicates the compound exceeded Residential Risk Based Concentrations.

Bold indicates the compound exceeded Industrial Risk Based Concentrations.

Italics indicates the compound exceeded the North Carolina Risk Analysis Framework Method I Target Concentrations.

TABLE 2-4

**INORGANIC COMPOUNDS EXCEEDING CRITERIA - SURFACE SOIL
EXPEDITED SITE CHARACTERIZATION AND EVALUATION
SITE 10
MCB, CAMP LEJEUNE, JACKSONVILLE, NC**

Constituent	Soil Criteria				Soil Results				
	(RBCs) Industrial Soils (mg/kg)	(RBCs) Residential Soils (mg/kg)	SS Background 2X (CTO 303)	North Carolina Risk AnalAnalysis Framework Method I Target Concentrations S1:G1 (mg/kg)	10-SB01-00 Soil	10-SB02-00 Soil	10-SB03-00 Soil	10-SB04-00 Soil	10-SB05-00 Soil
Total Analytes (mg/kg):									
Arsenic	3.3	0.37	1.3	26.2	0.36U	<i>0.59</i>	0.32U	0.43U	0.42U
Barium	140,000	5,500	17.4	848	4.1	<i>18.1</i>	3.7	16.2	3.5
Beryllium	1.3	0.15	0.2	--	0.27U	<i>0.39</i>	0.35U	0.37U	0.34U
Calcium	NC	NC	1,396.8	--	148	803	225	889	39.7
Cadmium	1,000	39	0.7	2.72	0.51U	0.54U	0.65U	0.7U	0.64U
Cobalt	120,000	4,700	1.9	--	0.4U	0.88	0.54	0.55U	0.5U
Chromium	10,000	390	6.7	27.2	1.8	2.6	2.1	0.95	0.97
Copper	76,000	2,900	7.2	704	1.3	3.2	1.4	2.4	1
Iron	NC	NC	3,755.1	151.2	<i>794</i>	<i>1,990</i>	<i>604</i>	<i>384</i>	<i>1,040</i>
Mercury	610	23	0.1	0.0154	0.11U	0.12U	0.1U	0.11U	0.1U
Potassium	NC	NC	199.6	--	144	129	146	213	121U
Manganese	10,000	390	18.5	65.2	13.3	<i>34.6</i>	3.2	3.9	2.8
Sodium	NC	NC	52.3	--	12.5	29.4	14.1	18.6	14.6
Nickel	41,000	1,600	3.4	56.4	2.1U	2.3U	<i>2.7U</i>	2.9U	2.6U
Lead	NC	400	23.7	270.06	28	<i>48.5</i>	25.7	12.1	2.1
Vanadium	14,000	550	11.6	--	2.4	5	2.9	3	3.5
Zinc	610,000	23,000	13.9	1100.4	8.6	<i>29.2</i>	10.1	7.6	0.75

Notes:

mg/kg = Milligrams per kilogram
 NC = No criteria available
 U = Analyzed, not detected

Industrial/Residential - Industrial and Residential Risk Based Concentrations (March 1995)
 Site Specific Background - MCB Camp Lejeune Base Background, updated through CTO 303 (August 1995)
 Italics indicates the compound exceeded site-specific background levels

 Indicates the compound exceeded North Carolina Risk Analysis Framework method I Target Concentrations, Draft, November, 1996.

TABLE 2-5

ORGANIC COMPOUNDS EXCEEDING CRITERIA - SUBSURFACE SOIL
 EXPEDITED SITE CHARACTERIZATION AND EVALUATION
 SITE 10
 MCB, CAMP LEJEUNE, JACKSONVILLE, NC

Constituent	Soil Criteria		Soil Results									
	(RBCs) Industrial Soils (µg/kg)	(RBCs) Residential Soils (µg/kg)	10-SB01-00 Soil	10-SB01-02 Soil	10-SB02-01 Soil	10-SB02-02 Soil	10-SB03-01 Soil	10-SB03-02 Soil	10-SB04-02 Soil	10-SB04-04 Soil	10-SB05-02 Soil	10-SB05-04 Soil
Semivolatiles (µg/kg):												
Benzo(a)pyrene	780	88	360U	350U	360U	410U	350J	400U	370J	430U	380U	350U

Notes:

- µg/kg = Micrograms per kilogram
- U = Analyzed, not detected
- J = Present below detection limit

Industrial/Residential - Industrial and Residential Risk Based Concentrations (March 1995)
 Shading indicates the compound exceeded Residential Risk Based Concentrations.

TABLE 2-6

INORGANIC COMPOUNDS EXCEEDING CRITERIA - SUBSURFACE SOIL
 EXPEDITED SITE CHARACTERIZATION AND EVALUATION
 SITE 10
 MCB, CAMP LEJEUNE, JACKSONVILLE, NC

Constituent	Industrial Soils (mg/kg)	Residential Soils (mg/kg)	SS Background 2X (CTO 303)	North Carolina Risk Analysis Framework Method I Target concentrations S3:G1 (mg/kg)	10-SB01-01 Soil	10-SB01-02 Soil	10-SB02-01 Soil	10-SB02-02 Soil
Total Analytes (mg/kg):								
Aluminum	1,000,000	78,000	7,375.0	--	4,680	717	2,290	782
Arsenic	3.3	0.37	2.0	26.2	1.2	0.3U	0.67	0.35U
Barium	140,000	5,500	14.2	848	15.4	3.2	11.2	1.8
Calcium	NC	NC	391.5	--	1,550	103	1,250	79.4
Copper	76,000	2,900	2.4	704	1.8	0.75	6.2	0.38
Iron	NC	NC	7,252.1	151.2	2,110	165	2,400	404
Mercury	610	23	0.1	0.0154	0.09U	0.09U	0.088U	0.083U
Manganese	10,000	390	7.9	65.2	9.1	1.9	23.5	2.5
Nickel	41,000	1,600	3.7	56.4	2.4U	2.4U	2.1U	2.2U
Lead	NC	400	8.3	270.06	10.7	1.1	99.8	2
Vanadium	14,000	550	13.5	--	6.1	1.4	3.4	1.3
Zinc	610,000	23,000	6.7	1,100.4	13.3	0.65U	148	11.1

TABLE 2-6 (Continued)

INORGANIC COMPOUNDS EXCEEDING CRITERIA - SUBSURFACE SOIL
 EXPEDITED SITE CHARACTERIZATION AND EVALUATION
 SITE 10
 MCB, CAMP LEJEUNE, JACKSONVILLE, NC

Constituent	10-SB03-01 Soil	10-SB03-02 Soil	10-SB04-02 Soil	10-SB04-04 Soil	10-SB05-02 Soil	10-SB05-04 Soil
Total Analytes (mg/kg):						
Aluminum	964	641	3,830	1,040	6,100	616
Arsenic	0.28U	0.29U	0.36	0.34U	0.97	0.29U
Barium	6.4	2	<i>18.1</i>	2.5	8.5	1.7
Calcium	247	66.8	76.7	29.3	43.4	18.5
Copper	2.1	0.59	1.5	0.6	1.5	0.41
Iron	950	161	1,730	278	3,590	235
Mercury	0.11U	0.086U	0.1U	0.097U	0.091U	0.071U
Manganese	6.3	1.3	4.1	2	3.8	1.6
Nickel	2.4U	2.7U	2.2U	2.8U	2.5U	2.1U
Lead	<i>19.2</i>	4	3.7	0.86	3.6	4.4
Vanadium	2.2	1.6	4.3	2	10.4	1.7
Zinc	<i>56.7</i>	7.7	0.67	0.74U	2.5	0.57U

Notes:

mg/kg = Milligrams per kilogram
 NC = No criteria available
 U = Analyzed, not detected

Industrial/Residential - Industrial and Residential Risk Based Concentrations (March 1995)

SS Background - MCB Camp Lejeune Base Background, updated through CTO 303 (August 1995)

Shading indicates the compound exceeded Residential Risk Based Concentrations.

Bold indicates the compound exceeded Industrial Risk Based Concentrations.

Italics indicates the compound exceeded site-specific background levels

 Cross-hatch indicates compound exceeded North Carolina Risk Analysis Framework Method I Target Concentrations (S3:G-1).

TABLE 2-7

**INORGANIC COMPOUNDS (TOTAL AND DISSOLVED) EXCEEDING CRITERIA - GROUNDWATER
EXPEDITED SITE CHARACTERIZATION AND EVALUATION
SITE 10
MCB, CAMP LEJEUNE, JACKSONVILLE, NC**

Constituent	Tap Water (µg/L)	MCL (µg/L)	NCWQS µg/L)	10-TW01 GW	10-TW01D GS-DIS	10-TW02 GW	10-TW02D GS-DIS	10-TW03 GW	10-TW03D GW-DIS
Total Analytes (µg/L):									
Aluminum	37,000	NC	NC	10,800	16.9U	145,000	117	75,100	85.2
Arsenic	0.038	50	50	1.8U	1.8U	17.6	1.8U	14.1	1.8U
Beryllium	0.016	4	NC	1.5U	1.5U	1.5U	1.5U	1.5U	1.5U
Cadmium	18	5	5	2.8U	2.8U	2.8U	2.8U	2.8U	2.8U
Chromium	180	100	50	15.2	2.4U	134	2.4U	74.6	2.4U
Iron	NC	NC	300	2,780	1,650	57,100	1,910	26,800	1,710
Mercury	11	2	1.1	0.2U	0.2U	0.2U	0.2U	0.2U	0.2U
Manganese	180	NC	50	32.9	28.7	127	27	92.2	38.5
Nickel	730	100	100	369	17.8	28	11.6U	215	53.5
Lead	NC	15	15	5.1	1.4U	48.4	3	45.9	1.4U
Vanadium	260	NC	NC	11.6	2.6U	338	2.6U	175	2.6U
Zinc	11,000	NC	2,100	6.5	3.1U	326	10.4	58.2	13.2

Notes:

µg/l = Micrograms per liter
 GW = Groundwater
 DIS = Dissolved fraction
 NC = No criteria available
 U = Analyzed, not detected

Tap Water - Risked Based Concentration (March 1995)
 MCL - Maximum Contaminant Level, Federal Register (May 1995)
 NCWQS - North Carolina Water Quality Standard (November 1993)
 Shading indicates the compound exceeded Tap Water Risk-Based Concentrations.
 Bold indicates the compound exceeded Federal MCL.
 Italics indicates the compound exceeded NCWQS.

TABLE 3-1

SITE INVESTIGATION OBJECTIVES - CTO-0369
 SITE 10 - ORIGINAL BASE LANDFILL
 MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	SI Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Site 10 - Soil	1a. Determine whether soils at the site have been contaminated by wastes disposed at the landfill.	Characterize contaminant levels in surface and subsurface soils in the vicinity of the site.	Soil Investigation
	1b. Assess human health risks associated with exposure to surface soils at the site.	Characterize contaminant levels in surface soils at the study area.	Soil Investigation Risk Assessment
	1c. Determine whether contamination from soils is migrating to groundwater.	Characterize subsurface soil. Characterize shallow groundwater.	Soil Investigation Groundwater Investigation
2. Site 10 - Groundwater	2a. Assess health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to groundwater criteria and risk-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess nature of shallow groundwater quality.	Characterize shallow groundwater quality.	Groundwater Investigation
	2c. Define groundwater flow direction.	Collect two sets of groundwater levels and establish groundwater elevation.	Groundwater Investigation Site Survey

TABLE 4-1

**SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS
SITE 10 - ORIGINAL BASE LANDFILL
FIELD SAMPLING ANALYSIS PLAN CTO-0369
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA**

Study Area	Investigation	Baseline No. of Samples ⁽¹⁾	Analysis	Analytical Method	Data Quality Objective	Laboratory Turnaround
Site10 - Original Base Landfill	Soil	32 soil borings/2 samples per boring	TCL Organics ⁽²⁾ TAL Metals ⁽³⁾	CLP/SOW CLP/SOW	IV IV	Routine ⁽⁴⁾ Routine
	Groundwater - One round of sampling	8 shallow temporary wells	TCL Organics TAL Metals	CLP/SOW CLP/SOW	IV IV	Routine Routine
Investigation Derived Waste	Purge Water	1 sample	TCL Organics TAL Metals	CLP/SOW CLP/SOW	IV IV	Routine Routine
	Soil	1 composite from drum(s)	TCLP ⁽⁵⁾ RCRA ⁽⁶⁾ TCL PCBs	SW846 SW846 CLP/SOW	IV IV IV	Routine Routine Routine

Notes:

- (1) Baseline number of samples do not include QA/QC samples.
- (2) TCL Organics: volatile organics, semivolatile organics, pesticides/PCBs
- (3) TAL Metals:

Aluminum	EPA 3010/EPA 200.7	Cobalt	EPA 3010/EPA 200.7	Potassium	EPA 3010/EPA 200.7
Antimony	EPA 3010/EPA 200.7	Copper	EPA 3010/EPA 200.7	Selenium	EPA 3020/EPA 270.2
Arsenic	EPA 3020/EPA 206	Iron	EPA 3010/EPA 200.7	Silver	EPA 3010/EPA 200.7
Barium	EPA 3010/EPA 200.7	Lead	EPA 3020/EPA 239	Sodium	EPA 3010/EPA 200.7
Beryllium	EPA 3010/EPA 200.7	Magnesium	EPA 3010/EPA 200.7	Thallium	EPA 3020/EPA 279
Cadmium	EPA 3010/EPA 200.7	Manganese	EPA 3010/EPA 200.7	Vanadium	EPA 3010/EPA 200.7
Calcium	EPA 3010/EPA 200.7	Mercury	EPA 3010/EPA 245.1	Zinc	EPA 3010/EPA 200.7
Chromium	EPA 3010/EPA 200.7	Nickel	EPA 3010/EPA 200.7		

- (4) Routine analytical turnaround is 35 days following receipt of samples.
- (5) TCLP = Analysis of volatile & semivolatile organics, pesticides, herbicides and metals on a leachate.
- (6) RCRA = Corrosivity, Reactivity (reactive sulfide & cyanide), and Ignitability

**WORK PLAN
FIGURES**

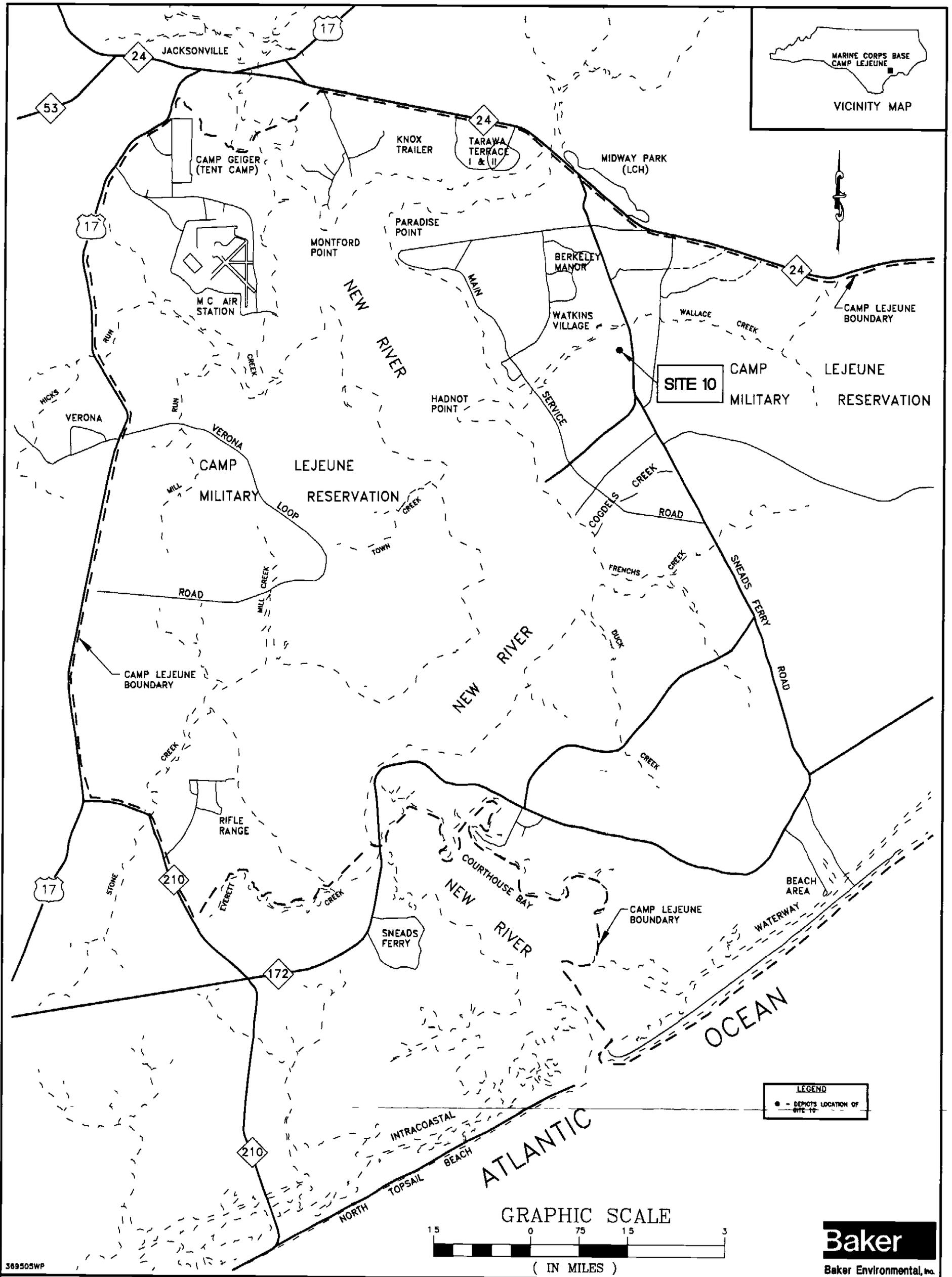
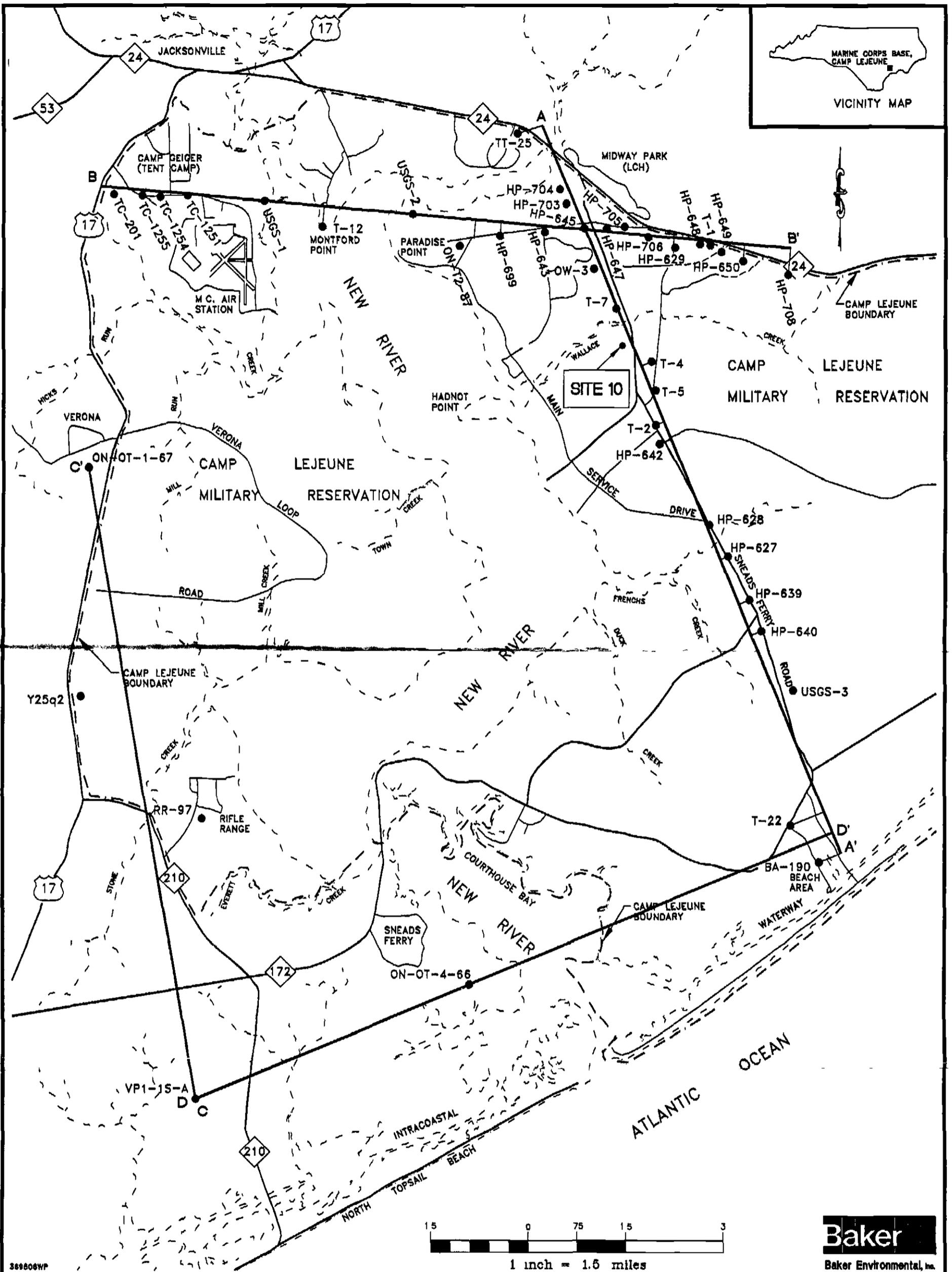


FIGURE 2-1
 CAMP LEJEUNE AND SITE
 LOCATION MAP
 SITE 10, ORIGINAL BASE LANDFILL
 CTO - 0369
 MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

01787E01Z

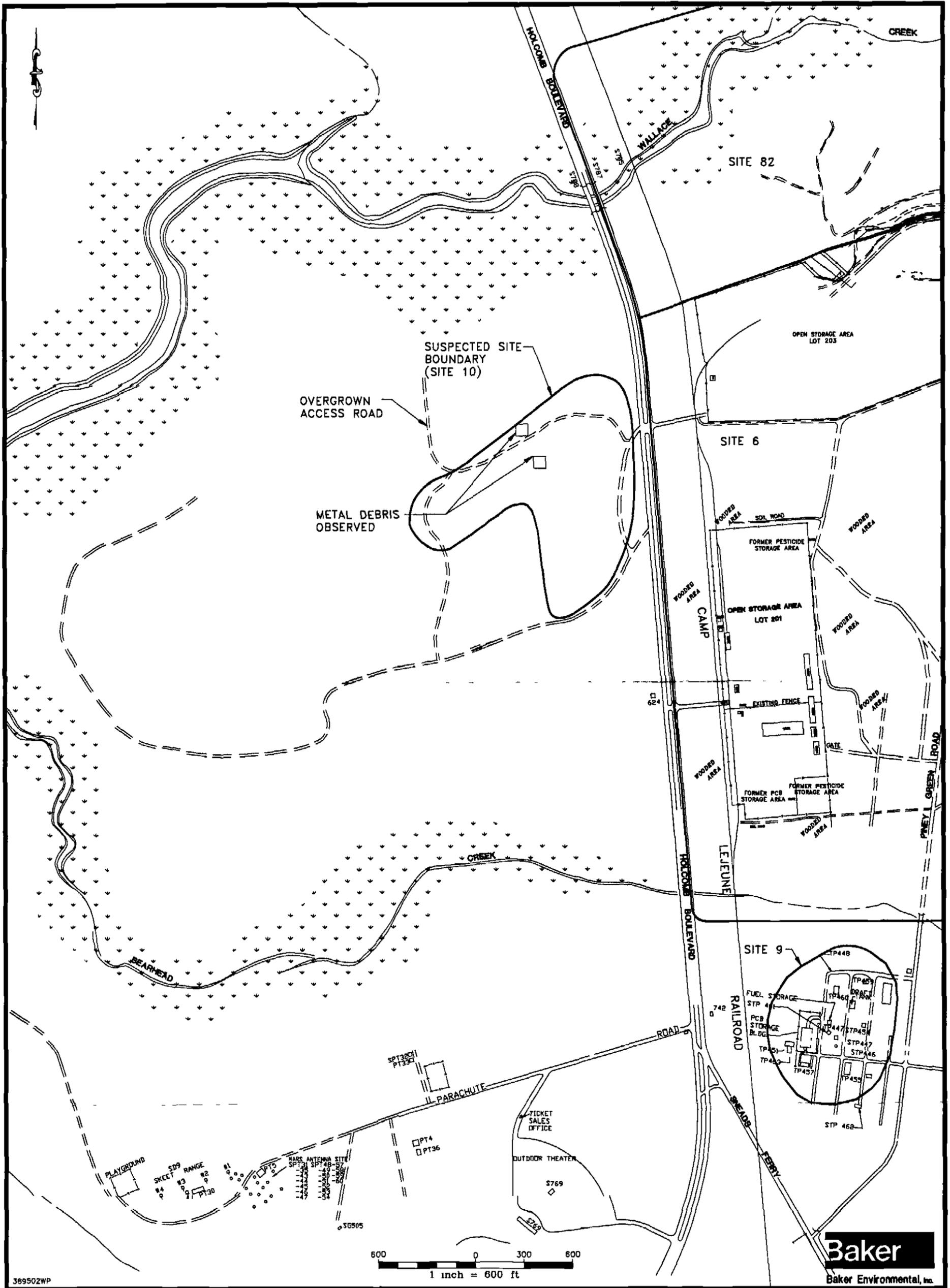


389808WP

SOURCE: U.S. GEOLOGICAL SURVEY,
WATER-RESOURCES INVESTIGATIONS
REPORT, 93-4049, FIGURE 9

FIGURE 2-2
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
SITE 10, ORIGINAL BASE LANDFILL
SITE INVESTIGATION, CTO - 0369
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01787E02Z



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LEGEND

**FIGURE 2-4
GENERAL SITE LAYOUT
SITE 10, ORIGINAL BASE LANDFILL
CTO - 0369**

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01787E03Z



Baker

Baker Environmental, Inc.

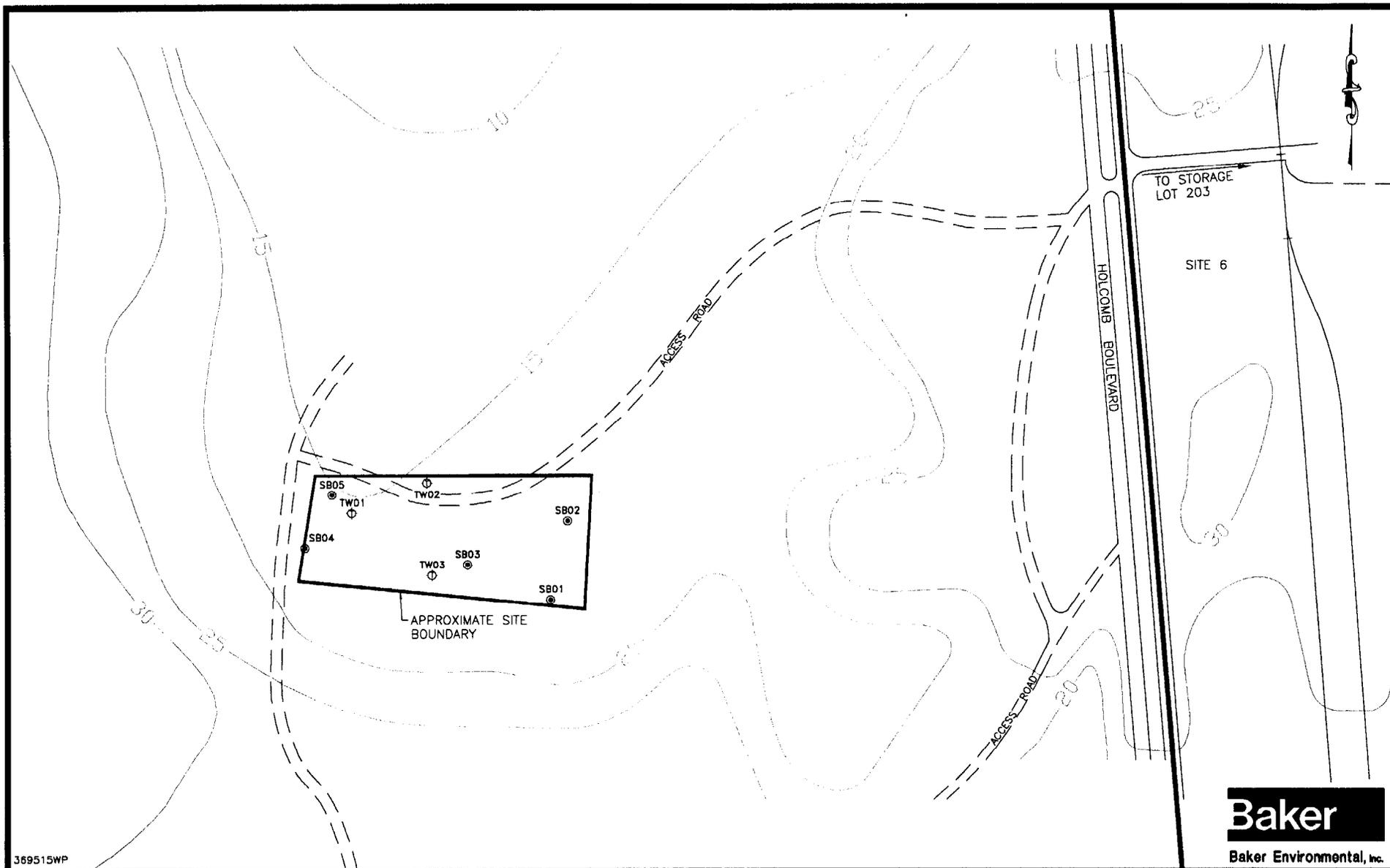
608 0 304 608
1 inch = 608 ft.



FIGURE 2-5
AERIAL PHOTOGRAPH, OCTOBER 21, 1949
SITE 10 - ORIGINAL BASE LANDFILL
SITE INVESTIGATION, CTO-0369
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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Baker Environmental, Inc.

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LEGEND

- SB01 SOIL BORING LOCATION
- TWO1 TEMPORARY GROUNDWATER MONITORING WELL
- == ACCESS ROAD
- 25 TOPOGRAPHIC CONTOUR (MSL)

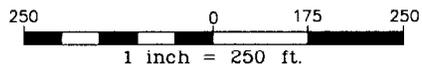


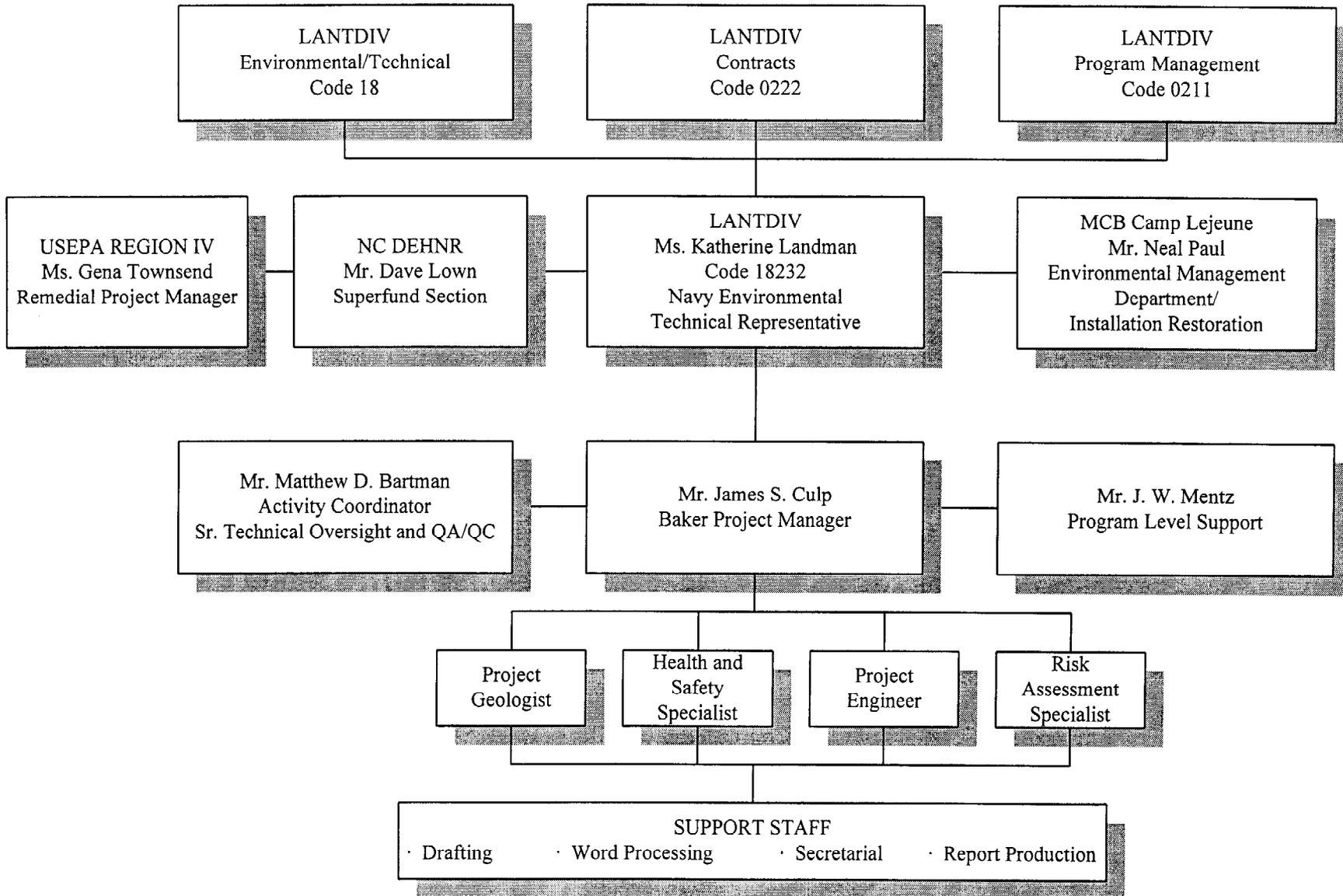
FIGURE 2-6
EXPEDITED SITE CHARACTERIZATION
SOIL AND GROUNDWATER SAMPLING LOCATIONS
SITE 10 - ORIGINAL BASE LANDFILL

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, FEB. 1992

FIGURE 5-1

PROJECT ORGANIZATION



FINAL

**SITE INVESTIGATION
FIELD SAMPLING AND ANALYSIS PLAN
SITE 10 - ORIGINAL BASE LANDFILL
MCB CAMP LEJEUNE, NORTH CAROLINA**

CONTRACT TASK ORDER 0369

JANUARY 20, 1998

Prepared for:

**DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
*Norfolk, Virginia***

Under:

**LANTDIV CLEAN Program
Contract N62470-89-D-4814**

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- APPENDIX B Justification Criteria for Use of PVC Well Casing and Screen Material
- APPENDIX C Groundwater Sample Acquisition
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- APPENDIX K Drum Sampling
- APPENDIX L Wastewater Sample Acquisition
- APPENDIX M Sample Preservation and Handling
- APPENDIX N Chain-of-Custody
- APPENDIX O Field Logbook

1.0 INTRODUCTION

This Field Sampling and Analysis Plan (FSAP) presents the sampling and analytical requirements for the Site Investigation (SI) to be conducted at Site 10 (Original Base Landfill), Marine Corps Base, Camp Lejeune, North Carolina.

The primary purpose of the FSAP is to provide guidance for all project field activities by describing in detail the sampling and data collection methods to be used to implement the various field tasks identified in the Site Investigation (SI) Work Plan for Site 10. This document also helps to ensure that project activities are carried out in accordance with U.S. Environmental Protection Agency (USEPA) Region IV and Naval Facilities Engineering Service Center (NFESC) practices, so that data obtained during the field investigation are of sufficient quantity and quality to determine if contamination exists within various media, to determine groundwater flow direction in the shallow aquifer, estimate human health risks using conservative receptors, qualitatively assess all data against applicable criteria, and to evaluate the potential need for a Remedial Investigation/Feasibility Study (RI/FS).

2.0 SITE BACKGROUND

A description of the history and setting of Marine Corps Base (MCB), Camp Lejeune and Site 10 is contained in Section 2.0 of the SI Work Plan.

3.0 SAMPLING OBJECTIVES

The sampling and data quality objectives (DQOs) for field investigations at Site 10 are summarized in Section 3.0 of the SI Work Plan.

4.0 SAMPLING LOCATIONS AND FREQUENCY

This section of the FSAP describes the location, quantity and type of environmental samples to be collected during the sampling program. Support activities, sampling locations, sample matrix, and constituents to be analyzed for are discussed within this section. Detailed investigation procedures, sampling handling, and analytical requirements are described in Sections 6.0 and 7.0, respectively.

The following investigations and support activities will be conducted at Site 10:

- Soil Investigation
- Groundwater Investigation
- Surveying

Each activity and investigation is described in the following subsections.

4.1 Soil Investigation

A soil investigation will be conducted at Site 10 to determine whether debris disposed at the site have contaminated the soils and potentially the groundwater. The following subsections provide a description of the proposed investigation.

4.1.1 Sampling Locations

A 250 foot by 250 foot grid will be established over the suspected disposal area and two areas where additional debris was observed during the site visit. A line of five sample locations will parallel Holcomb Boulevard heading north approximately 100 feet north of the southern-most site access road. Subsequent lines of sample points will be offset by 100 feet north and 200 feet west until the suspected area of the site is covered. The grid will be used to determine the locations of approximately 23 soil borings (Figure 4-1). Two additional borings will be advanced west and south of the limits of the expedited site characterization. A single boring will be advanced west of the site and used as a control sample point. A utility clearance will be conducted prior to boring and well installation. The soil borings will be advanced until groundwater is encountered (expected to be within 10 feet of the ground surface). Eight of the 26 soil borings will be used for installation of temporary wells, and will extend approximately 7 feet into the water table. Two soil samples from each boring will be submitted for chemical analysis. These samples will be collected from the surface (0 to 1 foot) and just above the water table. A mid-depth sample may be collected from these soil borings if contamination is evident based on visual observations, elevated PID readings are observed, or if groundwater is encountered at depths greater than 10 feet below ground surface. Section 6.1 describes the procedures for collecting samples from each soil boring location.

4.1.2 Analytical Requirements

All soil samples will be analyzed for full Target Compound List (TCL) organics, including volatiles, semivolatiles, pesticides and PCBs, and Target Analyte List (TAL) metals in accordance with Contract Laboratory Program (CLP) methods, DQO Level IV. All soil samples will be analyzed on a routine, 28 day turnaround time.

4.2 Groundwater Investigation

A groundwater investigation will be conducted at Site 10 to determine the presence or absence of contamination in the surficial aquifer resulting from disposal activities, to determine the direction of flow for the surficial aquifer, and to provide data for the risk assessment. The following subsections provide a description of the proposed investigation.

4.2.1 Well Construction and Locations

Eight temporary, shallow groundwater wells are proposed for this investigation (Figure 4-1). Three wells will be installed within the suspected boundaries of the site and four will be installed just beyond the perimeter. One well, located west of the site, will be intended to serve as a background well. All wells will be constructed of 1 inch outside diameter (OD) PVC pipe, with 10 feet of 0.01 inch slot well screen. Section 6.2 presents specific details on procedures for monitoring well installation.

4.2.2 Sampling and Analysis

One round of groundwater samples will be collected from the eight temporary wells. Samples will be collected using low flow purging and sampling methodology as discussed in Section 6.3.

All groundwater samples will be analyzed for full TCL organics and TAL total metals in accordance with CLP methods, DQO Level IV.

4.2.3 Surface Water Sample Collection

The following procedures will be used for the collection of surface water samples at the site. At each of the six stations, samples will be collected at the approximate mid-vertical point or near the bank of the surface water body. Care will be taken to ensure that the sampler does not contact and/or stir up the sediments, while still being relatively close to the sediment-water interface.

The surface water samples will be collected by dipping the laboratory-supplied sample bottles directly into the water. Clean nitrile gloves will be worn by sampling personnel at each sampling station.

The water samples will be collected from near mid-stream at each station, where applicable. Water samples at the furthest downstream station will be collected first, with subsequent samples taken at the next upstream station(s). Sediment samples will be collected after the water samples to minimize sediment disturbance and suspension. Sampling personnel shall stand downstream at each station in order to minimize sediment disturbance.

All sample containers not containing preservative will be rinsed at least once with the sample water prior to final sample collection. In addition, the sampling container used to transfer the water into sample bottles containing preservatives will be rinsed once with sample water.

Care will be taken when collecting samples for analysis for VOCs to avoid excessive agitation that could result in loss of VOCs. VOC samples will be collected prior to the collection of the samples for analysis of the other parameters. Sample bottles will be filled in the same order at all sampling stations.

The following information will be recorded in the field log book:

- Project location, date and time
- Weather
- Sample location, number, and identification number
- Flow conditions (i.e., high, low, in flood, etc.)
- Visual description of water (i.e., clear, cloudy, muddy, etc.)
- Sketch of sampling location including boundaries of the water body, sample location and depth, and relative position with respect to the site
- Names of sampling personnel
- Sampling technique, procedure, and equipment used

4.2.4 Sediment Sample Collection

The following procedures will be used for the collection of sediment samples. At each of the six stations, surface and near surface sediment samples will be collected at a depth of 0 to 6 inches, and 6 to 12 inches. These intervals of sediment will be collected using a stainless steel hand-held coring instrument. A new or decontaminated stainless steel liner tube, fitted with an eggshell catcher to prevent sample loss, will be used at each station.

The coring device will be pushed into the sediments to a minimum depth of 15 inches, or until refusal, whichever is encountered first. The sediments in the 0 to 6-inch interval and 6 to 12-inch interval will be extruded with a decontaminated extruder into the appropriate sample containers. If less than 12 inches of sediments are obtained, the first 6 inches will be placed in the 0 to 6-inch container and the remaining sediment will be placed into the 6 to 12-inch container.

The sampling procedures for using the hand-held coring instrument (i.e., stainless-steel core sampler) are outlined below:

1. Inspect and prepare the corer:
 - a. Inspect the core tube and, if one is being used, the core liner. Core tube and core liner must be firmly in place, free of obstruction throughout its length. Bottom edge of core tube, or of the nose piece, should be sharp and free of nicks or dents.
 - b. Check the flutter valve for ease of movement.
 - c. Check the flutter valve seat to make sure it is clear of any obstruction that could prevent a tight closure.
 - d. Attach a line securely to the core sampler. The line should be free of any frayed or worn sections, and sufficiently long to reach bottom.
2. Get in position for the sampling operation -- keeping in mind that disturbance of the bottom area to be sampled should be avoided.
3. Line up the sampler, aiming it vertically for the point where the sample is to be taken.
4. Push the core sampler, in a smooth and continuous movement, through the water and into the sediments -- increasing the thrust as necessary to obtain the penetration desired.

5. If the corer has not been completely submerged, close the flutter valve by hand and press it shut while the sample is retrieved. Warning: the flutter valve must be kept very wet if it is to seal properly.
6. Lift the core sampler clear of the water, keeping it as nearly vertical as possible, and handle the sample according to the type of the core tube.
7. Secure and identify the new sample. Unscrew the nose cone. Pull the liner out. Push out any extra sediments (greater than 12 inches). Push out the sediments within the 6 to 12-inch interval, then push out the 0 to 6-inch sediment interval. Samples (with the exception of VOAs) will first be homogenized prior to being transferred to their containers.
8. Seal all sample jars tightly.
9. Label all samples.

4.3 Surveying

The site survey will involve the surveying of the estimated extent of the landfill, tree line, access roads, new wells and borings and any areas where debris was discovered outside of the landfill boundary.

The location and elevation of a reference point on top of the PVC riser, and elevation of the ground surface will be surveyed for each temporary well. The location of each boring and the corresponding elevation will be surveyed. Survey points will include a latitude coordinate, a longitude coordinate, and an elevation expressed in feet above mean sea level. The vertical accuracy of the survey will be within 0.01 feet and the horizontal accuracy will be within 0.1 feet. All survey points will be correlated to the North Carolina State Plane Coordinate System.

4.4 QA/QC Samples

QA/QC requirements for this investigation are presented in the Quality Assurance Project Plan (QAPP). The following QA/QC samples will be collected during field sampling activities:

- **Trip Blanks**

Trip blanks are defined as samples which originate from the analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the volatile organic analysis (VOA) samples. One trip blank will accompany each cooler containing samples for volatile organic analysis. The blanks will only be analyzed for volatile organics. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory.

- **Equipment Rinsates (Equipment Blanks)**

Equipment rinsates are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. Equipment rinsates will be collected daily during each sampling event. One rinsate per media sampled per day will be collected. For example, if groundwater and soil samples were collected on one given day, two rinsates would be collected. Initially, samples from every other day will be analyzed. If analytes

pertinent to the project are found in the rinsates, the remaining samples must be analyzed. The results from the rinsates will be used to evaluate the decontamination methods. This comparison is made during data validation and the rinsates are analyzed for the same parameters as the related samples.

- **Field Blanks**

Field blanks consist of the source water used in decontamination. Field blanks will be collected by pouring the water from the container directly into sample bottles. Field blanks should not be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled. One field blank will be prepared at the commencement of the project.

- **Field Duplicates**

Field duplicates for soil samples are collected, homogenized, and split. All samples except VOAs are homogenized and split. Volatiles are not mixed, but select segments of soil are taken from the length of the core and placed in sampling jars. The duplicates for water samples should be collected simultaneously. The water samples will not be composited.

Field duplicates will be collected at a frequency of 10 percent.

- **Matrix Spike/Matrix Spike Duplicates (MS/MSD)**

MS/MSD samples are collected to evaluate the matrix effect of the sample upon the analytical methodology. A matrix spike and matrix spike duplicate must be performed for each group of samples of a similar matrix

MS/MSD samples will be collected at a frequency of 5 percent.

4.5 Investigation Derived Waste Handling

Drill cuttings or excavated soils will be collected and contained in drums if they are determined in the field to be potentially contaminated based on visual observations and HNu readings. A single rigid storage tank with a capacity of 1,000 gallons will be stationed at the site for containing groundwater development and purge water. A composite soil sample from the drums will be collected and analyzed for full TCLP (organics and inorganics) and RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability), and PCBs. A sample will be collected from the tank and analyzed for full TCL organics and TAL total metals. Additional details regarding IDW handling and disposal are provided in Section 6.7.

5.0 SAMPLE DESIGNATION

In order to identify and accurately track the various samples, all samples collected during this investigation, including QA/QC samples, will be designated with a unique number. The number will serve to identify the investigation, the site, the area within the site, the sample media, sampling location, the depth (soil) or round (groundwater) of sample, and QA/QC qualifiers.

The sample designation format is as follows:

Site#-Media/Station# -Depth/Round or QA/QC

An explanation of each of these identifiers is given below.

Site#	This investigation involves only Site 10.
Media	SB = Soil Boring (soil sample from a boring) TW = Temporary Well (groundwater sample from a temporary well)
Station#	Each soil test boring or monitoring well will be identified with a unique identification number.
Depth/Round	Depth indicators will be used for soil samples. The number will reference the depth interval of the sample. For example: 00 = ground surface to 1 foot below ground surface 01 = 1 to 3 feet below ground surface 02 = 3 to 5 feet below ground surface 03 = 5 to 7 feet below ground surface Round indicator will be used for groundwater samples. For example: 01 = initial round of sampling 02 = second round of sampling
QA/QC	(FB) = Field Blank (D) = Duplicate Sample (following depth/round) (TB) = Trip Blank (ER) = Equipment Rinsate

Under this sample designation format the sample number 10-TW04-01D refers to:

<u>10</u> -TW04-01D	Site 10
10- <u>TW</u> 04-01D	Groundwater sample from a temporary well
10-TW <u>04</u> -01D	Temporary well #4

10-TW04-0 <u>1</u> D	Round 1
10-TW04-01 <u>D</u>	Duplicate (QA/QC) sample

The sample designation 10SB11-00D refers to:

<u>1</u> 0SB11-00D	Site 10
10 <u>S</u> B11-00D	Soil sample from a soil boring
10SB <u>1</u> 1-00D	Soil Boring #11
10SB11- <u>0</u> 0D	Sample depth interval 0 to 12"
10SB11-00 <u>D</u>	Duplicate (QA/QC) sample

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

6.0 INVESTIGATIVE PROCEDURES

The investigative procedures to be used for Site 10 will be discussed in the following subsections. These procedures include soil sample collection, temporary well installation, groundwater sample collection, surveying, water level measurements, decontamination procedures and handling of site investigation derived wastes. Note that all of these procedures will follow the field methods described in the USEPA, Region IV, Environmental Services Division (ESD), Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPOAM, May 1996. Additional guidance from other sources such as ASTM may be used, but if the ASTM and ESD methods conflict, the ESD procedure will be used. Additionally, in instances where the ESD has no standard operating procedures (SOP), other guidance sources will be used, such as manufacturer's manuals.

6.1 Soil Sample Collection

Surface and subsurface soil samples will be collected throughout Site 10. Soil samples will be collected from borings advanced by a direct-push soil sampler. Soil borings will either be advanced by a pick-up truck mounted rig, or by a hand sampler unit. All boring locations will receive utility clearance from the appropriate on-base personnel. Appendix A contains an SOP for direct-push (GeoProbe) soil sampling system.

Soil samples from borings advanced either by a direct-push rig, or by hand and will be collected using a GeoProbe "Macro-Core Sampler", or "Large Bore Soil Sampler", respectively. Some borings may be difficult to access by pick-up truck. In those instances, the samples will be collected using the hand sampler.

The Macro-Core Sampler is a 48 inch long, stainless-steel tube with a 2 inch OD. Threaded to the base, is a 1-1/2 inch inside diameter (ID) cutting shoe. Soil samples are collected in a 45 inch long by 1-1/2 inch wide acetate liner that is inserted into the tube. Although the sampler is capable of collecting 45 inch long samples, the sampler will be driven 24 inches for higher percentage recoveries.

The Large Bore Sampler is a 24 inch long, stainless-steel tube with a 1-3/8 inch OD. Attached at its base is a 1-1/16 inch ID cutting shoe. Soil samples are collected in a 22 inch long by 1-1/8 inch wide acetate liner that is inserted into the tube.

Samples will be collected continuously from the ground surface to the water table. Soil samples that will be converted into shallow monitoring wells will be advanced approximately 7 feet below the water table. Soils will be classified according to the Unified Soil Classification System (USCS). Soil sample descriptions will be recorded in the field geologist's notebook.

The surface sample from each boring (0 to 1 foot) will be collected by hand. The remaining samples will be collected using the GeoProbe samplers. The following procedure will be used for collecting samples:

1. A stainless steel spoon will be used to remove the soil from the ground surface. The upper inch of soil will be discarded. Soil for volatile organic analysis will be placed directly into the sample jar. Soil for all other analysis will be placed into an aluminum pan, thoroughly mixed, then placed into the remaining sample jar(s).

2. A 2 inch OD pre-probe will be used to ream the surface sample hole to 2 inches in diameter. A 1-3/8 inch pre-probe will be used to ream the surface sample hole at the hand sampler locations.
3. The sampler will be placed into the hole. The sampler will be driven 24 inches by the truck-mounted hydraulic drive assembly or by a hand-held drive hammer. Once at the desired depth, the sampler will be pulled from the hole.
4. The sampler will be disassembled, and the liner containing the sample will be handed to the geologist for logging and, as necessary, containerization for chemical analysis.
5. The sampler tube and cutting shoe will be decontaminated following procedures outlined in Section 6.4, and then reassembled using a new liner.
6. Repeat Steps 3, 4, and 5 until the desired, final depth is reached.

The following procedure will be used for subsurface soil samples to be submitted to the laboratory:

1. The sample will be removed from the liner by letting it fall gently onto a sheet of aluminum foil. In some instances, the soil sample may have to be pushed out from the top end using a wooden dowel covered with aluminum foil. PID measurements will then be taken.
2. Soil for volatile organic analysis will be placed directly into the sample jar. Small aliquots will be collected from discrete locations over the entire length of the sample interval. The VOA sample jar will be filled completely, without headspace, to minimize volatilization. Sample bottles will be labeled prior to sample collection.
3. A small, representative portion of sample will be set aside for description purposes. The remaining soil will be placed into an aluminum pan, and thoroughly mixed. The sample jar(s) for all other analysis will then be filled.
4. All pertinent sampling information such as soil description, sample depth, sample number and location, and the time of sample collection will be recorded in the field logbook. In addition, the sample bottles will be labeled as outlined in Section 7.0.
5. The sample jars will be stored in a cooler with ice until laboratory shipment.

6.2 Monitoring Well Installation

Temporary wells will be installed to monitor the shallow (water table) water-bearing zone. The wells will be installed such that the bottom of the screen is seven feet below the water table. The procedure for the installation and construction of the temporary wells is presented below (also see Figure 6-1):

1. A borehole will be advanced by direct-push sampling, using the Macro-Core Sampler. Samples will be collected as described in Section 6.1.
2. Upon completion of the borehole to the desired depth, a pre-assembled monitoring well will be installed into the open borehole. Well construction is detailed below.

3. The system will be allowed to equilibrate before sampling.

Ten feet of 1 inch OD, Schedule 40, #10 slot (0.010 inch) PVC screen with a bottom plug will be used. The screen will be wrapped with polyester "well sock" material, that will be used as filter media. The screen will be connected to threaded, flush-joint, 1 inch OD, Schedule 40, PVC casing. The casing will extend 2 to 3 feet above the ground surface. A PVC slip-cap, with a vent hole, will be placed at the top of the casing.

PVC was selected for well materials based on its inertness with respect to metals, its likely exposure to only low concentrations of organic compounds, and short duration of use (Appendix B contains a seven-point justification). Polyester was selected for the filter media based on its inertness with respect to metals, its likely exposure to only low concentrations of organic compounds, and its durability.

6.3 Groundwater Sample Collection

The temporary wells will be sampled via low-flow methods. Low-flow is defined as a flow rate similar to the ambient flow rate in the screened formation. A peristaltic pump will be used to purge the wells and collect the samples. VOC loss through suction degassing is expected to be insignificant due to the very slow flow rates to be used. Baker personnel report observance of minimal bubbling in the groundwater stream during recent peristaltic pump use. The procedure for collecting groundwater samples is detailed in this section, and has been assembled from ESD guidance and recently published papers and other documents.

6.3.1 Low-Flow Purging Vs. High-Flow Purging

A number of recent studies have demonstrated that low-flow purging and sampling is a preferable to bailing or high-flow purging and sampling. High-rate pumping is described as a rate greater than, or similar to, the development rate. Some findings include:

- High-flow pumping and bailing may overdevelop a well, causing damage to the well and filter pack (USEPA, 1992).
- High-flow pumping and bailing may disturb accumulated corrosion/reaction products, or sediment (USEPA, 1992), or potentially mobilize particulate or colloidal matter from the formation (Barcelona, Wehrmann and Varljen, 1994).
- High-flow pumping and bailing may cause loss of VOCs. The velocities at which groundwater enters a bailer can actually correspond to unacceptably high purge rates (USEPA, 1992).
- The use of bailers can result in composite averaging by mixing of water across the screen interval (Barcelona, Wehrmann and Varljen, 1994), resulting in unreproducible and unrepresentative data.

6.3.2 Selection of Water Quality Indicator Parameters

The water quality indicator parameters (WQP) for stabilization will include turbidity, pH, temperature and specific conductance. Use of these WQPs has precedence in recent studies. Dissolved oxygen and turbidity are more sensitive indicators of "fresh" groundwater than pH, specific conductance, and temperature (Puls and Powell, 1995). Barcelona, Wehrmann and Varljen, 1994, suggest that dissolved oxygen and specific conductance are good indicators of

stabilization with respect to VOA sampling. Puls and Paul, 1995 used dissolved oxygen, turbidity, pH, and specific conductance as indicators of stabilization.

6.3.3 Purge Requirements

Consistent with EPA's EISOPQAM (May 1996), a minimum of three well volumes will be purged.

6.3.4 Purging and Sampling Procedure

The following then, is the low-flow purge and sampling procedure that will be used at Site 10:

1. The well cap will be removed, and escaping gases will be measured at the well head using a PID or FID. This will determine the need for respiratory protection.
2. The temporary well will be allowed to equilibrate to atmospheric pressure, in the event that a vent hole was not installed in the well.
3. The static water level will be measured. The total depth of the well will not be measured, as not to stir up any sediment. The total depth will be obtained from boring logs. The water volume in the well will then be calculated.
4. The sampling device intake (virgin, 1/4 inch ID Teflon tubing) will be slowly lowered until the bottom end is 2 to 3 feet below the top of water. Based on water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the well, just above the water.
5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. At the onset of purging, the tubing will be lowered to the bottom of the screen to remove any formation material. After the material has been removed from the bottom of the screen, the tubing will be raised to a point 1 to 2 feet below the water table, once again. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the well.) Flow rates of less than 1 liter per minute (L/min) are expected.
6. The WQPs, including temperature, turbidity, pH, and specific conductance will be measured frequently (e.g., every 2 minutes).
7. Purging will be complete when a minimum of three well volumes have been removed and three successive WQP readings have stabilized. Stabilization is defined as pH measurements remain within 0.1. Standard units specific conductance varies less than 10 percent, and temperature is consistent for at least three consecutive readings.
8. Upon WQP stabilization, groundwater samples will be collected. Samples for VOA analysis will be collected first, followed by semivolatiles, pesticides and PCBs, and total metals. Sample bottles will be labeled prior to sample collection.
9. The sample jars will be stored in a cooler with ice until laboratory shipment.

The temporary well will be removed from the ground once surveying is complete. The open borehole will be backfilled with cuttings mixed with bentonite powder.

Sample preservation and handling procedures are outlined in Section 7.0. Appendix C presents a generic SOP for groundwater sampling.

6.4 Surface Water Sample Collection

The following procedures will be used for the collection of surface water samples at the site. At each of the six stations, samples will be collected at the approximate mid-vertical point or near the bank of the surface water body. Care will be taken to ensure that the sampler does not contact and/or stir up the sediments, while still being relatively close to the sediment-water interface.

The surface water samples will be collected by dipping the laboratory-supplied sample bottles directly into the water. Clean nitrile gloves will be worn by sampling personnel at each sampling station.

The water samples will be collected from near mid-stream at each station, where applicable. Water samples at the furthest downstream station will be collected first, with subsequent samples taken at the next upstream station(s). Sediment samples will be collected after the water samples to minimize sediment disturbance and suspension. Sampling personnel shall stand downstream at each station in order to minimize sediment disturbance.

All sample containers not containing preservative will be rinsed at least once with the sample water prior to final sample collection. In addition, the sampling container used to transfer the water into sample bottles containing preservatives will be rinsed once with sample water.

Care will be taken when collecting samples for analysis for VOCs to avoid excessive agitation that could result in loss of VOCs. VOC samples will be collected prior to the collection of the samples for analysis of the other parameters. Sample bottles will be filled in the same order at all sampling stations.

The following information will be recorded in the field log book:

- Project location, date and time
- Weather
- Sample location, number, and identification number
- Flow conditions (i.e., high, low, in flood, etc.)
- Visual description of water (i.e., clear, cloudy, muddy, etc.)
- Sketch of sampling location including boundaries of the water body, sample location and depth, and relative position with respect to the site
- Names of sampling personnel
- Sampling technique, procedure, and equipment used

6.5 Sediment Sample Collection

The following procedures will be used for the collection of sediment samples. At each of the six stations, surface and near surface sediment samples will be collected at a depth of 0 to 6 inches, and 6 to 12 inches. These intervals of sediment will be collected using a stainless steel hand-held coring instrument. A new or decontaminated stainless steel liner tube, fitted with an eggshell catcher to prevent sample loss, will be used at each station.

The coring device will be pushed into the sediments to a minimum depth of 15 inches, or until refusal, whichever is encountered first. The sediments in the 0 to 6-inch interval and 6 to 12-inch interval will be extruded with a decontaminated extruder into the appropriate sample containers. If

less than 12 inches of sediments are obtained, the first 6 inches will be placed in the 0 to 6-inch container and the remaining sediment will be placed into the 6 to 12-inch container.

The sampling procedures for using the hand-held coring instrument (i.e., stainless-steel core sampler) are outlined below:

1. Inspect and prepare the corer:
 - a. Inspect the core tube and, if one is being used, the core liner. Core tube and core liner must be firmly in place, free of obstruction throughout its length. Bottom edge of core tube, or of the nose piece, should be sharp and free of nicks or dents.
 - b. Check the flutter valve for ease of movement.
 - c. Check the flutter valve seat to make sure it is clear of any obstruction that could prevent a tight closure.
 - d. Attach a line securely to the core sampler. The line should be free of any frayed or worn sections, and sufficiently long to reach bottom.
2. Get in position for the sampling operation -- keeping in mind that disturbance of the bottom area to be sampled should be avoided.
3. Line up the sampler, aiming it vertically for the point where the sample is to be taken.
4. Push the core sampler, in a smooth and continuous movement, through the water and into the sediments -- increasing the thrust as necessary to obtain the penetration desired.
5. If the corer has not been completely submerged, close the flutter valve by hand and press it shut while the sample is retrieved. Warning: the flutter valve must be kept very wet if it is to seal properly.
6. Lift the core sampler clear of the water, keeping it as nearly vertical as possible, and handle the sample according to the type of the core tube.
7. Secure and identify the new sample. Unscrew the nose cone. Pull the liner out. Push out any extra sediments (greater than 12 inches). Push out the sediments within the 6 to 12-inch interval, then push out the 0 to 6-inch sediment interval. Samples (with the exception of VOAs) will first be homogenized prior to being transferred to their containers.
8. Seal all sample jars tightly.
9. Label all samples.

6.6 Decontamination

Equipment and materials that require decontamination fall into two broad categories:

1. Field measurement, sampling, and monitoring equipment (e.g. water level meters, stainless steel spoons, etc.)

2. Machinery, equipment, and materials (e.g. drilling rigs, backhoes, drilling equipment, monitoring well materials, etc.)

Appendices D and E detail procedures for decontaminating the two categories of equipment and materials, respectively.

6.7 Monitoring and Data Collection Equipment

Field support activities and investigations will require the use of monitoring and data collection equipment. Dissolved oxygen, turbidity, specific conductance, temperature, pH, and Eh readings will be recorded during groundwater sample collection. Appendix F, On-Site Water Quality Testing, provides specific procedures for collecting conductance, temperature, and pH readings. This SOP does not include the procedure for operation of a turbidity meter. A copy of an instruction manual for the LaMotte 2008 turbidity meter has been included as Attachment C of the SOP.

Additional monitoring well information may be obtained using water level meters, water-product level meters, and well depth meters. The operation and various uses of this data collection equipment is provided in Appendix G.

Health and safety monitoring and environmental media screening will be conducted using a photoionization detector (PID) and a combustible gas/oxygen meters (O₂/LEL). The operation and use of the PID is described in Appendix H. The Bacharach O₂/LEL meter will also be used during the sampling program, primarily to monitor health and safety conditions. Appendix I provides a description of the Bacharach O₂/LEL meter and operating procedures.

6.8 Land Survey

Site 10 will require survey information. Horizontal and vertical survey tolerances are addressed within the survey requirements under Section 4.0. Appendix J provides a more detailed description of survey procedures and surveyor qualifications.

6.9 Investigation Derived Waste Handling

The following sections deal with the responsibilities, sources, containerization, sampling and analysis, and disposal of Investigation Derived Wastes (IDW). These wastes include soil from borings, groundwater from purging wells, decontamination fluids, and personal protection equipment.

6.9.1 Responsibilities

LANTDIV - Atlantic Division, Naval Facilities Engineering Command (LANTDIV) or the facility must ultimately be responsible for the final disposition of site wastes. As such, a LANTDIV or MCB, Camp Lejeune representative will sign waste disposal manifests as the generator of the material, in the event off-site disposal is required. However, it may be the responsibility of Baker, depending on the contingency discussions during execution of the investigation, to provide assistance to LANTDIV in arranging for final disposition and preparing manifests.

Baker Project Manager - It is the responsibility of the Baker Project Manager to work with the LANTDIV-Technical Representative in determining the final disposition of site investigation wastes. The Baker Project Manager will relay the results and implications of the chemical analysis of waste or associated material, and advise on the regulatory requirements and prudent measures appropriate to the disposition of the material. The Baker Project Manager also is responsible for

ensuring that field personnel involved in site investigation waste handling are familiar with the procedures to be implemented in the field, and that all required field documentation has been completed.

Baker Field Team Leader - The Baker Field Team Leader or Site Manager is responsible for the on site supervision of the waste handling procedures during the site investigations. The Baker Field Team Leader also is responsible for ensuring that all other field personnel are familiar with these procedures.

6.9.2 Sources of Investigation Derived Wastes

Field investigation activities often result in the generation and handling of potentially contaminated materials that must be properly managed to protect the public and the environment, as well as to meet legal requirements. These wastes may be either hazardous or nonhazardous in nature. The nature of the waste (i.e., hazardous or nonhazardous) will determine how the wastes will be handled during the field investigation.

The sources of waste material depend on the site activities planned for the project. The following types of activities or sources, typical of site investigations, may result in the generation of waste material which must be properly handled:

- Subsurface soil sampling and monitoring well construction (soil cuttings)
- Groundwater sampling (purge water)
- Sampling equipment decontamination (decontamination fluids)
- Personal protection equipment (health and safety disposables)

It is likely that only a small amount of IDW will be generated for these investigations.

6.9.3 Designation of Potentially Hazardous and Nonhazardous Investigation Derived Wastes

Wastes generated during the field investigation can be categorized as either potentially hazardous or nonhazardous in nature. The designation of such wastes will determine how the wastes are handled. The criteria for determining the nature of the waste, and the subsequent handling of the waste is described below for each type of anticipated investigative waste.

6.9.3.1 Drill Cuttings

Minimal amounts of soil cuttings will be generated during soil sample acquisition and monitoring well installation. These cuttings will be containerized in DOT approved drums for temporary storage on site, and subsequent treatment and/or disposal.

6.9.3.2 Purge Water

All purge water shall be containerized in a single, 1,000 gallon tank. Purge water that exhibits elevated HNu readings should be kept separate from water that does not exhibit elevated levels for purposes of subsequent treatment and/or disposal.

6.9.3.3 Decontamination Fluids

Equipment and personal decontamination fluids shall be containerized in 55-gallon drums. The fluids shall be collected from the decon/wash pads.

6.9.3.4 Personal Protective Equipment

All personal protective equipment (i.e., tyveks, gloves, and other health and safety disposables) shall be placed in garbage bags and disposed in trash dump boxes.

6.9.4 **Investigation Derived Waste Sampling and Analysis**

A composite sample shall be collected from the drums containing soil cuttings. This sample will be analyzed for TCL organics and TAL inorganics. RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability). Appendix K contains procedures for collecting samples from drums.

For the container of purge water, a sample shall be collected for full TCL organic and TAL metal analysis. Procedures for collecting wastewater samples are presented in Appendix L.

Decontamination fluids collected during the investigation shall be sampled and analyzed for full TCL organics and TAL metals.

6.9.5 **Labeling**

If 55-gallon drums are used to containerize drill cuttings, the containers will be numbered and labeled by the field team during the site investigation. Information shall be stenciled in paint on both the container lid and side. Container labels shall include, at a minimum:

- LANTDIV CTO (number)
- Project name
- Drum number
- Boring or well number
- Date
- Source
- Contents

If laboratory analysis reveals that containerized materials are hazardous or contain PCBs, additional labeling of containers may be required. The Project Manager will assist LANTDIV in additional labeling procedures, if necessary, after departure of the field team from the facility. These additional labeling procedures will be based upon the identification of material present; USEPA regulations applicable to labeling hazardous and PCB containing wastes are contained in 40 CFR Parts 261, 262, and 761.

6.9.6 **Container Log**

A container log shall be maintained in the site logbook. The container log shall contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample.

6.9.7 **Container Storage**

Containers of site investigative wastes shall be stored on site or in a specially designated secure area that is managed by the MCB, Camp Lejeune Environmental Management Division until disposition is determined. All containers shall be covered with plastic sheeting to provide protection from the weather.

If the laboratory analysis reveal that the containers hold hazardous or PCB wastes, additionally required storage security may be implemented; in the absence of the investigative team, these will be the responsibility of LANTDIV or the facility, as confirmed by the contingency discussions.

Baker will assist LANTDIV in devising the storage requirements, which may include the drums being staged on wooden pallets or other structures to prevent contact with the ground and being staged to provide easy access. Weekly inspections by facility personnel of the temporary storage area may also be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. These weekly inspections and whatever precipitation removal is necessary shall be recorded in the site logbook.

6.9.8 Container Disposition

The disposition of the containers of site investigation generated wastes shall be determined by LANTDIV, with the assistance of Baker, as necessary. Container disposition shall be based on quantity of materials, types of materials, and analytical results. If necessary, specific samples of contained materials may be collected to identify further characteristics which may affect disposition. Typically, container disposition will not be addressed until after receipt of applicable analytical results; these results are usually not available until long after completion of the field investigation at the facility.

6.9.9 Disposal of Contaminated Materials

Actual disposal methods for IDW will be determined following receipt of chemical analyses. The usual course will be a contractor specialist retained to conduct the disposal. However, regardless of the mechanism used, all applicable Federal, state, and local regulations shall be observed. USEPA regulations applicable to generating, storing, and transporting PCB or hazardous wastes are contained in 40 CFR Parts 262, 263, and 761.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable on-site disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment (i.e., drums or other containers) shall be evaluated for use as long-term storage. Also, other site conditions, such as drainage control, security and soil types must be considered in order to provide proper storage.

Disposal options considered for the soils generated during this project include: on-site disposal, off-site landfilling, off-site incineration, and off-site thermal desorption. Groundwater collected at the site will be transported to the groundwater treatment plant at Site 82 and treated.

7.0 SAMPLE HANDLING AND ANALYSIS

Field activities will be conducted in accordance with the ESD's EISOPQAM. Procedures for sample preservation, labeling, handling, and maintaining a field logbook are detailed in SOPs. Because these procedures are not specific to this project, they are provided as appendices, rather than detailed herein. Major components of sample handling and analysis are discussed in the following subsections.

The number of samples, analytical methods, data quality objectives, and laboratory turnaround times are presented in Table 7-1.

7.1 Sample Preservation and Handling

Sample preservation, sample bottle packing and shipping are important components to maintaining the integrity of the samples. Preservation and handling procedures to be used in this investigation are detailed in Appendix M and Section 6.1 of the Quality Assurance Project Plans (QAPP).

7.2 Chain-of-Custody

Chain-of-custody is another important component to maintaining sample integrity. Chain-of-custody procedures to be followed during this investigation are detailed in Appendix N. This SOP details sample bottle labeling and chain-of-custody procedures.

Chain-of-custody procedures ensure a documented, traceable link between measurement results and the sample or parameter they represent. These procedures are intended to provide a legally acceptable record of sample collection, identification, preparation, storage, shipping, and analysis.

7.3 Field Logbook

Field logbooks will be used to record sampling activities and information. Entries will include general and specific sampling information so that site activities may be reconstructed. In addition to the logbook, field forms, such as boring logs, will be completed as support documentation for the logbook. Appendix O describes a general format for the logbook.

Each field person will have and maintain a logbook. Logbooks will be copied daily and stored at the field trailer as back-up in case the original is lost or destroyed. Additionally, copies of completed logbooks will be filed in the project files.

8.0 SITE MANAGEMENT

This section outlines the responsibilities and reporting requirements of on-site personnel.

8.1 Field Team Responsibilities

The field portion of this project will consist of one field team. All field activities will be coordinated by a Site Manager. The Site Manager will ensure that all field activities are conducted in accordance with the project plans (the Work Plan, this Field Sampling and Analysis Plan, the Quality Assurance Project Plan, and the Health and Safety Plan).

The Field Team will employ one direct push rig for soil boring and monitoring well installation. The rig will be supervised by a Baker geologist. A sampling technician will be assigned to the field team to assist with soil boring/monitoring well installation, groundwater sampling and will serve as the Site Health and Safety Officer.

8.2 Reporting Requirements

The Site Manager will report a summary of each day's field activities to the Project Manager or his/her designee. This may be done by telephone or telefax. The Site Manager will include, at a minimum, the following in his/her daily report:

- Baker personnel on site.
- Other personnel on site.
- Major activities of the day.
- Subcontractor quantities (e.g., drilling footages).
- Samples collected.
- Problems encountered.
- Planned activities.

The Site Manager will receive direction from the Project Manager regarding changes in scope of the investigation. All changes in scope will be discussed and agreed upon by LANTDIV, Camp Lejeune EMD, EPA Region IV, and the North Carolina DEHNR.

9.0 REFERENCES

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**FIELD SAMPLING AND ANALYSIS PLAN
TABLES**

TABLE 7-1

SUMMARY OF SAMPLING AND ANALYTICAL OBJECTIVES
 SITE 10 - ORIGINAL BASE LANDFILL
 FIELD SAMPLING ANALYSIS PLAN CTO-0369
 MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Baseline No. of Samples ⁽¹⁾	Analysis	Analytical Method	Data Quality Objective	Laboratory Turnaround
Site10 - Original Base Landfill	Soil	32 soil borings/2 samples per boring	TCL Organics ⁽²⁾ TAL Metals ⁽³⁾	CLP/SOW CLP/SOW	IV IV	Routine ⁽⁴⁾ Routine
	Groundwater - One round of sampling	8 shallow temporary wells	TCL Organics TAL Metals	CLP/SOW CLP/SOW	IV IV	Routine Routine
Investigation Derived Waste	Purge Water	1 sample	TCL Organics TAL Metals	CLP/SOW CLP/SOW	IV IV	Routine Routine
	Soil	1 composite from drum(s)	TCLP ⁽⁵⁾ RCRA ⁽⁶⁾ TCL PCBs	SW846 SW846 CLP/SOW	IV IV IV	Routine Routine Routine

Notes:

(1) Baseline number of samples do not include QA/QC samples.

(2) TCL Organics: volatile organics, semivolatile organics, pesticides/PCBs

(3) TAL Metals:

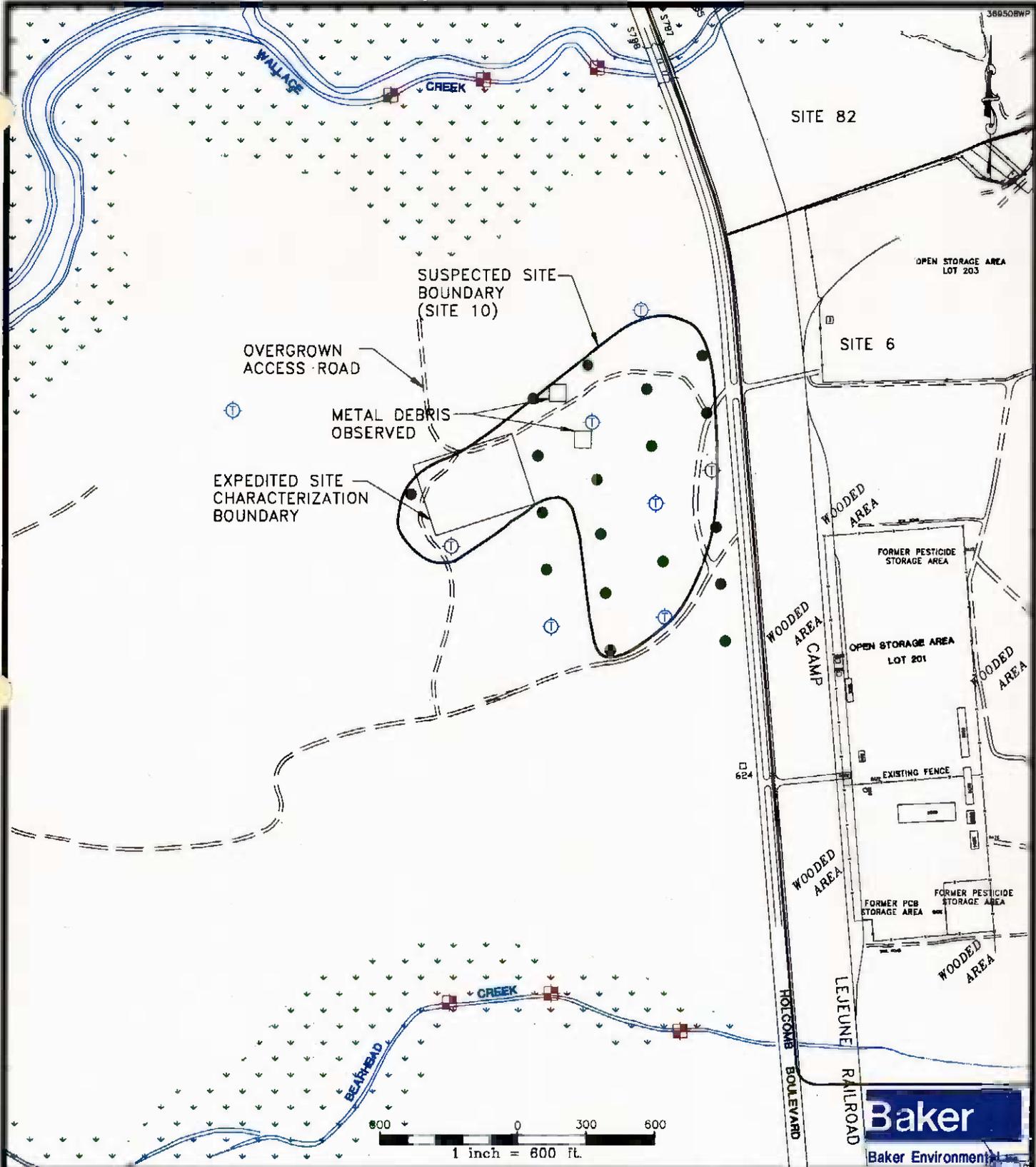
Aluminum	EPA 3010/EPA 200.7	Cobalt	EPA 3010/EPA 200.7	Potassium	EPA 3010/EPA 200.7
Antimony	EPA 3010/EPA 200.7	Copper	EPA 3010/EPA 200.7	Selenium	EPA 3020/EPA 270.2
Arsenic	EPA 3020/EPA 206	Iron	EPA 3010/EPA 200.7	Silver	EPA 3010/EPA 200.7
Barium	EPA 3010/EPA 200.7	Lead	EPA 3020/EPA 239	Sodium	EPA 3010/EPA 200.7
Beryllium	EPA 3010/EPA 200.7	Magnesium	EPA 3010/EPA 200.7	Thallium	EPA 3020/EPA 279
Cadmium	EPA 3010/EPA 200.7	Manganese	EPA 3010/EPA 200.7	Vanadium	EPA 3010/EPA 200.7
Calcium	EPA 3010/EPA 200.7	Mercury	EPA 3010/EPA 245.1	Zinc	EPA 3010/EPA 200.7
Chromium	EPA 3010/EPA 200.7	Nickel	EPA 3010/EPA 200.7		

(4) Routine analytical turnaround is 35 days following receipt of samples.

(5) TCLP = Analysis of volatile & semivolatile organics, pesticides, herbicides and metals on a leachate.

(6) RCRA = Corrosivity, Reactivity (reactive sulfide & cyanide), and Ignitability

FIELD SAMPLING AND ANALYSIS PLAN
FIGURES



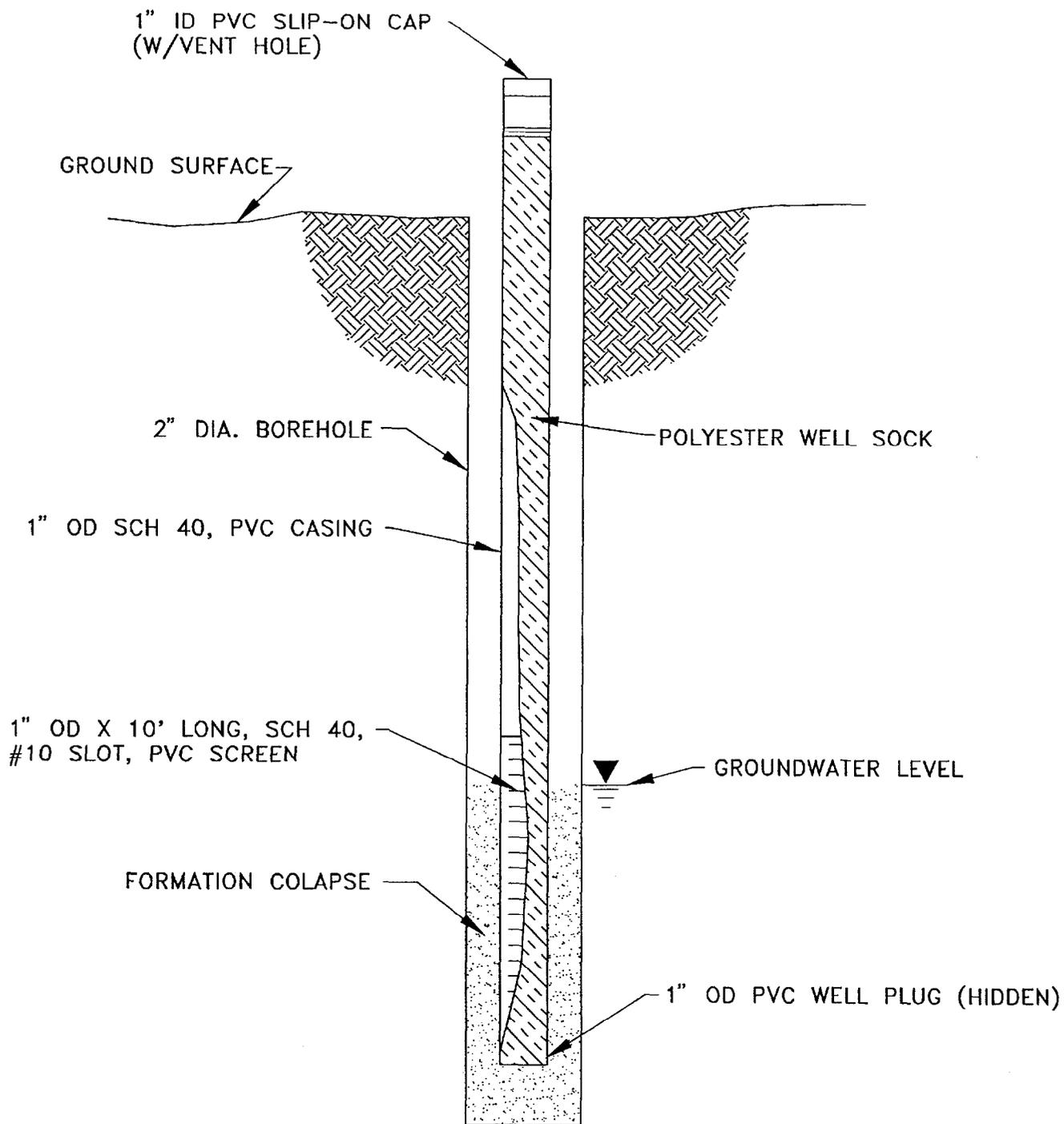
LEGEND

- ⊕ - TEMPORARY WELL LOCATION WITH SURFACE AND SUBSURFACE SOIL SAMPLES
- - SURFACE AND SUBSURFACE SOIL LOCATION
- ⊞ - SEDIMENT/SURFACE WATER SAMPLE LOCATION

FIGURE 4-1
PROPOSED SAMPLING LOCATIONS
SITE 10, ORIGINAL BASE LANDFILL
CTO - 0369

MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

01787E06Y



N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 6-1
TYPICAL TEMPORARY, SHALLOW GROUNDWATER
MONITORING WELL
SITE 10, ORIGINAL BASE LANDFILL
CTO-0369
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

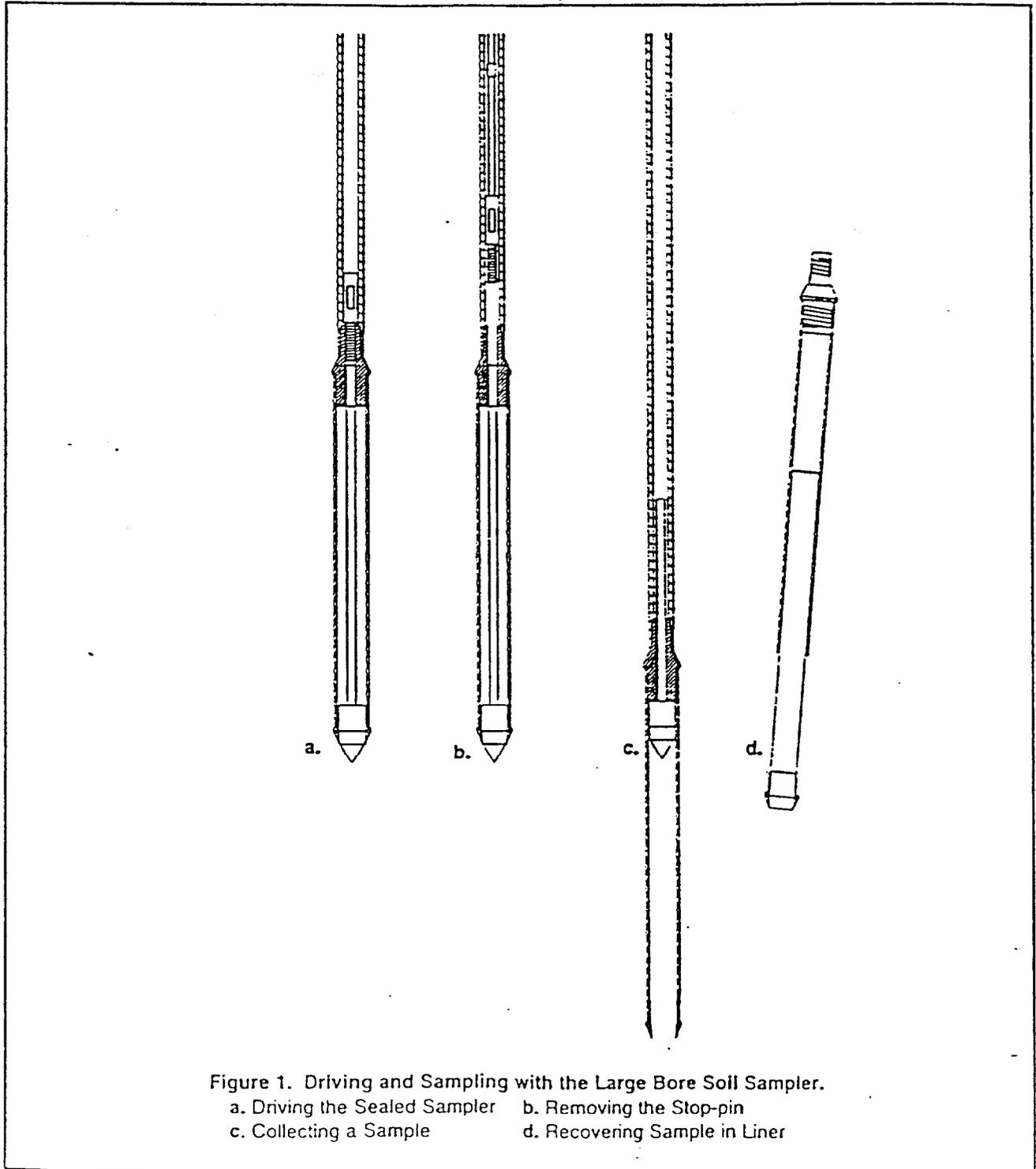
APPENDIX A
GEOPROBE SYSTEMS® SOP

GEOPROBE AT-660 SERIES LARGE BORE SOIL SAMPLER

Standard Operating Procedure (SOP)

Technical Bulletin No. 93-660

PREPARED: 9/21/1993



1.0 OBJECTIVE

The objective of this procedure is to collect a discrete soil sample at depth and recover it for visual inspection and/or chemical analysis.

2.0 BACKGROUND

2.1 Definitions

Geoprobe*: A vehicle-mounted, hydraulically-powered, soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or ground water samples.

**(Geoprobe is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.)*

Large Bore Sampler: A 24-inch long x 1-3/8-inch diameter piston-type soil sampler capable of recovering a discrete sample that measures up to 320 ml in volume. in the form of a 22-inch x 1-1/16-inch core contained inside a removable liner.

Liner: A 24-inch long x 1-1/8-inch diameter removable/replaceable, thin-walled tube inserted inside the Large Bore Sampler body for the purpose of containing and storing soil samples. Liner materials include brass, stainless steel, Teflon, and clear plastic (either PETG or cellulose acetate butyrate).

2.2 Discussion

In this procedure, the assembled Large Bore Sampler is connected to the leading end of a Geoprobe brand probe rod and driven into the subsurface using a Geoprobe machine. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a reverse-threaded stop-pin at the trailing end of the sampler. When the sampler tip has reached the top of the desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. The extension rods are then rotated clock-wise (using a handle). The male threads on the leading end of the extension rods engage the female threads on the top end of the stop-pin, and the pin is removed. After the extension rods and stop-pin have been removed, the tool string is advanced an additional 24 inches. The piston is displaced inside the sampler body by the soil as the sample is cut. To recover the sample, the sampler is recovered from the hole and the liner containing the soil sample is removed. The operation is illustrated in Figure 1.

3.0 REQUIRED EQUIPMENT

The following equipment is required to recover soil core samples using the Geoprobe Large Bore Sampler and driving system. (Figure 2.) Note that the sample liners for the Large Bore Sampler are available in four different materials. Liner materials should be selected based on sampling purpose, analytical parameters, and data quality objectives.

Large Bore Sampler Parts	Quantity	Part Number
STD Piston Stop-pin, O-ring	1	AT-63, 63 R
LB Cutting Shoe	1	AT-660
LB Drive Head	1	AT-661
LB Sample Tube	1	AT-662
LB Piston Tip	1	AT-663
LB Piston Rod	1	AT-664
LB Clear Plastic Liner	variable	AT-665
LB Brass Liner	variable	AT-666
LB Stainless Steel Liner	variable	AT-667
LB Teflon* Liner	variable	AT-668
LB Cutting Shoe Wrench	1	AT-669
Vinyl End Caps	variable	AT-641
Teflon* Tape	variable	AT-640 T

**(Teflon is a Registered Trademark of E.I. du Pont de Nemours & Co.)*

Geoprobe Tools	Quantity	Part Number
Probe Rod (3 foot)	variable	AT-10 B
Probe Rod (2 foot)	1	AT-10 B
Probe Rod (1 foot)	1	AT-10 B
Drive Cap	1	AT-11 B
Pull Cap	1	AT-12 B
Extension Rod	variable	AT-67
Extension Rod Coupler	variable	AT-68
Extension Rod Handle	1	AT-69

Optional

LB Manual Extruder	1	AT-659 K
Extension Rod Jig	1	GW-469
LB Pre-Probe	1	AT-146B

Additional Tools

- Vise Grips
- Open Ended Wrench (3/8-inch)
- 1-inch or Adjustable Wrench

4.0 OPERATION

4.1 Decontamination

Before and after each use, thoroughly clean all parts of the soil sampling system according to project specific requirements. A clean, new liner is recommended for each use. Parts should also be inspected for wear or damage at this time.

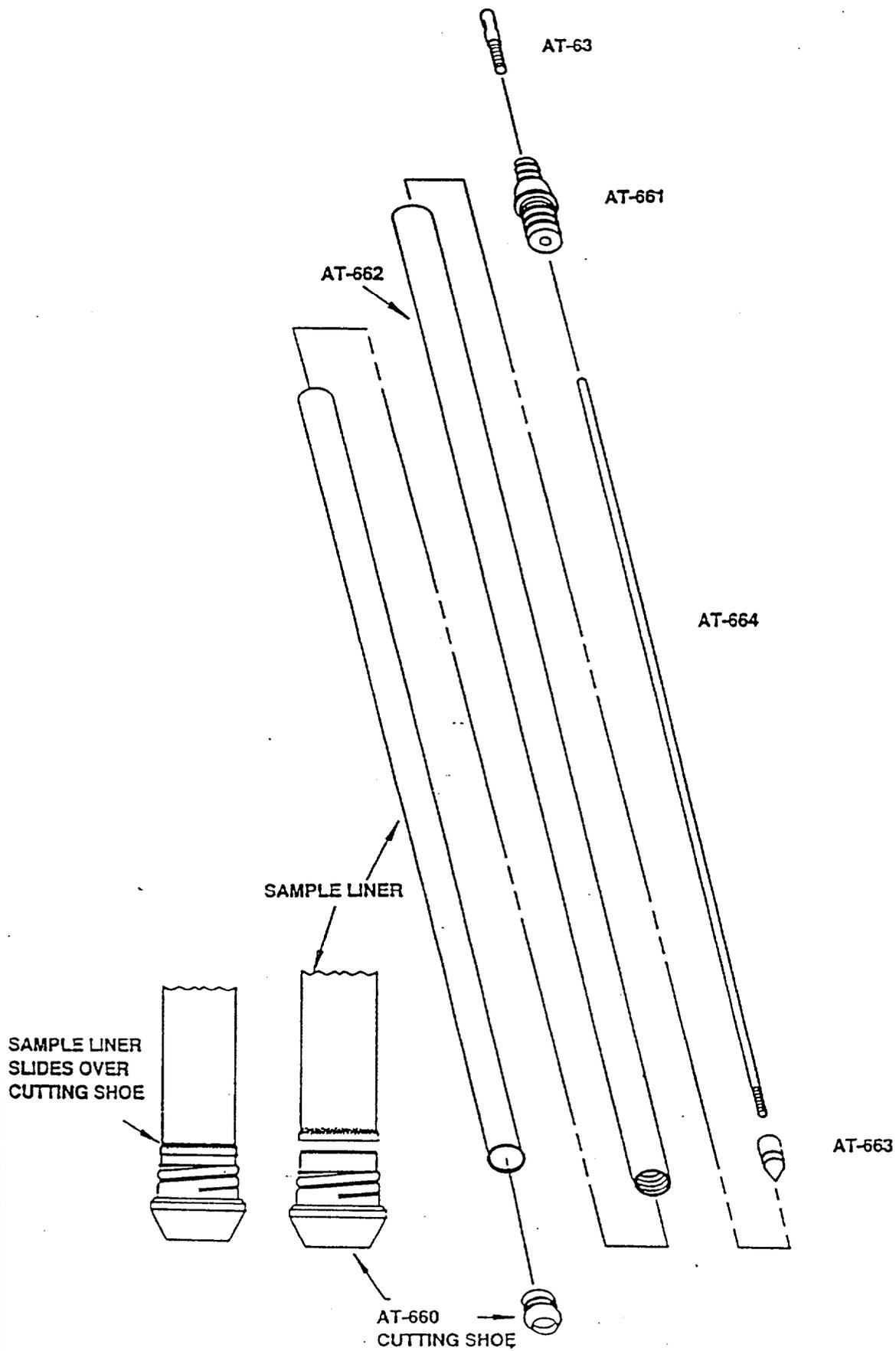


Figure 2. Large Bore Sampler Parts

4.2 Assembly

1. Install a new AT-63R O-ring into the O-ring groove on the AT-63 Stop-pin.
2. Seat the pre-flared end of the LB Liner (AT-665, -666, -667, or -668) over the interior end of the AT-660 Cutting Shoe. (Figure 3.) It should fit snugly.
3. Insert the liner into either end of the AT-662 Sample Tube and screw the cutting shoe and liner into place. If excessive resistance is encountered during this task, it may be necessary to use the AT-669 LB Shoe Wrench. Place the wrench on the ground and position the sampler assembly with the shoe end down so that the recessed notch on the cutting shoe aligns with the pin in the socket of the wrench. (Figure 4.) Push down on the sample tube while turning it, until the cutting shoe is threaded tightly into place.
4. Screw the AT-664 Piston Rod into the AT-663 Piston Tip. Insert the piston tip and rod into the sample tube from the end opposite the cutting shoe. Push and rotate the rod until the tip is seated completely into the cutting shoe.
5. Screw the AT-661 Drive Head onto the top end of the sample tube, aligning the piston rod through the center bore.
6. Screw the reverse-threaded AT-63 Stop-pin into the top of the drive head and turn it counter-clockwise with a 3/8-inch wrench until tight. Hold the drive head in place with a 1-inch or adjustable wrench while completing this task to assure that the drive head stays completely seated. The assembly is now complete.

4.3 Pilot Hole

A pilot hole is appropriate when the surface to be penetrated contains gravel, asphalt, hard sands, or rubble. Pre-probing can prevent unnecessary wear on the sampling tools. A Large Bore Pre-Probe (AT-146B) may be used for this purpose. The pilot hole should be made only to a depth above the sampling interval. Where surface pavements are present, a hole may be drilled with the Geoprobe using a Drill Steel (AT-32, -33, -34, or -35, depending upon the thickness of the pavement), tipped with a 1.5-inch diameter Carbide Drill Bit (AT-36) prior to probing. For pavements in excess of 6 inches, the use of compressed air to remove cuttings is recommended.

4.4 Driving

1. Attach an AT-106B 1-foot Probe Rod to the assembled sampler and an AT-11B Drive Cap to the probe rod. Position the assembly for driving into the subsurface.
2. Drive the assembly into the subsurface until the drive head of the LB sample tube is just above the ground surface.
3. Remove the drive cap and the 1-foot probe rod. Secure the drive head with a 1-inch or adjustable wrench and re-tighten the stop-pin with a 3/8-inch wrench. (Figure 5.)

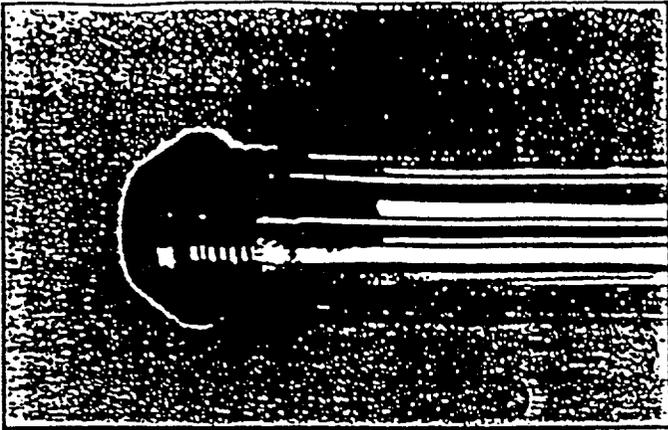


Figure 3. Liner fits snugly over interior end of cutting shoe.

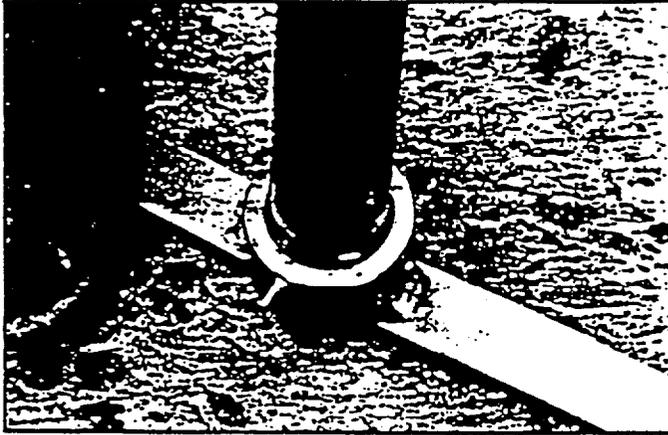


Figure 4. Using the AT-669 Cutting Shoe Wrench to attach cutting shoe.

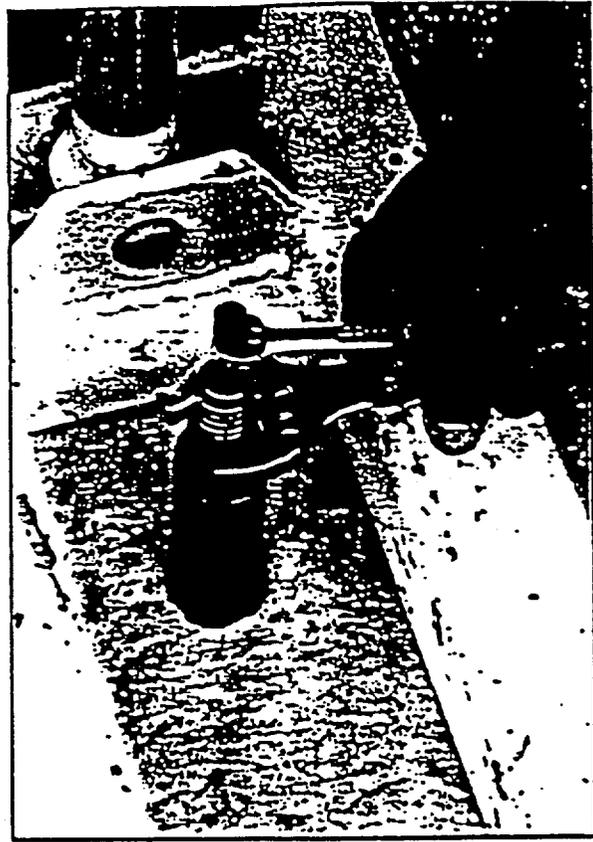


Figure 5. Tightening the Stop-pin.

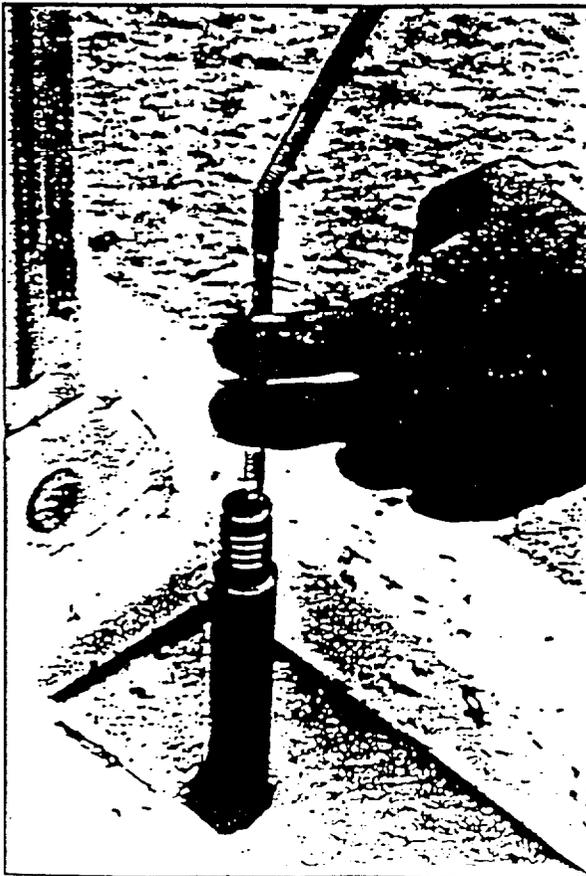


Figure 6. Coupling Extension Rods together.

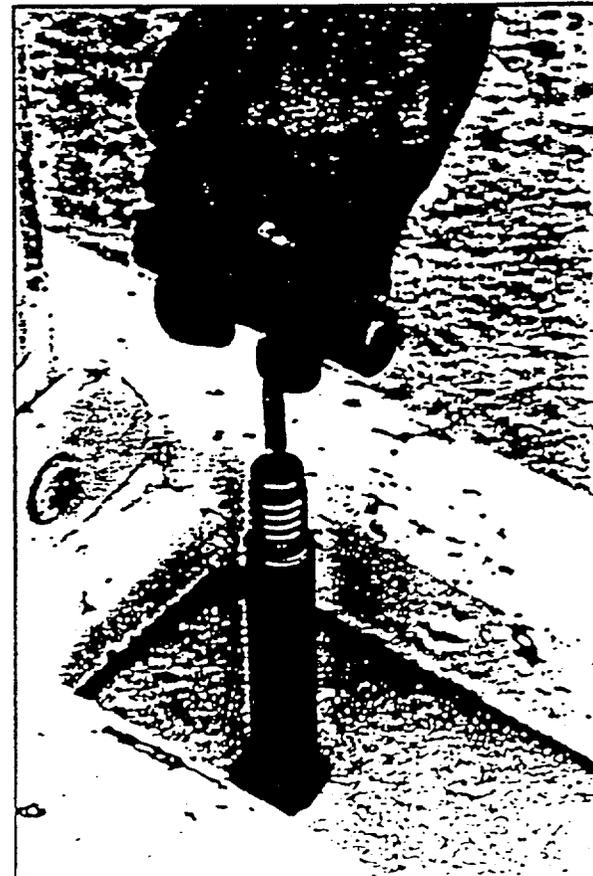


Figure 7. Rotating the Extension Rod Handle.

4.4 Driving (continued from page 5)

4. Attach an AT-105B 2-foot Probe Rod and a drive cap, and continue to drive the sampler into the ground. Attach AT-10B 3-foot Probe Rods in succession until the leading end of the sampler reaches the top of the desired sampling interval.

4.5 Preparing to Sample

1. When sampling depth has been reached, position the Geoprobe machine away from the top of the probe rod to allow room to work.

2. Insert an AT-67 Extension Rod down the inside diameter of the probe rods. Hold onto it and place an AT-68 Extension Rod Coupler on the top threads of the extension rod (the down-hole end of the leading extension rod should remain uncovered). Attach another extension rod to the coupler and lower the jointed rods down-hole. (Figure 6.)

3. Couple additional extension rods together in the same fashion as in Step 2. Use the same number of extension rods as there are probe rods in the ground. The leading extension rod must reach the stop-pin at the top of the sampler assembly. When coupling extension rods together, you may opt to use the GW-469 Extension Rod Jig to hold the down-hole extension rods while adding additional rods.

4. When the leading extension rod has reached the stop-pin down-hole, attach the AT-69 Extension Rod Handle to the top extension rod.

5. Turn the handle clockwise (right-handed) until the stop-pin detaches from the threads on the drive head. (Figure 7.) Pull up lightly on the extension rods during this procedure to check thread engagement.

6. Remove the extension rods and uncouple the sections as each joint is pulled from the hole. The Extension Rod Jig may be used to hold the rod couplers in place as the top extension rods are removed.

7. The stop-pin should be attached to the bottom of the last extension rod upon removal. Inspect it for damage. Once the stop-pin has been removed, the sampler is ready to be re-driven to collect a sample.

4.6 Sample Collection

1. Reposition the Geoprobe machine over the probe rods, adding an additional probe rod to the tool string if necessary. Make a mark on the probe rod 24 inches above the ground surface (this is the distance the tool string will be advanced).

2. Attach a drive cap to the probe rod and drive the tool string and sampler another 24 inches. Use of the Geoprobe's hammer function during sample collection may increase the sample recovery in certain formations. Do not over-drive the sampler.

4.7 Retrieval

1. Remove the drive cap on the top probe rod and attach an AT-12B Pull Cap. Lower the probe shell and close the hammer latch over the pull cap.
2. With the Geoprobe foot firmly on the ground, pull the tool string out of the hole. Stop when the top (drive head) of the sampler is about 12 inches above the ground surface.
3. Because the piston tip and rod have been displaced inside the sample tube, the piston rod now extends into the 2-foot probe rod section. In loose soils, the 2-foot probe rod and sampler may be recovered as one piece by using the foot control to lift the sampler the remaining distance out of the hole.
4. If excessive resistance is encountered while attempting to lift the sampler and probe rod out of the hole using the foot control, unscrew the drive head from the sampler and remove it with the probe rod, the piston rod, and the piston tip. Replace the drive head onto the sampler and attach a pull cap to it. Lower the probe shell and close the hammer latch over the pull cap and pull the sampler the remaining distance out of the hole with the probe machine foot firmly on the ground.

4.8 Sample Recovery

1. Detach the 2-foot probe rod if it has not been done previously.
2. Unscrew the cutting shoe using the AT-669 LB Cutting Shoe Wrench, if necessary. Pull the cutting shoe out with the liner attached. (Figure 8.) If the liner doesn't slide out readily with the cutting shoe, take off the drive head and push down on the side wall of the liner. The liner and sample should slide out easily.

4.9 Core Liner Capping

1. The ends of the liners can be capped off using the AT-641 Vinyl End Cap for further storage or transportation. A black end cap should be used at the bottom (down end) of the sample core and a red end cap at the top (up end) of the core.
2. On brass, stainless steel, and teflon liners, cover the end of the sample tube with AT-640T Teflon Tape before placing the end caps on the liner. (Figure 9.) The tape should be smoothed out and pressed over the end of the soil core so as to minimize headspace. However, care should be taken not to stretch and, therefore, thin the teflon tape.

4.10 Sample Removal

1. Large Bore Clear Plastic and Teflon Liners can be slit open easily with a utility knife for the samples to be analyzed or placed in appropriate containers.
2. Large Bore Brass and Stainless Steel liners separate into four 6-inch sections. The AT-659K Large Bore Manual Extruder may be used to push the soil cores out of the liner sections for analysis or for transfer to other containers. (Figure 10.)

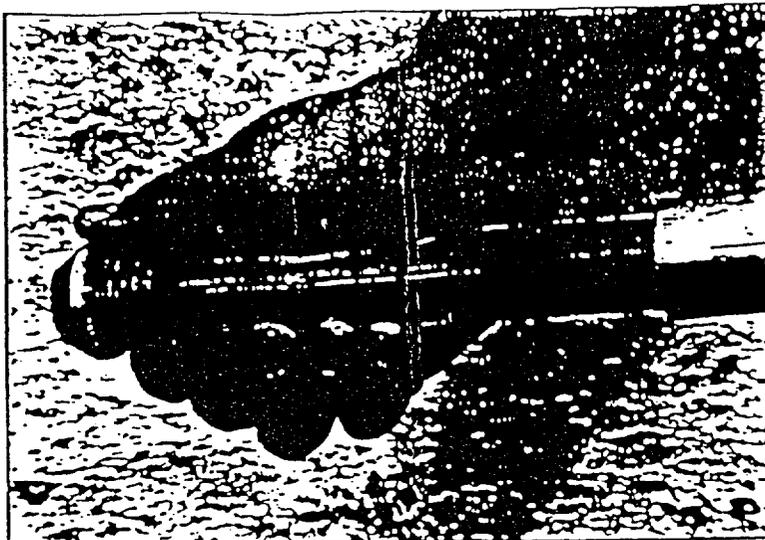


Figure 8. Removing the liner to recover the Sample.

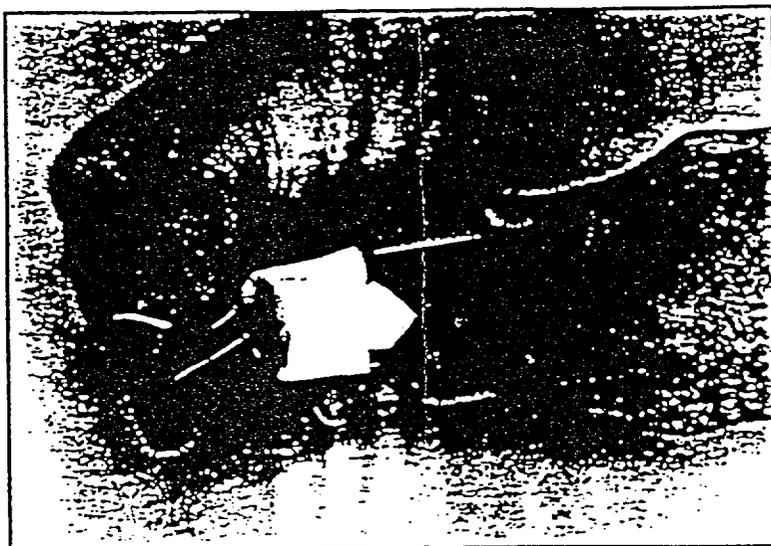


Figure 9. Covering the liner end with Teflon tape for capping.

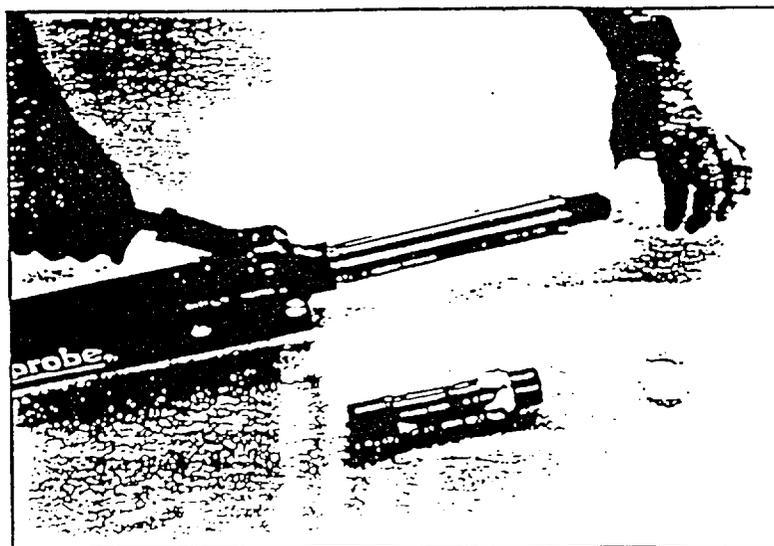


Figure 10. Extruding a sample in a metal liner using the AT-659K manual extruder.

5.0 REFERENCES

Geoprobe Systems, August 1993, "1993-94 Equipment and Tools Catalog".



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Hydraulic Probing Machines • Mobile Laboratories • Small Diameter Sampling Tools

APPENDIX B
JUSTIFICATION CRITERIA FOR USE OF PVC WELL CASING
AND SCREEN MATERIAL

The following is USEPA Region IV minimum seven point information requirements to justify the use of PVC as an alternate casing material for groundwater monitoring wells. If requested, justification of the use of PVC should be developed by addressing each of the following items:

1. The DQOs for the groundwater samples to be collected.

Level IV DQOs will be used for analyses of groundwater samples collected during this project. Analytical parameters have been selected to characterize the presence or absence of contamination and to assess any associated risks to human health or the environment.

2. The anticipated (organic) compounds.

There are two primary concerns regarding sample bias associated with use of PVC well casing under these conditions. One is that organic contaminants will leach from the PVC well casing. The other is that organic contaminants that may be present in the groundwater would adsorb onto the PVC. Either of these could result in biased analytical results.

3. The anticipated residence time of the sample in the well and the aquifer's productivity.

It is important to note that all stagnant water from inside the well casing is purged immediately before sample collection. The time required to do this is expected to be much less than that required for groundwater sampling bias phenomena (adsorbing/leaching) to develop.

Samples collected immediately after purging (i.e., "fresh" from the aquifer).

Aquifer productivity: Subsurface soils samples are mostly fine sand.

The wells should recharge (enough to sample) before any sorbing/leaching of organics can occur.

4. The reasons for not using other casing materials.

Costs associated with use of stainless steel and teflon casing materials are prohibitive. PVC strength will be sufficient for this investigation. Existing groundwater quality data indicate that leaching/sorbing of organic materials from/onto the PVC will not be extensive enough to bias future groundwater analysis. PVC is lighter and more flexible than stainless steel.

5. Literature on the adsorption characteristics of the compounds and elements of interest.

The following was originally presented in National Water Well Association (NWWA, 1989):

Miller (1982) conducted a study to determine if PVC exhibited any tendency to sorb potential contaminants from solution. Trichloroethene and 1,1,2-trichloroethane did not sorb to PVC. Reynolds and Gillham (1985) found that 1,1,2,2-tetrachloroethane could sorb to PVC. The sorption was slow enough that groundwater sampling bias would not be significant if well development (purging the well of stagnant water) and sampling were to

take place in the same day. No data was available for the organic compounds listed in Item #2.

6. **Whether the wall thickness of the PVC casing would require a larger annular space when compared to other well construction materials.**

It will not. The 2" diameter borehole will be of sufficient diameter for installation of the 1" PVC casing and screen.

7. **The type of PVC to be used and, if available, the manufacturers specifications, and an assurance that the PVC to be used does not leach, mask, reach or otherwise interfere with the contaminants being monitored within the limits of the DQOs.**

Bake will request the appropriate manufacturers specifications and assurances regarding this requirement. This material will be supplied to Baker by the drilling subcontractor.

References for Attachment A:

National Water Well Association, 1989, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, Dublin, Ohio, 398 pgs.

Miller, G.D., 1982, Uptake of lead, chromium and trace level volatile organics exposed to synthetic well casings. Proceedings of the Second national Symposium on Aquifer Restoration and Ground-Water Monitoring, National Water Well Association, Dublin, Ohio, pp. 236-245.

Reynolds, G.W. and Robert W. Gillham, 1985, Adsorption of halogenated organic compounds by polymer materials commonly used in ground-water monitors. Proceedings of the Second Canadian/American Conference on Hydrogeology, National Water Well Association, Dublin, Ohio, pp. 125-132.

APPENDIX C
GROUNDWATER SAMPLE ACQUISITION

**GROUNDWATER SAMPLE ACQUISITION
TABLE OF CONTENTS**

- 1.0 PURPOSE**
- 2.0 SCOPE**
- 3.0 DEFINITIONS**
- 4.0 RESPONSIBILITIES**
- 5.0 PROCEDURES**
 - 5.1 Sampling, Monitoring, and Evaluation Equipment**
 - 5.2 Calculations of Well Volume**
 - 5.3 Evacuation of Static Water (Purging)**
 - 5.3.1 Evacuation Devices**
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 - 5.4.1 Sampling Methods**
 - 5.4.2 Sample Containers**
 - 5.4.3 Preservation of Samples and Sample Volume Requirements**
 - 5.4.4 Field Filtration**
 - 5.4.5 Handling and Transportation Samples**
 - 5.4.6 Sample Holding Times**
- 6.0 QUALITY ASSURANCE RECORDS**
- 7.0 REFERENCES**

GROUNDWATER SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this guideline is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This guideline provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team

Leader and the Project Manager. The sampling personnel are responsible for the proper acquisition of groundwater samples.

5.0 PROCEDURES

To be useful and accurate, a groundwater sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to minimize any changes in water quality parameters.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells (Attachment A). This reference is not intended as a monitoring plan or procedure for a specific application, but rather is a review of methods. Specific methods shall be stated in the Sampling and Analysis Plan (SAP).

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain largely isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be pumped or bailed prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.
2. Wells that can be pumped or bailed to dryness with the sampling equipment being used, shall be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of at least three well volumes of water is preferred; otherwise, a sample will be taken when enough water is available to fill the sample containers.

Stratification of contaminants may exist in the aquifer formation. This is from concentration gradients due to dispersion and diffusion processes in a homogeneous layer, and from

separation of flow streams by physical division (for example, around clay leases) or by contrasts in permeability (for example, between a layer of silty, fine sand and a layer of medium sand).

Pumping rates and volumes for non-production wells during sampling development should be moderate; pumping rates for production wells should be maintained at the rate normal for that well. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, thus result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Disposition of purge water is usually site specific and must be addressed in the Sampling and Analysis Plan.

5.1 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with EPA regulations for the appropriate contaminants and to the specific Quality Assurance Project Plan.

The following list is an example of the type of equipment that generally must be on hand when sampling groundwater wells:

1. Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, and appropriate packing cartons and filler, labels and chain-of-custody documents.
2. Field tools and instrumentation - Thermometer; pH meter; specific conductivity meter; appropriate keys (for locked wells) or bolt-cutter; tape measure; water-level indicator; and, where applicable, flow meter.
3. Pumps
 - a. Shallow-well pumps - Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing), as applicable.
 - b. Deep-well pumps - Submersible pump and electrical power generating unit, bladder pump with compressed air source, or air-lift apparatus, as applicable.
4. Tubing - Sample tubing such as teflon, polyethylene, polypropylene, or PVC. Tubing type shall be selected based on specific site requirements and must be chemically inert to the groundwater being sampled.
5. Other Sampling Equipment - Bailers, teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with

tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

6. Pails - Plastic, graduated.
7. Decontamination solutions - Decontamination materials are discussed in SOP F501 and F502.

Ideally, sample withdrawal equipment should be completely inert, economical, easily cleaned, sterilized, and reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.2 Calculations of Well Volume

Calculation of gallons/linear feet from a well

$$V = \pi r^2 h$$

Where: V = volume of standing water in well
 r = well radius
 h = feet of standing water in well

Table 5-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameter.

TABLE 5-1
 WELL VOLUMES

Diameter of Casing or Hole (in.)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth
1	0.041	0.0055
2	0.163	0.0218
4	0.653	0.0873
6	1.469	0.1963
8	2.611	0.3491
10	4.080	0.5454

Notes:

1. Gallons per foot of depth will be multiplied by amount of standing water to obtain well volume quantity.
2. 1 gallon = 3.785 liters
 1 meter = 3.281 feet
 1 gallon water weighs 8.33 pounds = 3.785 kilograms
 1 liter water weighs 1 kilogram = 2.205 pounds
 1 gallon per foot of depth = 12.419 liters per foot of depth
 1 gallon per meter of depth = 12.419 x 10⁻³ cubic meters per meter of depth

To insure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well pipe or casing. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).
2. Determine well or casing diameter.
3. Measure and record static water level (depth below ground level or top of casing reference point), using one of the methods described in Section 5.1 of SOP F202.
4. Determine the depth of the well (if not known from past records) to the nearest 0.01-foot by sounding using a clean, decontaminated weighted tape measure.
5. Calculate number of linear feet of static water (total depth or length of well pipe or casing minus the depth to static water level).
6. Calculate the volume of water in the casing:

$$VW = \pi D^2 (TD - DW)$$

$$V_{gal} = VW \times 7.48 \text{ gallons/ft}^3$$

$$V_{purge} = V_{gal} (\# \text{ Well Vol})$$

Where:

V_W	= Volume of water in well in cubic feet (i.e., one well volume)
π	= pi, 3.14
D	= Well diameter in feet (use $(D/12)$ if D is in inches)
TD	= Total depth of well in feet (below ground surface or top of casing)
DW	= Depth to water in feet (below ground surface or top of casing)
V_{gal}	= Volume of water in well in gallons
V_{purge}	= Volume of water to be purged from well in gallons
$\# \text{ Well Vol.}$	= Number of well volumes of water to be purged from the well (typically three to five)

7. Determine the minimum number of gallons to be evacuated before sampling. (Note: V_{purge} should be rounded to the next highest whole gallon. For example, 7.2 gallons should be rounded to 8 gallons.)

5.3 Evacuation of Static Water (Purging)

The amount of flushing a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from a wide area. Generally, three to five well volumes are considered effective for purging a well.

An alternative method of purging a well, and one accepted in EPA Regions I and IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize. The well is considered properly purged when the values have stabilized.

The Project Manager shall define the objectives of the groundwater sampling program in the Sampling and Analysis Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.3.1 Evacuation Devices

The following discussion is limited to those devices which are commonly used at hazardous waste sites. Note that all of these techniques involve equipment which is portable and readily available.

Bailers - Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line (e.g., Teflon-coated) is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Inexpensive.
- Minimal outgassing of volatile organics while the sample is in the bailer.
- Relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- Potentially excessively time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps - There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (generally not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 10 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps will cause significant loss of dissolved gases, including volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

Gas-Lift Samples - This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift pumps are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics. An inert gas such as nitrogen is generally used as a gas source.

Submersible Pumps - Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed air or

electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for two-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- Potentially low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.4 Sampling

The sampling approach consisting of the following, should be developed as part of the Sampling and Analysis Plan prior to the field work:

1. Background and objectives of sampling.
2. Brief description of area and waste characterization.
3. Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
4. Sampling equipment to be used.
5. Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these should be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.
6. Sample preservation requirements.
7. Schedule.
8. List of team members.
9. Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.4.1 Sampling Methods

The collection of a groundwater sample includes the following steps:

1. First open the well cap and use volatile organic detection equipment (HNu or OVA) on the escaping gases at the well head to determine the need for respiratory protection. This task is usually performed by the Field Team Leader, Health and Safety Officer, or other designee.
2. When proper respiratory protection has been donned, sound the well for total depth and water level (decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well according to Section 5.2 of this SOP.
3. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (e.g., DOT-approved 55-gallon drum).
4. Measure the rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.
5. Observe peristaltic pump intake for degassing "bubbles" and all pump discharge lines. If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. The preferred method for collecting volatile organic samples and the accepted method by EPA Regions I through IV is with a bailer.
6. Purge a minimum of three to five well volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recharge as necessary, but preferably to 70 percent of the static water level, and then sample.
7. Record measurements of specific conductance, temperature, and pH during purging to ensure the groundwater stabilizes. Generally, these measurements are made after three, four, and five well volumes.
8. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling (this requires use of other than a "bucket-type" bailer). Purged water should be collected in a designated container and disposed of in an acceptable manner.
9. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers should always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
10. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in

the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

11. Add preservative if required (see SOP F301). Label, tag, and number the sample bottle(s).
12. Purgeable organics vials (40 ml) should be completely filled to prevent volatilization and extreme caution should be exercised when filling a vial to avoid turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure.
13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.
14. Pack the samples for shipping (see SOP F301). Attach custody seals to the shipping container. Make sure that Chain-of-Custody forms and Sample Analysis Request forms are properly filled out and enclosed or attached (see SOP F302).
15. Decontaminate all equipment.

5.4.2 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory. SOP F301 describes the required sampling containers for various analytes at various concentrations. Container requirements shall follow those given in NEESA 20.2-047B.

5.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. SOP F301 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Sample volume and preservation requirements shall follow those given in NEESA 20.2-047B.

5.4.4 Field Filtration

In general, preparation and preservation of water samples involve some form of filtration. All filtration must occur in the field immediately upon collection. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) utilizing the pressure provided by the upstream pumping device for its operation.

In Region I, all inorganics are to be collected and preserved in the filtered form, including metals. In Region II, metals samples are to be collected and preserved unfiltered. In Regions III and IV, samples collected for metals analysis are also to be unfiltered. However, if metals analysis of monitoring wells is required, then both an unfiltered and filtered sample are to be collected, regardless of regulatory requirements. Filtration and preservation are to occur immediately in the field with the sample aliquot passing through a 0.45 micron filter. Samples for organic analyses shall never be filtered. Filters must be prerinsed with organic-free, deionized water.

5.4.5 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it should be double-bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged, and thus possibly become cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SOP F301.

5.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in NEESA 20.2-047B.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method; volume of water purged prior to sampling; number of well volumes purged).
- Sample disposition (preservatives added; lab sent to; date and time).
- Additional remarks, as appropriate.

Proper chain-of-custody procedures play a crucial role in data gathering. SOP F302 describes the requirements for correctly completing a chain-of-custody form. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

7.0 REFERENCES

American Society of Testing and Materials. 1987. Standard Guide for Sampling Groundwater Monitoring Wells. Method D4448-85A, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

ATTACHMENT A

ASTM D4448-85A

STANDARD GUIDE FOR SAMPLING GROUNDWATER MONITORING WELLS



Standard Guide for Sampling Groundwater Monitoring Wells¹

This standard is issued under the fixed designation D 4448; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers procedures for obtaining valid, representative samples from groundwater monitoring wells. The scope is limited to sampling and "in the field" preservation and does not include well location, depth, well development, design and construction, screening, or analytical procedures.

1.2 This guide is only intended to provide a review of many of the most commonly used methods for sampling groundwater quality monitoring wells and is not intended to serve as a groundwater monitoring plan for any specific application. Because of the large and ever increasing number of options available, no single guide can be viewed as comprehensive. The practitioner must make every effort to ensure that the methods used, whether or not they are addressed in this guide, are adequate to satisfy the monitoring objectives at each site.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Guide

2.1 The equipment and procedures used for sampling a monitoring well depend on many factors. These include, but are not limited to, the design and construction of the well, rate of groundwater flow, and the chemical species of interest. Sampling procedures will be different if analyzing for trace organics, volatiles, oxidizable species, or trace metals is needed. This guide considers all of these factors by discussing equipment and procedure options at each stage of the sampling sequence. For ease of organization, the sampling process can be divided into three steps: well flushing, sample withdrawal, and field preparation of samples.

2.2 Monitoring wells must be flushed prior to sampling so that the groundwater is sampled, not the stagnant water in the well casing. If the well casing can be emptied, this may be done although it may be necessary to avoid oxygen contact with the groundwater. If the well cannot be emptied, procedures must be established to demonstrate that the sample represents groundwater. Monitoring an indicative parameter such as pH during flushing is desirable if such a parameter can be identified.

2.3 The types of species that are to be monitored as well as the concentration levels are prime factors for selecting sampling devices (1, 2).² The sampling device and all materials and devices the water contacts must be constructed of materials that will not introduce contaminants or alter the analyte chemically in any way.

2.4 The method of sample withdrawal can vary with the parameters of interest. The ideal sampling scheme would employ a completely inert material, would not subject the sample to negative pressure and only moderate positive pressure, would not expose the sample to the atmosphere, or preferably, any other gaseous atmosphere before conveying it to the sample container or flow cell for on-site analysis.

2.5 The degree and type of effort and care that goes into a sampling program is always dependent on the chemical species of interest and the concentration levels of interest. As the concentration level of the chemical species of analytical interest decreases, the work and precautions necessary for sampling are increased. Therefore, the sampling objective must clearly be defined ahead of time. For example, to prepare equipment for sampling for mg/L (ppm) levels of Total Organic Carbon (TOC) in water is about an order of magnitude easier than preparing to sample for $\mu\text{g/L}$ (ppb) levels of a trace organic like benzene. The specific precautions to be taken in preparing to sample for trace organics are different from those to be taken in sampling for trace metals. No final Environmental Protection Agency (EPA) protocol is available for sampling of trace organics. A short guidance manual, (3) and an EPA document (4) concerning monitoring well sampling, including considerations for trace organics are available.

2.6 Care must be taken not to cross contaminate samples or monitoring wells with sampling or pumping devices or materials. All samples, sampling devices, and containers must be protected from the environment when not in use. Water level measurements should be made before the well is flushed. Oxidation-reduction potential, pH, dissolved oxygen, and temperature measurements and filtration should all be performed on the sample in the field, if possible. All but temperature measurement must be done prior to any significant atmospheric exposure, if possible.

2.7 The sampling procedures must be well planned and all sample containers must be prepared and labeled prior to going to the field.

3. Significance and Use

3.1 The quality of groundwater has become an issue of national concern. Groundwater monitoring wells are one of

¹ This guide is under the jurisdiction of ASTM Committee D-34 on Waste Disposal and is the direct responsibility of Subcommittee D34.01 on Sampling and Monitoring.

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² The boldface numbers in parentheses refer to a list of references at the end of this guide.

TABLE 1 Typical Container and Preservation Requirements for a Ground-Water Monitoring Program

Sample and Measurement	Volume Required (mL)	Container P—Polyethylene G—Glass	Preservative	Maximum Holding Time
Metals As/Ba/Cd/Cr/Fc Pb/Se/ Ag/Mn/Na	1000-2000	P/G (special acid cleaning)	high purity nitric acid to pH <2	6 months
Mercury	200-300	P/G (special acid cleaning)	high purity nitric acid to pH <2 +0.05 % K ₂ Cr ₂ O ₇	28 days
Radioactivity alpha/beta/radium	4000	P/G (special acid cleaning)	high purity nitric acid to pH <2	6 months
Phenolics	500-1000	G	cool, 4°C H ₂ SO ₄ to pH <2	28 days
Miscellaneous	1000-2000	P	cool, 4°C	28 days
Fluoride	300-500	P		28 days
Chloride	50-200	P/G		28 days
Sulfate	100-500	P/G		48 hours
Nitrate	100-250	P/G		6 h
Coliform	100	P/G		on site/24 h
Conductivity	100	P/G		on site/6 h
pH	100	P/G		48 h
Turbidity	100	P/G		
Total organic carbon (TOC)	25-100	P/G	cool, 4°C or cool, 4°C HCl or H ₂ SO ₄ to pH <2	24 h 28 days
Pesticides, herbicides and total organic halogen (TOX)	1000-4000	G/TFE-fluoro- carbon lined cap solvent rinsed	cool, 4°C	7 days/extraction +30 days/analysis
Extractable organics	1000-2000	G/TFE-fluoro- carbon-lined cap solvent rinsed	cool, 4°C	7 days/extraction +30 days/analysis
Organic purgeables acrolein/acrylonitrile	25-120	G/vial TFE-fluorocar- bon-lined sep- tum	cool, 4°C	14 days 3 days

the more important tools for evaluating the quality of groundwater, delineating contamination plumes, and establishing the integrity of hazardous material management facilities.

3.2 The goal in sampling groundwater monitoring wells is to obtain samples that are truly representative of the aquifer or groundwater in question. This guide discusses the advantages and disadvantages of various well flushing, sample withdrawal, and sample preservation techniques. It reviews the parameters that need to be considered in developing a valid sampling plan.

4. Well Flushing (Purging)

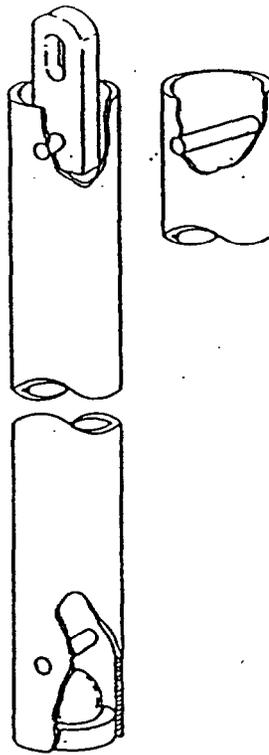
4.1 Water that stands within a monitoring well for a long period of time may become unrepresentative of formation water because chemical or biochemical change may cause water quality alterations and even if it is unchanged from the time it entered the well, the stored water may not be representative of formation water at the time of sampling, or both. Because the representativeness of stored water is questionable, it should be excluded from samples collected from a monitoring well.

4.2 The surest way of accomplishing this objective is to remove all stored water from the casing prior to sampling. Research with a tracer in a full scale model 2 in. PVC well (5) indicates that pumping 5 to 10 times the volume of the well via an inlet near the free water surface is sufficient to remove all the stored water in the casing. The volume of the well may

be calculated to include the well screen and any gravel pack if natural flow through these is deemed insufficient to keep them flushed out.

4.3 In deep or large diameter wells having a volume of water so large as to make removal of all the water impractical, it may be feasible to lower a pump or pump inlet to some point well below the water surface, purge only the volume below that point then withdraw the sample from a deeper level. Research indicates this approach should avoid most contamination associated with stored water (5, 6, 7). Sealing the casing above the purge point with a packer may make this approach more dependable by preventing migration of stored water from above. But the packer must be above the top of the screened zone, or stagnant water from above the packer will flow into the purged zone through the well's gravel/sand pack.

4.4 In low yielding wells, the only practical way to remove all standing water may be to empty the casing. Since it is not always possible to remove all water, it may be advisable to let the well recover (refill) and empty it again at least once. If introduction of oxygen into the aquifer may be of concern, it would be best not to uncover the screen when performing the above procedures. The main disadvantage of methods designed to remove all the stored water is that large volumes may need to be pumped in certain instances. The main advantage is that the potential for contamination of samples with stored water is minimized.



NOTE—Taken from Ref (15).

FIG. 1 Single Check Valve Bailer

4.5 Another approach to well flushing is to monitor one or more indicator parameters such as pH, temperature, or conductivity and consider the well to be flushed when the indicator(s) no longer change. The advantage of this method is that pumping can be done from any location within the casing and the volume of stored water present has no direct bearing on the volume of water that must be pumped. Obviously, in a low yielding well, the well may be emptied before the parameters stabilize. A disadvantage of this approach is that there is no assurance in all situations that the stabilized parameters represent formation water. If significant drawdown has occurred, water from some distance away may be pulled into the screen causing a steady parameter reading but not a representative reading. Also, a suitable indicator parameter and means of continuously measuring it in the field must be available.

4.6 Gibb (4, 8) has described a time-drawdown approach using a knowledge of the well hydraulics to predict the percentage of stored water entering a pump inlet near the top of the screen at any time after flushing begins. Samples are taken when the percentage is acceptably low. As before, the advantage is that well volume has no direct effect in the duration of pumping. A current knowledge of the well's hydraulic characteristics is necessary to employ this approach. Downward migration of stored water due to effects other than drawdown (for example density differences) is not accounted for in this approach.

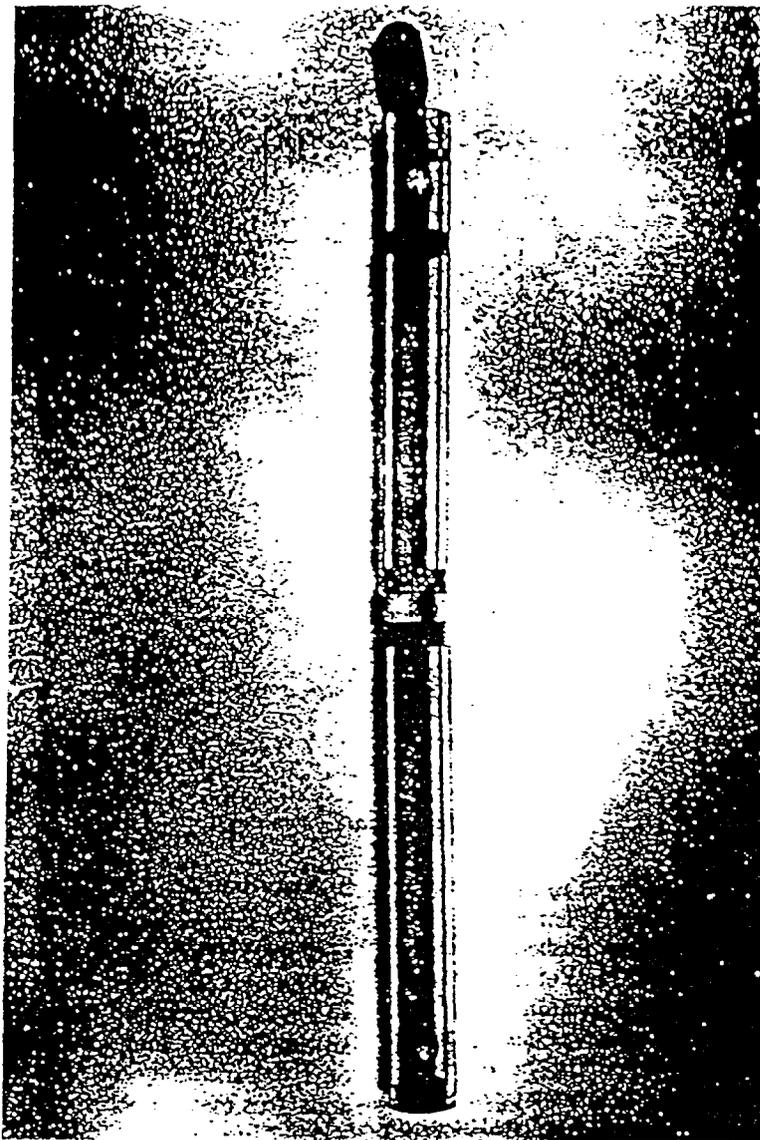
4.7 In any flushing approach, a withdrawal rate that minimizes drawdown while satisfying time constraints should be used. Excessive drawdown distorts the natural flow patterns around a well and can cause contaminants that were not present originally to be drawn into the well.

5. Materials and Manufacture

5.1 The choice of materials used in the construction of sampling devices should be based upon a knowledge of what compounds may be present in the sampling environment and how the sample materials may interact via leaching, adsorption, or catalysis. In some situations, PVC or some other plastic may be sufficient. In others, an all glass apparatus may be necessary.

5.2 Most analytical protocols suggest that the devices used in sampling and storing samples for trace organics analysis ($\mu\text{g/L}$ levels) must be constructed of glass or TFE-fluorocarbon resin, or both. One suggestion advanced by the EPA is that the monitoring well be constructed so that only TFE-fluorocarbon tubing be used in that portion of the sampling well that extends from a few feet above the water table to the bottom of the borehole. (3, 5) Although this type of well casing is now commercially available, PVC well casings are currently the most popular. If adhesives are avoided, PVC well casings are acceptable in many cases although their use may still lead to some problems if trace organics are of concern. At present, the type of background presented by PVC and interactions occurring between PVC and groundwater are not well understood. Tin, in the form of an organotin stabilizer added to PVC, may enter samples taken from PVC casing. (9)

5.3 Since the most significant problem encountered in trace organics sampling, results from the use of PVC adhesives in monitoring well construction, threaded joints might avoid the problem (3, 5). Milligram per litre (parts per million) levels of compounds such as tetrahydrofuran, methyl-ethyl-ketone, and toluene are found to leach into



NOTE—Taken from Ref (17).

FIG. 2 Acrylic Point Source Bailer

groundwater samples from monitoring well casings sealed with PVC solvent cement. Pollutant phthalate esters (8, 10) are often found in water samples at ppb levels; the EPA has found them on occasion at ppm levels in their samples. The ubiquitous presence of these phthalate esters is unexplained, except to say that they may be leached from plastic pipes, sampling devices, and containers.

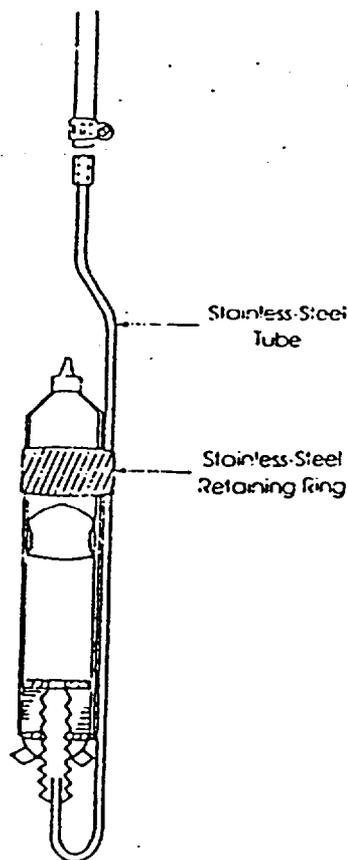
5.4 TFE-fluorocarbon resins are highly inert and have sufficient mechanical strength to permit fabrication of sampling devices and well casings. Molded parts are exposed to high temperature during fabrication which destroys any organic contaminants. The evolution of fluorinated compounds can occur during fabrication, will cease rapidly, and does not occur afterwards unless the resin is heated to its melting point.

5.5 Extruded tubing of TFE-fluorocarbon for sampling may contain surface traces of an organic solvent extrusion aid. This can be removed easily by the fabricator and, once

removed by flushing, should not affect the sample. TFE-fluorocarbon FEP and TFE-fluorocarbon PFA resins do not require this extrusion aid and may be suitable for sample tubing as well. Unsintered thread-sealant tape of TFE-fluorocarbon is available in an "oxygen service" grade and contains no extrusion aid and lubricant.

5.6 Louneman, et al. (11) alludes to problems caused by a lubricating oil used during TFE-fluorocarbon tubing extrusion. This reference also presents evidence that a fluorinated ethylene-propylene copolymer adsorbed acetone to a degree that later caused contamination of a gas sample.

5.7 Glass and stainless steel are two other materials generally considered inert in aqueous environments. Glass is probably among the best choices though it is not inconceivable it could adsorb some constituents as well as release other contaminants (for example, Na, silicate, and Fe). Of course glass sampling equipment must be handled carefully in the field. Stainless steel is strongly and easily machined



NOTE—Taken from Ref (21).

FIG. 3 Schematic of the Inverted Syringe Sampler

fabricate equipment. Unfortunately, it is not totally immune to corrosion that could release metallic contaminants. Stainless steel contains various alloying metals, some of these (for example Ni) are commonly used as catalysts for various reactions. The alloyed constituents of some stainless steels can be solubilized by the pitting action of nonoxidizing anions such as chloride, fluoride, and in some instances sulfate, over a range of pH conditions. Aluminum, titanium, polyethylene, and other corrosion resistant materials have been proposed by some as acceptable materials, depending on groundwater quality and the constituents of interest.

5.8 Where temporarily installed sampling equipment is used, the sampling device that is chosen should be non-plastic (unless TFE-fluorocarbon), cleanable of trace organics, and must be cleaned between each monitoring well use in order to avoid cross-contamination of wells and samples. The only way to ensure that the device is indeed "clean" and acceptable is to analyze laboratory water blanks and field water blanks that have been soaked in and passed through the sampling device to check for the background levels that may result from the sampling materials or from field conditions. Thus, all samplings for trace materials should be accompanied by samples which represent the field background (if possible), the sampling equipment background, and the laboratory background.

5.9 Additional samples are often taken in the field and spiked (spiked-field samples) in order to verify that the sample handling procedures are valid. The American Chem-

ical Society's committee on environmental improvement has published guidelines for data acquisition and data evaluation which should be useful in such environmental evaluation (10, 12).

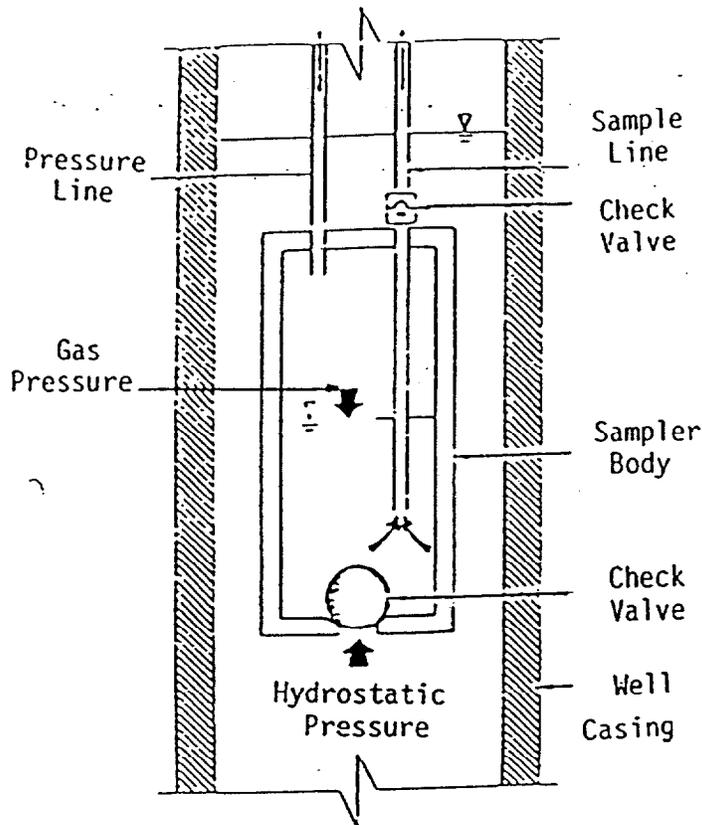
6. Sampling Equipment

6.1 There is a fairly large choice of equipment present available for groundwater sampling from single screen wells and well clusters. The sampling devices can be categorized into the following eight basic types.

6.1.1 Down-Hole Collection Devices:

6.1.1.1 Bailers, messenger bailers, or thief samplers (14) are examples of down-hole devices that probably provide valid samples once the well has been flushed. They are not practical for removal of large volumes of water. The devices can be constructed in various shapes and sizes from a variety of materials. They do not subject the sample to pressure extremes.

6.1.1.2 Bailers do expose part of the sample to the atmosphere during withdrawal. Bailers used for sampling of volatile organic compounds should have a sample cock or draft valve in or near the bottom of the sampler to allow withdrawal of a sample from the well below the exposed surface of the water or the first few inches of the sample should be discarded. Suspension lines for bailers and other samplers should be kept off the ground and free of other contaminating materials that could be carried into the well. Down-hole devices are not very practical for use in deep



NOTE—Taken from Ref (5).

FIG. 4 The Principal of Gas Displacement Pumping

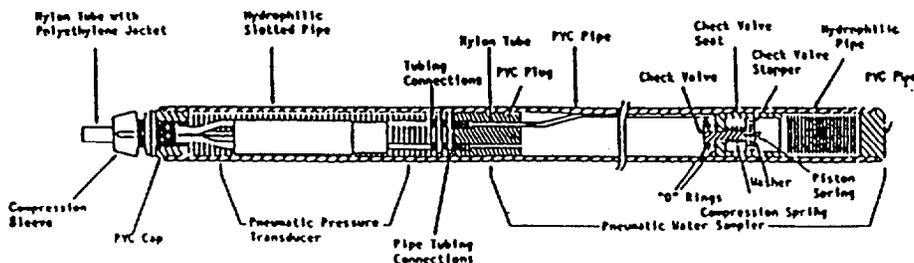
wells. However, potential sample oxidation during transfer of the sample into a collection vessel and time constraints for lowering and retrieval for deep sampling are the primary disadvantages.

6.1.1.3 Three down-hole devices are the single and double check valve bailers and thief samplers. A schematic of a single check valve unit is illustrated in Fig. 1. The bailer may be threaded in the middle so that additional lengths of blank casing may be added to increase the sampling volume. TFE-fluorocarbon or PVC are the most common materials used for construction (15).

6.1.1.4 In operation, the single check valve bailer is lowered into the well, water enters the chamber through the bottom, and the weight of the water column closes the check

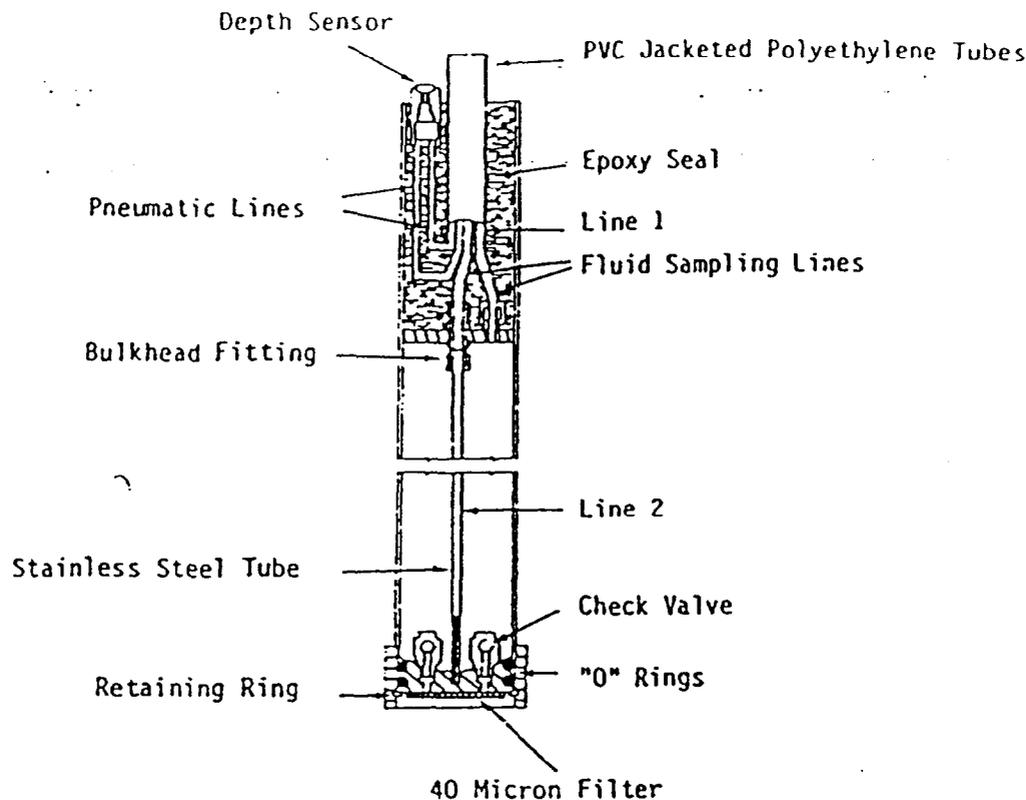
valve upon bailer retrieval. The specific gravity of the ball should be about 1.4 to 2.0 so that the ball almost sits on the check valve seat during chamber filling. Upon bailer withdrawal, the ball will immediately seat without any samples loss through the check valve. A similar technique involves lowering a sealed sample container within a weighted bottle into the well. The stopper is then pulled from the bottle via a line and the entire assembly is retrieved upon filling of the container (14, 16).

6.1.1.5 A double check valve bailer allows point source sampling at a specific depth (15, 17). An example is shown in Fig. 2. In this double check valve design, water flows through the sample chamber as the unit is lowered. A venturi tapered inlet and outlet ensures that water passes freely through the



NOTE—Taken from Ref (41).

FIG. 5 Pneumatic Water Sampler With Internal Transducer



NOTE—Taken from Ref (42).

FIG. 6 Pneumatic Sampler With Externally Mounted Transducer

unit. When a depth where the sample is to be collected is reached, the unit is retrieved. Because the difference between each ball and check valve seat is maintained by a pin that blocks vertical movement of the check ball, both check valves close simultaneously upon retrieval. A drainage pin is placed into the bottom of the bailer to drain the sample directly into a collection vessel to reduce the possibility of air oxidation. The acrylic model in Fig. 2 is threaded at the midsection allowing the addition of threaded casing to increase the sampling volume.

6.1.1.6 Another approach for obtaining point source samples employs a weighted messenger or pneumatic change to "trip" plugs at either end of an open tube (for example, tube water sampler or thief sampler) to close the chamber (18). Foerst, Kemmerer, and Bacon samplers are of this variety (14, 17, 19). A simple and inexpensive pneumatic sampler was recently described by Gillham (20). The device (Fig. 3) consists of a disposable 50 mL plastic syringe modified by sawing off the plunger and the finger grips. The syringe is then attached to a gas-line by means of a rubber stopper assembly. The gas-line extends to the surface, and is used to drive the stem-less plunger, and to raise and lower the syringe into the hole. When the gas-line is pressurized, the rubber plunger is held at the tip of the syringe. The sampler is then lowered into the installation, and when the desired depth is reached, the pressure in the gas-line is reduced to atmospheric (or slightly less) and water enters the syringe. The sampler is then retrieved from the installation and the syringe detached from the gas-line. After the tip is sealed, the syringe is used as a short-term storage container. A number

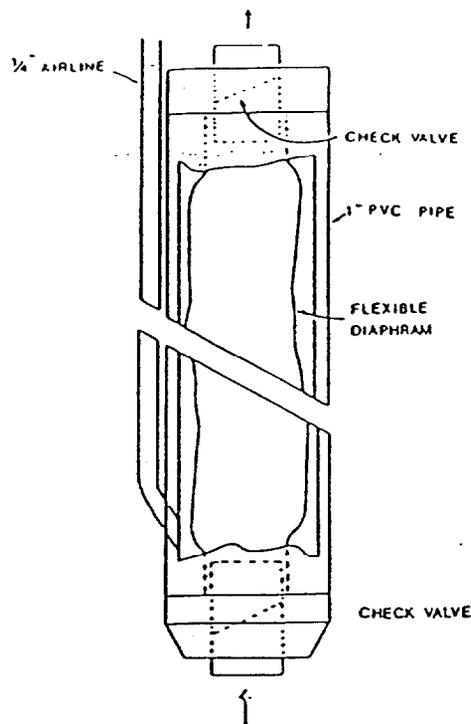
of thief or messenger devices are available in various materials and shapes.

6.1.2 Suction Lift Pumps:

6.1.2.1 Three types of suction lift pumps are the direct line, centrifugal, and peristaltic. A major disadvantage of any suction pump is that it is limited in its ability to raise water by the head available from atmospheric pressure. Thus, if the surface of the water is more than about 25 ft below the pump, water may not be withdrawn. The theoretical suction limit is about 34 ft, but most suction pumps are capable of maintaining a water lift of only 25 ft or less.

6.1.2.2 Many suction pumps draw the water through some sort of volute in which impellers, pistons, or other devices operate to induce a vacuum. Such pumps are probably unacceptable for most sampling purposes because they are usually constructed of common materials such as brass or mild steel and may expose samples to lubricants. They often induce very low pressures around rotating vanes or other such parts such that degassing or even cavitation may occur. They can mix air with the sample via small leaks in the casing, and they are difficult to adequately clean between uses. Such pumps are acceptable for purging of wells, but should not generally be used for sampling.

6.1.2.3 One exception to the above statements is a peristaltic pump. A peristaltic pump is a self-priming, low volume suction pump which consists of a rotor with ball bearing rollers (21). Flexible tubing is inserted around the pump rotor and squeezed by heads as they revolve in a circular pattern around the rotor. One end of the tubing is placed into the well while the other end can be connected



NOTE—Taken from Ref (4).

FIG. 7 Bladder Pump

directly to a receiving vessel. As the rotor moves, a reduced pressure is created in the well tubing and an increased pressure (<40 psi) on the tube leaving the rotor head. A drive shaft connected to the rotor head can be extended so that multiple rotor heads can be attached to a single drive shaft.

6.1.2.4 The peristaltic pump moves the liquid totally within the sample tube. No part of the pump contacts the liquid. The sample may still be degassed (cavitation is unlikely) but the problems due to contact with the pump mechanism are eliminated. Peristaltic pumps do require a fairly flexible section of tubing within the pumphead itself. A section of silicone tubing is commonly used within the peristaltic pumphead, but other types of tubing can be used particularly for the sections extending into the well or from the pump to the receiving container. The National Council of the Paper Industry for Air and Stream Improvement (22) recommends using medical grade silicone tubing for organic sampling purposes as the standard grade uses an organic vulcanizing agent which has been shown to leach into samples. Medical grade silicone tube is, however, limited to use over a restricted range of ambient temperatures. Various manufacturers offer tubing lined with TFE-fluorocarbon or Viton³ for use with their pumps. Gibb (1, 8) found little difference between samples withdrawn by a peristaltic pump and those taken by a bailer.

6.1.2.5 A direct method of collecting a sample by suction consists of lowering one end of a length of plastic tubing into the well or piezometer. The opposite end of the tubing is connected to a two way stopper bottle and a hand held or

mechanical vacuum pump is attached to a second tubing leaving the bottle. A check valve is attached between the two lines to maintain a constant vacuum control. A sample can then be drawn directly into the collection vessel without contacting the pump mechanism (5, 23, 24).

6.1.2.6 A centrifugal pump can be attached to a length of plastic tubing that is lowered into the well. A foot valve is usually attached to the end of the well tubing to assist in priming the tube. The maximum lift is about 4.6 m (15 ft) for such an arrangement (23, 25, 26).

6.1.2.7 Suction pump approaches offer a simple sample retrieval method for shallow monitoring. The direct line method is extremely portable though considerable oxidation and mixing may occur during collection. A centrifugal pump will agitate the sample to an even greater degree although pumping rates of 19 to 151 Lpm (5 to 40 gpm) can be attained. A peristaltic pump provides a lower sampling rate with less agitation than the other two pumps. The withdrawal rate of peristaltic pumps can be carefully regulated by adjustment of the rotor head revolution.

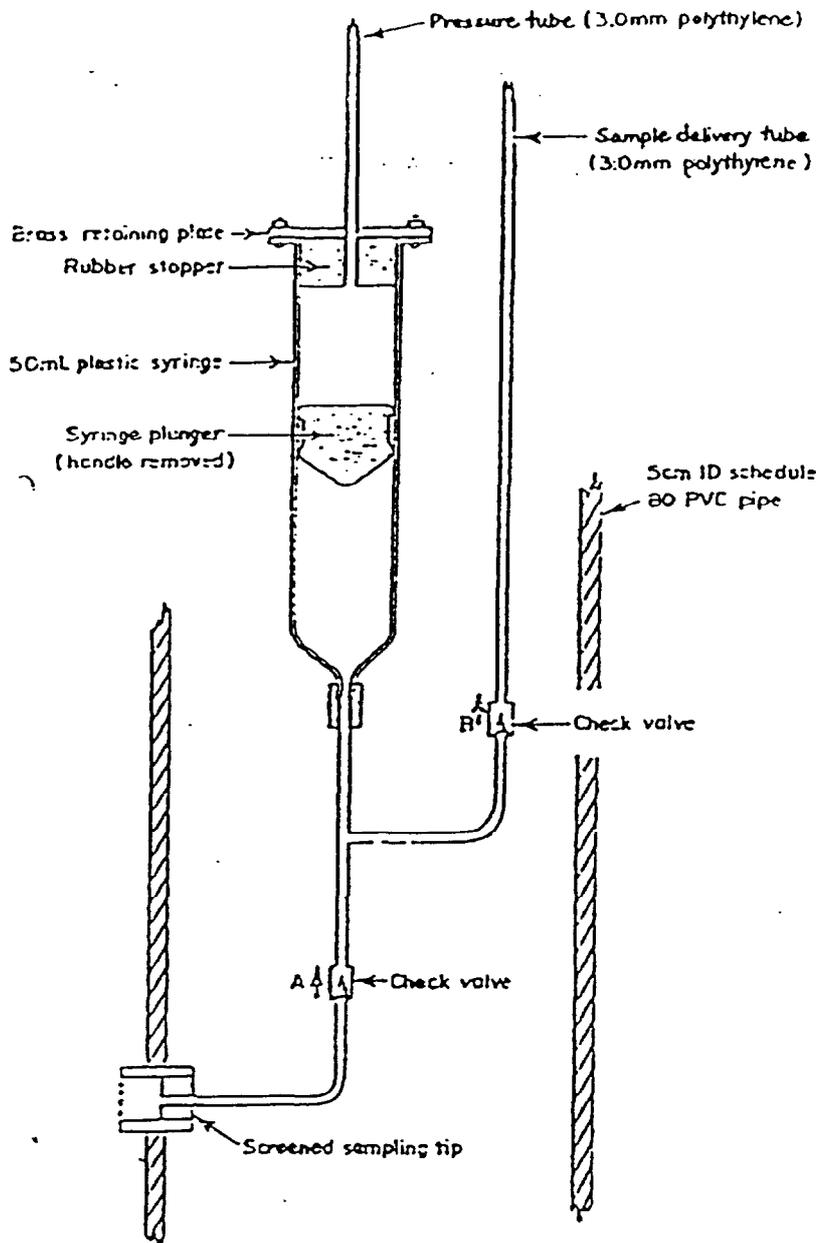
6.1.2.8 All three systems can be specially designed so that the water sample contacts only the TFE fluorocarbon or silicone tubing prior to sample bottle entry. Separate tubing is recommended for each well or piezometer sampled.

6.1.3 Electric Submersible Pumps:

6.1.3.1 A submersible pump consists of a sealed electric motor that powers a piston or helical single thread worm at a high rpm. Water is brought to the surface through an access tube. Such pumps have been used in the water well industry for years and many designs exist (5, 26).

6.1.3.2 Submersible pumps provide relatively high discharge rates for water withdrawal at depths beyond suction.

³ Viton is a trademark of E. I. du Pont de Nemours & Co., Wilmington, DE 19898 and has been found suitable for this purpose.



NOTE—Taken from Ref (48).

FIG. 8 Positive Displacement Syringe Pump

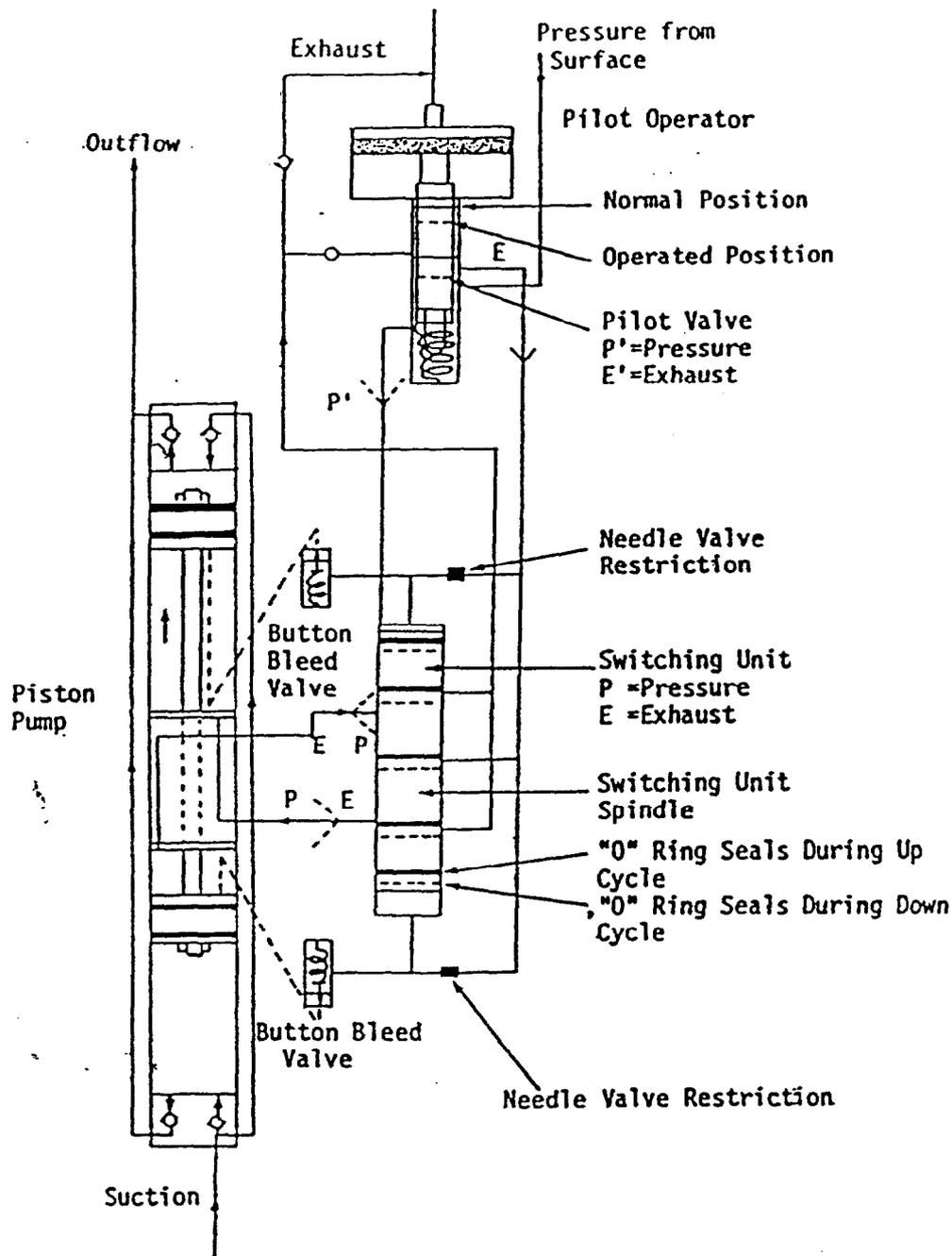
lift capabilities. A battery operated unit 3.6 cm (1.4 in.) in diameter and with a 4.5 Lpm (1.2 gpm) flow rate at 33.5 m (110 ft) has been developed (27). Another submersible pump has an outer diameter of 11.4 cm (4.5 in.) and can pump water from 91 m (300 ft). Pumping rates vary up to 53.0 Lpm (14 gpm) depending upon the depth of the pump (28).

6.1.3.3 A submersible pump provides higher extraction rates than many other methods. Considerable sample agitation results, however, in the well and in the collection tube during transport. The possibility of introducing trace metals into the sample from pump materials also exists. Steam cleaning of the unit followed by rinsing with unchlorinated, deionized water is suggested between sampling when analysis for organics in the parts per million (ppm) or parts per billion (ppb) range is required (29).

6.1.4 Gas-Lift Pumps:

6.1.4.1 Gas-lift pumps use compressed air to bring a water sample to the surface. Water is forced up an eductor pipe that may be the outer casing or a smaller diameter pipe inserted into the well annulus below the water level (30, 31).

6.1.4.2 A similar principle is used for a unit that consists of a small diameter plastic tube perforated in the lower end. This tube is placed within another tube of slightly larger diameter. Compressed air is injected into the inner tube; the air bubbles through the perforations, thereby lifting the water sample via the annulus between the outer and inner tubing (32). In practice, the eductor line should be submerged to a depth equal to 60 % of the total submerged eductor length during pumping (26). A 60 % ratio is considered optimal although a 30 % submergence ratio is adequate.



NOTE—Taken from Ref (49).

FIG. 9 Gas Driven Piston Pump

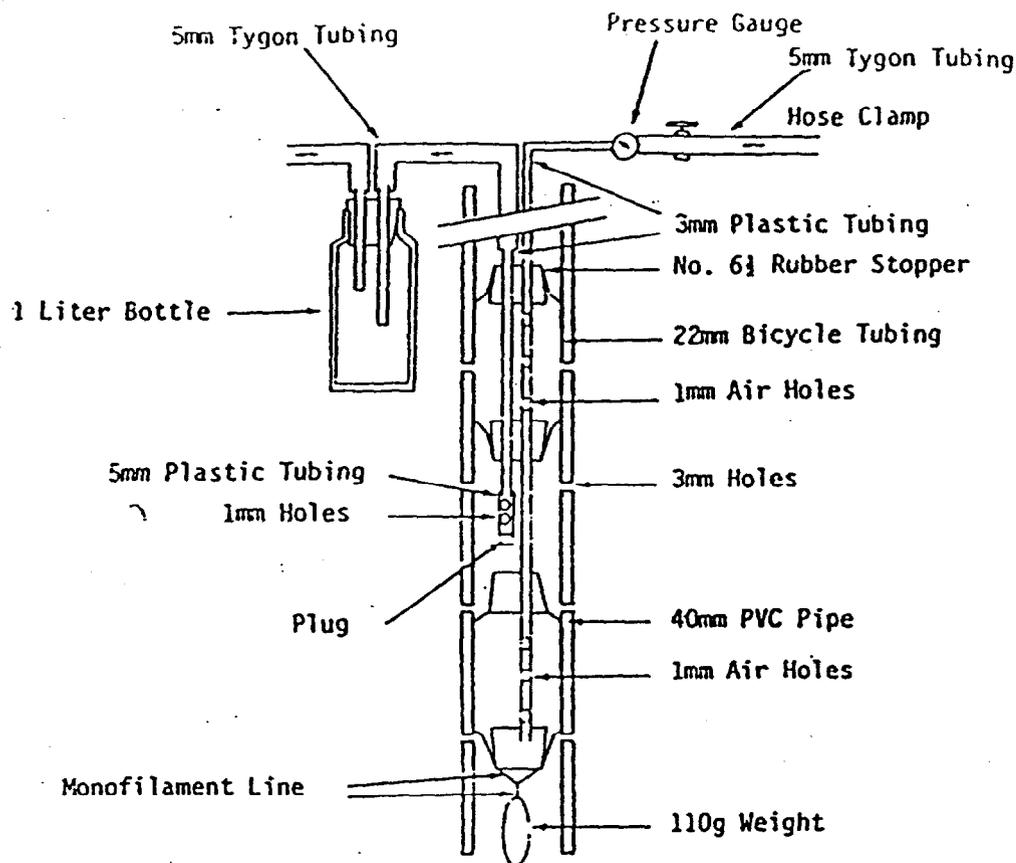
6.1.4.3 The source of compressed gas may be a hand pump for depths generally less than 7.6 m (25 ft). For greater depths, air compressors, pressurized air bottles, and air compressed from an automobile engine have been used.

6.1.4.4 As already mentioned, gas-lift methods result in considerable sample agitation and mixing within the well, and cannot be used for samples which will be tested for volatile organics. The eductor pipe or weighted plastic tubing is a potential source of sample contamination. In addition, Gibb (8) uncovered difficulties in sampling for inorganics. These difficulties were attributed to changes in redox, pH,

and species transformation due to solubility constant changes resulting from stripping, oxidation, and pressure changes.

6.1.5 Gas Displacement Pumps:

6.1.5.1 Gas displacement or gas drive pumps are distinguished from gas-lift pumps by the method of sample transport. Gas displacement pumps force a discrete column of water to the surface via mechanical lift without extensive mixing of the pressurized gas and water as occurs with air-lift equipment. The principle is shown schematically in Fig. 9. Water fills the chamber. A positive pressure is applied to



NOTE—Taken from Ref (53).

FIG. 10 Packer Pump Arrangement

gas line closing the sampler check valve and forcing water up the sample line. By removing the pressure the cycle can be repeated. Vacuum can also be used in conjunction with the gas (30). The device can be permanently installed in the well (33, 34, 35) or lowered into the well (36, 37).

6.1.5.2 A more complicated two stage design constructed of glass with check valves made of TFE-fluorocarbon has been constructed (38, 39). The unit was designed specifically for sample testing for trace level organics. Continuous flow rates up to 2.3 Lpm (0.6 gpm) are possible with a 5.1 cm (2 in.) diameter unit.

6.1.5.3 Gas displacement pumps have also been developed with multiple functions. The water sample in Fig. 5 provides piezometric data measurements with an internally mounted transducer (40). A sample with its transducer exposed externally for piezometric measurements is illustrated in Fig. 6 (41). The sensor can activate the gas source at the surface to cause sample chamber pressurization at the predetermined depth. Another design can be used as a water sampler or as a tool for injecting brine or other tracers into a well (42).

6.1.5.4 Gas displacement pumps offer reasonable potential for preserving sample integrity because little of the driving gas comes in contact with the sample as the sample is conveyed to the surface by a positive pressure. There is, however, a potential loss of dissolved gasses or contamination from the driving gas and the housing materials.

6.1.6 Bladder Pumps:

6.1.6.1 Bladder pumps, also referred to as gas-operated squeeze pumps, consist of a flexible membrane enclosed by a rigid housing. Water enters the membrane through a check valve in the vessel bottom; compressed gas injected into the cavity between the housing and bladder forces the sample through a check valve at the top of the membrane and into a discharge line (Fig. 7). Water is prevented from re-entering the bladder by the top check valve. The process is repeated to cycle the water to the surface. Samples taken from depths of 30.5 m (100 ft) have been reported.

6.1.6.2 A variety of design modifications and materials are available (43, 44). Bladder materials include neoprene, rubber, ethylene propylene terpolymer (E.P.T.), nitrile, and the fluorocarbon Viton.³ A bladder made of TFE-fluorocarbon is also under development (45). Automated sampling systems have been developed to control the time between pressurization cycles (46).

6.1.6.3 Bladder pumps provide an adaptable sampling tool due primarily to the number of bladder shapes that are feasible. These devices have a distinct advantage over gas displacement pumps in that there is no contact with the driving gas. Disadvantages include the large gas volumes required, low pumping rates, and potential contamination from many of the bladder materials, the rigid housing, or both.

6.1.7 Gas Driven Piston Pumps:

6.1.7.1 A simple and inexpensive example of a gas driven piston pump is a syringe pump (47). The pump (Fig. 8) is constructed from a 50 mL plastic syringe with plunger stem removed. The device is connected to a gas line to the surface and the sample passes through a check valve arrangement to a sampling container at the surface. By successively applying positive and negative pressure to the gas-line, the plunger is activated driving water to the surface.

6.1.7.2 A double piston pump powered by compressed air is illustrated in Fig. 9. Pressurized gas enters the chamber between the pistons; the alternating chamber pressurization activates the piston which allows water entry during the suction stroke of the piston and forces the sample to the surface during the pressure stroke (48). Pumping rates between 9.5 and 30.3 L/hr (2.5 to 8 gal/hr) have been reported from 30.5 m (100 ft). Depths in excess of 457 m (1500 ft) are possible.

6.1.7.3 The gas piston pump provides continuous sample withdrawal at depths greater than is possible with most other approaches. Nevertheless, contribution of trace elements from the stainless steel and brass is a potential problem and the quantity of gas used is significant.

6.1.8 Packer Pump Arrangement:

6.1.8.1 A packer pump arrangement provides a means by which two expandable "packers" isolate a sampling unit between two packers within a well. Since the hydraulic or pneumatic activated packers are wedged against the casing wall or screen, the sampling unit will obtain water samples only from the isolated well portion. The packers are deflated for vertical movement within the well and inflated when the desired depth is attained. Submersible, gas lift, and suction pumps can be used for sampling. The packers are usually constructed from some type of rubber or rubber compound (48, 49, 50, 51). A packer pump unit consisting of a vacuum sampler positioned between two packers is illustrated in Fig. 10 (52).

6.1.8.2 A packer assembly allows the isolation of discrete sampling points within a well. A number of different samplers can be situated between the packers depending upon the analytical specifications for sample testing. Vertical movement of water outside the well casing during sampling is possible with packer pumps but depends upon the pumping rate and subsequent disturbance. Deterioration of the expandable materials will occur with time with the increased possibility of undesirable organic contaminants contributing to the water sample.

7. Sample Containers and Preservation

7.1 Complete and unequivocal preservation of samples, whether domestic wastewater, industrial wastes, or natural waters, is practically impossible. At best, preservation techniques only retard the chemical and biological changes that inevitably continue after the sample is removed from the source. Therefore, insuring the timely analysis of a sample should be one of the foremost considerations in the sampling plan schedule. Methods of preservation are somewhat limited and are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce the volatility of constituents. Preservation methods are generally limited to pH control, chemical addition, refrigeration and freezing. For water samples, immediate

refrigeration just above freezing (4°C in wet ice) is often the best preservation technique available, but it is not the only measure nor is it applicable in all cases. There may be special cases where it might be prudent to include a recording thermometer in the sample shipment to verify the maximum and minimum temperature to which the samples were exposed. Inexpensive devices for this purpose are available.

7.2 All bottles and containers must be specially pre-cleaned, pre-labelled, and organized in ice-chests (isolating samples and sampling equipment from the environment) before one goes into the field. Otherwise, in any comprehensive program utter chaos usually develops in the field or laboratory. The time in the field is very valuable and should be spent on taking field notes, measurements, and in documenting samples, not on labelling and organizing samples. Therefore, the sampling plan should include clear instructions to the sampling personnel concerning the information required in the field data record logbook (notebook), the information needed on container labels for identification, the chain-of-custody protocols, and the methods for preparing field blanks and spiked samples. Example of detailed plans and documentation procedures have been published (14, 53).

7.3 The exact requirements for the volumes of sample needed and the number of containers to use may vary from laboratory to laboratory. This will depend on the specific analyses to be performed, the concentration levels of interest, and the individual laboratory protocols. The manager of the sampling program should make no assumptions about the laboratory analyses. He should discuss the analytical requirements of the sampling program in detail with the laboratory coordinator beforehand. This is especially the case since some analyses and preservation measures must be performed at the laboratory as soon as possible after the samples arrive. Thus, appropriate arrangements must be made.

7.4 There are a number of excellent references available which list the containers and preservation techniques appropriate for water and soils (13, 14, 50, 54, 55, 56). The "Handbook for Sampling and Sample Preservation of Water and Wastewater" is an excellent reference and perhaps the most comprehensive one (14). Some of this information is summarized in Table 1.

7.5 Sample containers for trace organic samples require special cleaning and handling considerations (57). The sample container for purgeable organics consist of a screw-cap vial (25 to 125 mL) fitted with a TFE-fluorocarbon faced silicone septum. The vial is sealed in the laboratory immediately after cleaning and is only opened in the field just prior to pouring sample into it. The water sample then must be sealed into the vial headspace free (no air bubbles) and immediately cooled (4°C) for shipment. Multiple samples (usually about four taken from one large sample container) are taken because leakage of containers may cause losses, may allow air to enter the containers, and may cause erroneous analysis of some constituents. Also, some analyses are best conducted on independent protected samples.

7.6 The purgeable samples must be analyzed by the laboratory within 14 days after collection, unless they are to be analyzed for acrolein or acrylonitrile (in which case they are to be analyzed within 3 days). For samples for solvent extractions (extractable organics-base neutrals, acids

pesticides), the sample bottles are narrow mouth, screw cap quart bottles or half-gallon bottles that have been pre-cleaned, rinsed with the extracting organic solvent and oven dried at 105°C for at least 1 h. These bottles must be sealed with TFE-fluorocarbon lined caps (Note). Samples for organic extraction must be extracted within 7 days and analyzed within 30 days after extraction. Special pre-cleaned, solvent rinsed and oven-dried stainless steel beakers (one for each monitoring well) may be used for transferring samples from the sampling device to the sample containers.

NOTE—When collecting samples, the bottles should not be overfilled or prerinse with sample before filling because oil and other materials may remain in the bottle. This can cause erroneously high results.

7.7 For a number of groundwater parameters, the most meaningful measurements are those made in the field at the time of sample collection or at least at an on-site laboratory. These include the water level in the well and parameters that sometimes can change rapidly with storage. A discussion of the various techniques for measuring the water level in the well is contained in a NCASI publication (5) and detailed procedures are outlined in a U.S. Geological Survey publication (58). Although a discussion of these techniques is beyond the scope of this guide, it is important to point out that accurate measurements must be made before a well is flushed or only after it has had sufficient time to recover. Parameters that can change rapidly with storage include specific conductance, pH, turbidity, redox potential, dissolved oxygen, and temperature. For some of the other

parameters, the emphasis in groundwater monitoring is on the concentration of each specific dissolved component, not the total concentration of each. Samples for these types of measurements should be filtered through 0.45 µm membrane filters ideally in the field or possibly at an on-site laboratory as soon as possible. Analyses often requiring filtered samples include all metals, radioactivity parameters, total organic carbon, dissolved orthophosphate (if needed), and total dissolved phosphorous (if needed) (13, 14). If metals are to be analyzed, filter the sample prior to acid preservation. For TOC organics, the filter material should be tested to assure that it does not contribute to the TOC. The type or size of the filter to be used is not well understood. However, if results of metal, TOC or other parameters that could be effected by solids are to be compared, the same filtering procedure must be used in each case. Repeated analytical results should state whether the samples were filtered and how they were filtered.

7.8 Shipment and receipt of samples must be coordinated with the laboratory to minimize time in transit. All samples for organic analysis (and many other parameters), should arrive at the laboratory within one day after it is shipped and be maintained at about 4°C with wet ice. The best way to get them to the laboratory in good condition is to send them in sturdy insulated ice chests (coolers) equipped with bottle dividers. 24-h courier service is recommended, if personal delivery service is not practical.

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APPENDIX D
DECONTAMINATION OF SAMPLING
AND MONITORING EQUIPMENT

**DECONTAMINATION OF SAMPLING AND
MONITORING EQUIPMENT**

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DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

1.0 PURPOSE

The purpose of this SOP is to provide a general methodology and protocol, and to reference information for the proper decontamination of field chemical sampling and analytical equipment.

2.0 SCOPE

This procedure applies to all field sampling equipment including, but not limited to, split-barrel soil samplers (split-spoons), bailers, beakers, trowels, filtering apparatus, and pumps. This procedure should be consulted when decontamination procedures are being developed as part of project-specific plans. Additionally, current USEPA regional procedures and decontamination guidance as well as state guidance should be reviewed.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring field personnel performing decontamination activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURES

In order to ensure that chemical analysis results reflect actual concentrations present at sampling locations, sampling equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sampling locations) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sampling locations and the transfer of contamination off site.

Preferably, sampling equipment should be dedicated to a given sampling location. If this is not possible, equipment must be decontaminated between sampling locations. Sampling personnel also must use disposable gloves and change them between sampling locations.

5.1 Sampling Equipment Decontamination Procedures

Soil and sediment sampling equipment including, but not limited to trowels, beakers, dredges, etc., shall be decontaminated using the following USEPA Region procedures.

The following sections summarize decontamination procedures for USEPA Regions I through IV for overall comparison. Each region should be contacted prior to initiation of sampling activities to assure that the most recent, accepted decontamination procedures are used.

USEPA Region I

Prior to use, all sampling equipment should be carefully cleaned using the following procedure:

1. A dilute hydrochloric acid rinse
2. Deionized water rinse
3. Methanol or acetone rinse; and,
4. Distilled, organic-free water rinse.

For badly contaminated equipment, a hot water detergent wash may be needed prior to the rinse procedure. Additionally, a hexane rinse also may be needed, prior to the final distilled water rinse, when sampling for low-level organic pollutants.

USEPA Region II

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Low-phosphate detergent wash (i.e., Alconox or Liquinox)
2. Tap water rinse
3. 10 percent nitric acid solution rinse
4. Tap water rinse
5. Methanol followed by a hexane or an acetone rinse
6. Analyte-free deionized water rinse
7. Air dry
8. Wrap in aluminum foil, shiny side out, for storage or transport

If the samples will not be analyzed for metals, then steps 3 and 4 may be omitted; if samples will not be analyzed for organics, then step 5 may be omitted. All solvents must be pesticide-grade.

USEPA Region III

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Potable water rinse
2. Alconox or Liquinox detergent wash
3. Scrubbing, as necessary
4. Potable water rinse
5. 10 percent nitric acid rinse
6. Distilled-deionized water rinse
7. Methanol or hexane rinse
8. Distilled-deionized water rinse
9. Air dry

USEPA Region IV

Prior to use, all sampling equipment will be decontaminated using the following procedures:

1. Clean with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.
 2. Rinse thoroughly with tap water.
 3. Rinse thoroughly with deionized water.
 4. Rinse twice with pesticide grade isopropanol.
 5. Rinse thoroughly with organic-free water and allow to air dry as long as possible.
 6. If organic-free water is not available, allow equipment to air dry as long as possible. Do not rinse with deionized or distilled water.
 7. Wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported.
- * Portable power augers (such as the Little Beaver®) or large soil boring/drill rigs should be cleaned before boring or drilling operations.

5.2 Field Analytical Equipment Decontamination

Field analytical equipment which may come in direct contact with the sample or sample media, including, but not limited to water level meters, water/product level meters, pH or specific ion probes, specific conductivity probes, thermometers, and/or borehole geophysical probes must be decontaminated before and after use, according to the procedures outlined in Section 5.1, unless manufacturers instructions indicate otherwise. Probes that contact water samples not used for laboratory analyses may be rinsed with distilled water. Probes which make no direct contact (e.g. HNu or OVA probes) will be wiped clean with clean paper towels or an alcohol-saturated cloth.

6.0 QUALITY ASSURANCE RECORDS

Decontamination procedures are monitored through the collection of equipment rinsate samples and field blanks. Collection of these samples shall be specified in the project-specific Sampling and Analysis and Quality Assurance Plans following the requirements of NEESA 20.2-047B. Documentation recorded in the field logbook also shall serve as a quality assurance record.

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7.0 REFERENCES

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APPENDIX E
DECONTAMINATION OF DRILL RIGS AND
MONITORING WELL MATERIALS

**DECONTAMINATION OF DRILLING RIGS
AND MONITORING WELL MATERIALS**

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6.0	QUALITY ASSURANCE RECORDS
7.0	REFERENCES

DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

1.0 PURPOSE

The purpose of this SOP is to provide a general reference regarding the proper decontamination of drilling rigs and monitoring well materials used in the performance of field investigations.

2.0 SCOPE

This procedure addresses drilling equipment, test pit equipment (i.e. backhoe) and monitoring well material decontamination and should be consulted during the preparation of project-specific plans. This procedure does not pertain to personnel decontamination, or to chemical sampling or field analytical equipment decontamination.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Drilling Inspector (Site Geologist, Rig Geologist etc.) - It is the responsibility of the drilling inspector to ensure that the drilling subcontractor follows these, or other project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURE

The various drilling equipment and materials involved with test boring, test pit excavation, subsurface soil sampling, and monitoring well construction must be properly decontaminated to ensure that chemical analysis results reflect actual concentrations present at sampling locations. These procedures will minimize the potential for cross contamination between sampling locations and the transfer of contamination off site.

5.1 Equipment

All drilling equipment involved in field sampling activities shall be decontaminated prior to drilling, excavation, or sampling activities. Such equipment includes drilling rigs, backhoes, augers, downhole tools, well casings, and screens. Split-spoon soil samplers and other similar soil sampling devices shall be decontaminated according to the procedures given in SOP F502.

5.2 Decontamination Procedures

Prior to drilling, or leaving the site, large equipment not directly utilized for sampling will be decontaminated by steam-cleaning in a designated area. The decontamination procedure consists of steam-cleaning the equipment, using potable water as the steam source, to remove visible signs of soils or wastes, and allowing the equipment to air dry. If necessary, the equipment may be cleaned with a scrub brush andalconox/liquinox-water solution prior to steam cleaning to remove visible signs of contamination.

The steam cleaning area will be designed to contain decontamination wastes and waste waters, and can be a lined, excavated pit or a bermed concrete or asphalt pad. For the latter, a floor-drain must be provided which is connected to a holding tank. A shallow, above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist

about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning area on site to minimize potential impacts.
- Enclose steam cleaning operations. For example, augers and drilling rods can be steam cleaned in drums. Tarpaulins also can be placed around the steam cleaning area to control emissions.

For a given project, the location of the steam cleaning area will be identified in the Sampling and Analysis Plan.

Decontamination wastes will be collected and contained unless otherwise directed by LANTDIV. The eventual disposition of these wastes will be determined on a project-specific basis, but may include on-site treatment and/or transport off site to an approved treatment/disposal facility.

6.0 QUALITY ASSURANCE RECORDS

Rinsate samples may be collected from steam-cleaned equipment as quality assurance records. The frequency of rinsate samples from either drilling tools or well casings/screens shall be specified in the Sampling and Analysis and Quality Assurance Project Plans for a given project, as appropriate. Documentation in the field logbook also shall serve as a quality assurance record of decontamination activities.

7.0 REFERENCES

None.

APPENDIX F
ON-SITE WATER QUALITY TESTING

**ON-SITE WATER QUALITY TESTING
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 - 5.2 Measurement of Specific Conductance/Salinity
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- 6.0 QUALITY ASSURANCE RECORDS**
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ON-SITE WATER QUALITY TESTING (FIELD PARAMETERS)

1.0 PURPOSE

This SOP describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance (Sc)/Salinity
- Temperature (T)
- Dissolved Oxygen Concentration (DO)
- Turbidity (Secchi Disc)

The first three are the usual field parameters; dissolved oxygen may be used in particular applications according to project requirements.

2.0 SCOPE

These procedures are applicable for use in an on-site water quality monitoring program to be conducted during a Remedial Investigation or Site Investigation at a hazardous or nonhazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

3.0 DEFINITIONS

Conductance - A measurement of water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in the water. The units of measurement for conductance (mhos) are the inverse of ohms, the unit commonly used to express resistance. Conductivity and specific conductance are used synonymously.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration. The range of pH is 0 to 14 standard units.

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's Law, $E = IR$, where E is the potential difference (in units of volts), I is the current (in units of Amperes), and R is the resistance (in units of ohms).

Secchi disc - A metal disc having four quadrants, two opposing ones painted black and the other two either white or unpainted. The Secchi disc is used to measure turbidity based on the depth of light penetration.

Turbidity - An optical property of water that causes light to be scattered or absorbed in the water, resulting in decrease in water transparency. It is a function of at least three variables: 1) dissolved chemicals, such as tannins, acids, or salts; 2) suspended particles, such as silt, clay, and organic matter; and, 3) density of microbial and planktonic life.

Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for determining which on-site water quality measurements shall be made, the data quality objectives (DQOs) for these measurements, and for ensuring that these measurements are made in accordance with project-specific plans.

Field Team Leader - The Field Team Leader is responsible for determining that these water quality measurement procedures are implemented in the field in accordance with this SOP, or in accordance with project-specific plans, and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures for collecting on-site water quality measurements including instrument calibration, quality control and recording of results, as well as care and maintenance of the instruments in the field.

5.0 PROCEDURES

The following sections provide general procedures for collecting pH, specific conductance/salinity, temperature, dissolved oxygen concentration and turbidity measurements.

5.1 Measurement of pH

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment, such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH also can be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis; specific measurement techniques for solids are not described here.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required; the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In most cases, use of a pH meter will be required.

5.1.1 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on the establishment of a potential difference across a glass or other type of membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

5.1.2 Equipment

The following equipment and reagents are needed for taking pH measurements:

- Portable pH meter, or pH indicator paper, such as Mydrion or Alkacid, to cover the pH range 2 through 12.

- Laboratory-prepared buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.3 Measurement Techniques for Field Determination of pH

A. pH Meter

Standardization, calibration, and operation and maintenance shall be performed according to the manufacturers instructions. The following procedure is used for measuring pH with a pH meter:

1. The batteries and instrument shall be checked and calibrated prior to initiation of the field effort.
2. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.
3. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.
4. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
5. Immerse the electrode(s) in a pH-7 buffer solution.
6. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). It is best to maintain the buffer solution at or near expected sample temperature before calibration, if possible.
7. Adjust the pH meter to read 7.0.

8. Remove the electrode(s) from the buffer and rinse well with distilled-deionized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.
9. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
10. After adjusting the temperature compensator to the sample temperature, read and record the pH of the solution. The pH value shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature. All measurements shall be recorded in the Field Logbook.
11. Upon completion of measurement and removal of the electrode from the sample, the electrode shall be thoroughly rinsed with deionized water.
12. The electrode(s) shall remain immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution within the electrode, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted in the Field Logbook.

B. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, or 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

5.2 Measurement of Specific Conductance/Salinity

Conductance provides a measure of dissolved ionic species in water and can be used to suggest the direction and extent of migration of contaminants in groundwater or surface water. Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants. One basic measure of salinity is the ability of water to conduct electric current, and, therefore, a measurement of specific conductance provides a measurement of salinity and the same instrument can be used. Salinity measurements are important in ecological field investigations because flora and fauna can be limited in their distribution based on the salinity of the sampled waters.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance and salinity measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.2.1 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions (cations) migrate toward the negative electrode (cathode), while the negatively charged ions (anions) migrate toward the positive electrode (anode). Most

inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell also may be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.2.2 Equipment

A portable conductivity meter, probe and thermometer are needed for taking specific conductance and salinity measurements. A variety of conductivity meters are available which also may be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirements of the sampling program.

5.2.3 Measurement Techniques for Specific Conductance/Salinity

Standardization, calibration, and operation and maintenance shall be performed according to manufacturers instructions. The steps involved in taking specific conductance and salinity measurements are listed below.

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Calibration information shall be recorded in the field logbook.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water.

4. Immerse the electrode in the sample and measure the conductivity and salinity. If specified, adjust the temperature setting to the sample temperature.
5. Read and record the results on the Calibration Form (in the absence of the Calibration Form, the Field Logbook will be used).
6. If the meter does not compensate for temperature variations, the corrections given in Attachment A shall be applied.
7. On some meters, specific conductivity and salinity measurements may need to be reported with the associated temperature measurement. If the conductivity and salinity has been corrected, the measurements shall be reported as "corrected to 25°C." (See Attachment A)
 - a. Do not take readings if the sample temperature is less than 10° C, because the calibration curve no longer follows a straight line below this temperature. If necessary, heat the sample in your vehicle to at least 10° C.
 - b. Measure the sample temperature to the nearest 0.1° C to comply with SW-846.
 - c. Only report results to the nearest two significant digits for the most circumstances, because of the inherent inaccuracy in the test and conversion procedure.

examples:

- a calculated reading of 2353 umhos/cm @ 25° C should be reported as 2400 umhos/cm @ 25° C
- a calculated reading of 2325 should be reported as 2300
- a calculated reading of 337 should be reported as 340
- etc.

5.3 Measurement of Temperature

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of

contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field prior to sample collection. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.1 Equipment

Temperature measurements may be taken with Thermistor, alcohol-toluene, mercury or bimetal thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature can be performed.

5.3.2 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a Field Logbook to the nearest 0.5 or 0.1°C, depending on the measurement device used.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to the manufacturer's recommendations with an approved thermometer.

5.4 Measurement of Dissolved Oxygen Concentration

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms, as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time, if the sample is not adequately preserved.

The method discussed here is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible. DO meters also are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.1 Principles of Equipment Operation

Dissolved oxygen probes normally are electrochemical cells that have two solid metal electrodes of different potential immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of higher nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not easily depolarized from the indicating electrode. If gaseous interference is suspected, it shall be noted in the Field Logbook and checked if possible. Temperature variations also can cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation normally is provided by the manufacturer. Attachment B presents variations of DO in water as a function of temperature and salinity.

5.4.2 Equipment

The following, similar or equivalent, equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor (or equivalent).
- Dissolved oxygen/temperature probe.
- Sufficient cable to allow the probe to contact the sample.

5.4.3 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration.

1. Calibrate equipment and check batteries in the laboratory before going to the field.
2. The probe shall be conditioned in a water sample for as long as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).
4. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers which are placed in wells should be moved up and down.
5. Record the dissolved oxygen content and temperature of the sample in a Field Logbook.

6. Recalibrate the probe when the membrane is replaced, or following similar maintenance, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This, however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or whether a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen dissolution and positive test interferences.

5.5 Measurement of Turbidity Using a Secchi Disc

In combination with other parameters, turbidity can be a useful indicator of the likelihood of biological action in a water body. It can be used to determine the depth of light penetration of surface water and the distribution and intensity of photosynthesis in the body of water. Turbidity measurements shall be taken in-situ with a Secchi disc.

5.5.1 Equipment

Turbidity measurements may be taken with a Secchi disc. In addition, turbidity may be measured using a colimeter or a spectrophotometer. These are ex-situ measurements conducted in a laboratory environment.

5.5.2 Measurement Techniques for Turbidity

Observations must be made through a shaded area of water surface.

- Standard conditions for the use of the Secchi disc are: 1) clear sky; (2) sun directly overhead; 3) shaded, protected side of boat or under a sun shade; 4) minimal waves or ripples; and, 5) any departure from these conditions should be specifically stated on field sheets.
- Rope accurately graduated in meters with 0.1 meter graduations for the first meter and 0.5 meters thereafter.

- Observer's eye should be 1 meter above the surface of the water.
- Observations should be made during the middle of the day.
- Lower the disc into the water, noting the depth at which it disappears, then lift the disc and note the depth at which it reappears. The average of the two readings is considered to be the limit of visibility and is recorded in a Field Logbook to the nearest 0.1 meter (first meter) or 0.5 meter, depending on the depth of visibility.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records for on-site water quality management consists principally of observations and measurements recorded in the Field Logbook. Records of instrument calibration, malfunction, repair, etc., shall be maintained in an Equipment Logbook as described in the Navy CLEAN Contractor Quality Control Plan.

7.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

ATTACHMENT A

SPECIFIC CONDUCTANCE CONVERSION TABLE

**ATTACHMENT A
SPECIFIC CONDUCTANCE CONVERSION TABLE**

Temperature Degrees C	Calculated Multiplier								
10	1.402	12	1.330	14	1.266	16	1.208	20	1.106
10.1	1.398	12.1	1.327	14.1	1.263	16.1	1.205	20.1	1.103
10.2	1.394	12.2	1.324	14.2	1.260	16.2	1.202	20.2	1.101
10.3	1.390	12.3	1.320	14.3	1.257	16.3	1.199	20.3	1.099
10.4	1.387	12.4	1.317	14.4	1.254	16.4	1.197	20.4	1.096
10.5	1.383	12.5	1.314	14.5	1.251	16.5	1.194	20.5	1.094
10.6	1.379	12.6	1.310	14.6	1.248	16.6	1.191	20.6	1.092
10.7	1.376	12.7	1.307	14.7	1.245	16.7	1.188	20.7	1.089
10.8	1.372	12.8	1.304	14.8	1.242	16.8	1.186	20.8	1.087
10.9	1.369	12.9	1.301	14.9	1.239	16.9	1.183	20.9	1.085
11	1.365	13	1.297	15	1.236	17	1.180	21	1.083
11.1	1.361	13.1	1.294	15.1	1.233	17.1	1.178	21.1	1.080
11.2	1.358	13.2	1.291	15.2	1.230	17.2	1.175	21.2	1.078
11.3	1.354	13.3	1.288	15.3	1.227	17.3	1.172	21.3	1.076
11.4	1.351	13.4	1.285	15.4	1.225	17.4	1.170	21.4	1.074
11.5	1.347	13.5	1.281	15.5	1.222	17.5	1.167	21.5	1.072
11.6	1.344	13.6	1.278	15.6	1.219	17.6	1.165	21.6	1.069
11.7	1.341	13.7	1.275	15.7	1.216	17.7	1.162	21.7	1.067
11.8	1.337	13.8	1.272	15.8	1.213	17.8	1.159	21.8	1.065
11.9	1.334	13.9	1.269	15.9	1.210	17.9	1.157	21.9	1.063

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals $1/(1 + 0.0191(t-25))$.
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

ATTACHMENT A (Continued)
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier								
22	1.061	24	1.019	26	0.981	28	0.946	30	0.913
22.1	1.059	24.1	1.017	26.1	0.979	28.1	0.944	30.1	0.911
22.2	1.057	24.2	1.016	26.2	0.978	28.2	0.942	30.2	0.910
22.3	1.054	24.3	1.014	26.3	0.976	28.3	0.941	30.3	0.908
22.4	1.052	24.4	1.012	26.4	0.974	28.4	0.939	30.4	0.907
22.5	1.050	24.5	1.010	26.5	0.972	28.5	0.937	30.5	0.905
22.6	1.048	24.6	1.008	26.6	0.970	28.6	0.936	30.6	0.903
22.7	1.046	24.7	1.006	26.7	0.969	28.7	0.934	30.7	0.902
22.8	1.044	24.8	1.004	26.8	0.967	28.8	0.932	30.8	0.900
22.9	1.042	24.9	1.002	26.9	0.965	28.9	0.931	30.9	0.899
23	1.040	25	1.000	27	0.963	29	0.929	31	0.897
23.1	1.038	25.1	0.998	27.1	0.961	29.1	0.927	31.1	0.896
23.2	1.036	25.2	0.996	27.2	0.960	29.2	0.926	31.2	0.894
23.3	1.034	25.3	0.994	27.3	0.958	29.3	0.924	31.3	0.893
23.4	1.032	25.4	0.992	27.4	0.956	29.4	0.922	31.4	0.891
23.5	1.029	25.5	0.991	27.5	0.954	29.5	0.921	31.5	0.890
23.6	1.027	25.6	0.989	27.6	0.953	29.6	0.919	31.6	0.888
23.7	1.025	25.7	0.987	27.7	0.951	29.7	0.918	31.7	0.887
23.8	1.023	25.8	0.985	27.8	0.949	29.8	0.916	31.8	0.885
23.9	1.021	25.9	0.983	27.9	0.948	29.9	0.914	31.9	0.884

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals $1/(1 + 0.0191[t-25])$.
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

ATTACHMENT B

**VARIATION OF DISSOLVED OXYGEN CONCENTRATION
IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY**

ATTACHMENT B

**VARIATION OF DISSOLVED OXYGEN CONCENTRATION
IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY**

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/ 100 mg chloride
	0	5,000	10,000	15,000	20,000	
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.106
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

ATTACHMENT B
(Continued)
VARIATION OF DISSOLVED OXYGEN CONCENTRATION
IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	Dissolved Oxygen mg/l					
	Chloride Concentration in Water					Difference/ 100 mg chloride
	0	5,000	10,000	15,000	20,000	
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore used to correct measured D.O. concentration) using Attachment A.

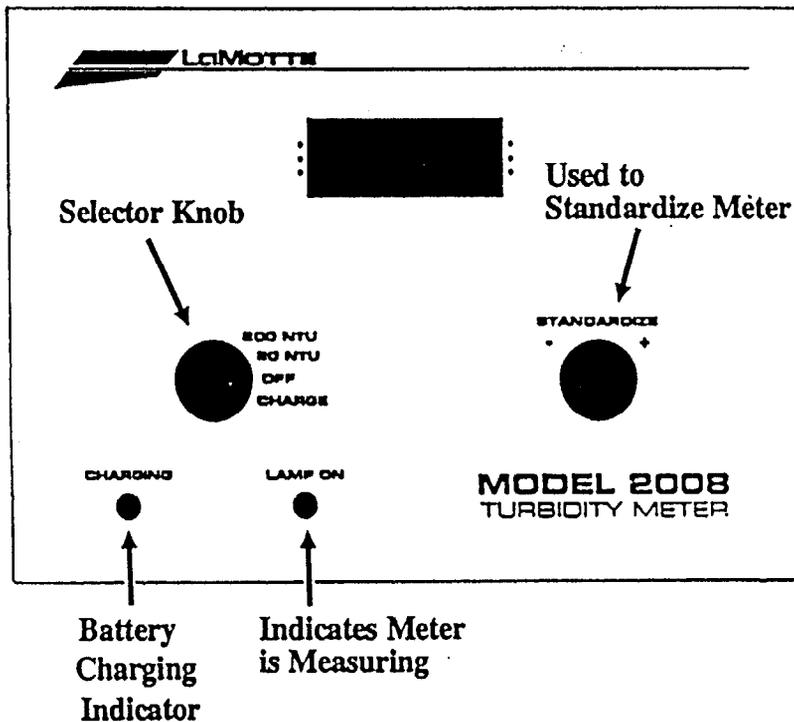
ATTACHMENT C
OPERATION MANUAL FOR LaMOTTE
MODEL 2008 TURBIDITY METER

LaMOTTE

**TURBIDITY MANUAL
MODEL 2008**



LaMOTTE COMPANY
HELPING PEOPLE SOLVE ANALYTICAL CHALLENGESSM
PO BOX 329 • CHESTERTOWN • MARYLAND • 21620
800-344-3100 • 410-778-3100 (in MD)



The Model 2008 portable turbidimeter is acceptable for turbidity measurements reportable under either the National Primary Drinking Water Regulations (NPDWR) or the EPA's Surface Water Treatment compliance monitoring program. This instrument is suitable for testing municipal waters, food and beverage processing waters, and any aqueous solutions in which control of clarity is critical. The unit may be operated from line power via an AC adapter or from self-contained rechargeable batteries.

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SPECIFICATIONS & ACCESSORIES

RANGE	0-19.99 NTU 0-199.9 NTU
ACCURACY	± 2% of reading or 0.05 NTU, whichever is greater, referenced to LaMotte AMCO® standards
DISPLAY	0.5" LCD
WARM-UP TIME	<2 seconds
PHOTODETECTOR	Silicon photodiode, aligned 90° to the incident light path
LAMP	Tungsten, lens-end long life, operated at a color temperature of 2230° K
SAMPLE	Distance traversed by incident light and scattered light within tube is 2.5 cm
LAMP LIFE	45,000 hours
RANGE SELECTOR	4-position: Charge only, Off, 0-20 NTU, 0-200 NTU
POWER SOURCE	Ni-Cad rechargeable batteries, not user replaceable
SIZE	19 cm x 7 cm x 14 cm 7.5" x 2¾" x 5⅜"
WEIGHT	1.1 Kg 2.4 lbs.

REPLACEMENT PARTS & ACCESSORIES

5115PT-J	Deionized Water, 100 mL
1793	AMCO® Turbidity Standard, 0.5 NTU
1794	AMCO® Turbidity Standard, 5.0 NTU
1795	AMCO® Turbidity Standard, 20.0 NTU
1796	AMCO® Turbidity Standard, 60.0 NTU
1797	AMCO® Turbidity Standard, 100.0 NTU
1798	AMCO® Turbidity Standard, 40.0 NTU
1744	AC Adapter, 9 Volt
0273	Turbidity tubes, set of 6
0943	Syringe
0598	Filter holder
1103-6	Member filters, 0.45 micron, pkg of 6

CALIBRATING

The Model 2008 has been calibrated at the factory using a primary standard manufactured by Advanced Polymer Systems, Inc., which is a suspension of uniformly sized plastic "microspheres." These AMCO® standards require no preparation, and are stable for longer periods of time than formazin. However, with proper preparation techniques, formazin standards should be equivalent to the AMCO® standards, and can be used as primary standards for meter calibration. For proper procedures, consult the current edition of *Standard Methods for the Examination of Water and Wastewater*.

AMCO® TURBIDITY STANDARDS

Two AMCO® turbidity standards are supplied with the Model 2008; additional standards are available from LaMotte Company. Only use LaMotte AMCO® standards with the Model 2008. These standards are manufactured exclusively for LaMotte and are guaranteed to be accurate to within ± 1%, if the following procedures are observed:

1. Once the seal on the bottle is broken, the standard is good for 9 months, and must be stored between 10° and 40° C. The standards are good indefinitely prior to opening if stored under the same conditions.
2. Never put any unused standard or other possible contaminant into the bottle.
3. Do not open the standards in a dusty environment, and guard against dust and other contaminants entering the bottle while opened.
4. Rinse sample tube with standard before filling with standard to be used.
5. Cap the sample tube and standard bottle immediately after filling tube with standard.

WHAT IS IT?

Water and other liquids vary widely in their color and clarity. Some liquids, such as bottled water, are clear, while others, such as heavily polluted industrial waste, are murky and cloudy. This murkiness is called turbidity.

Turbidity is caused by fine particles suspended in the water which cause light to scatter rather than traveling in a straight line through the water. Clay, silt, plankton and other microorganisms are all examples of particulate which cause turbidity.

Many of the causes of turbidity are not necessarily harmful to human health, but turbidity can be a sign of another, more serious problem. For instance, cloudy pool water may not be dangerous to the swimmer, but it could indicate the presence of excess carbonates, which may damage the pool itself. Generally, as the pollutant level of water increases, the turbidity increases. The EPA's Surface Water Treatment requirements state that finished water has turbidity levels below 1 NTU.

Over time, turbidity measurements can be used to determine if the pollution level of a lake or other water body has changed. Biologists and others monitoring the health of a specific lake will track the turbidity level over time to see if runoff from construction, agriculture, or other man-made changes is polluting the water.

HOW IS IT MEASURED?

Turbidity can be measured in many ways. Traditionally, the Jackson Candle method was used to measure turbidity, and results were expressed as Jackson Turbidity Units (JTU). In lakes and other deep waters, a Secchi Disk is commonly used to measure the turbidity. However, neither of these methods can accurately measure low turbidities, such as those encountered at a wastewater plant, so a turbidimeter must be used.

One type of turbidimeter is the nephelometer, which determines the turbidity level by measuring the amount of light scattered 90° by the suspended particles. A light of known strength is beamed through the solution, where particles will cause the light to scatter. The intensity of this scattered light is measured by sensors located on the sides of the chamber. The meter converts these measurements to a reading, which is displayed. Nephelometers give readings in Nephelometric Turbidity Units (NTU).

Since the nephelometer measures the amount of light which is scattered by the turbid solution, it is important that no stray light interfere with the test. For this reason many turbidimeters, including the Model 2008, include a cap to cover the sample chamber during testing. Additionally, scratches, fingerprints, and water droplets on the outside of the sample tubes can cause additional light scatter, leading to inaccurate readings.

In addition to scratches and water droplets, the actual glassware itself is very important in turbidity readings, and differences between tubes and their orientation in the chamber can cause differences in test results. To assure the tubes are always placed in the chamber in the same orientation, the cap can be marked in some way, such as with a piece of tape. If this cap is always used with the same tube, by orienting the tape in the same way in the chamber each time, more accurate results can be obtained.

The Model 2008 is a versatile turbidimeter. It offers a choice of two ranges, which measure from 0 to 19.99 NTU or 0 to 199.9 NTU, allowing it to be used in treated water, natural water, or wastewater. The meter is precalibrated prior to leaving LaMotte's manufacturing facility, but it should be standardized prior to use.

TURBIDITY TUBES

To assure accurate readings the tubes supplied with the Model 2008 should be paired with marked caps. Mark each cap with a piece of tape, and pair with a tube. When the tubes are inserted into the chamber, the tape should always be oriented the same way, for instance, the tape should always point toward the operator. If greater accuracy is required, for instance for Surface Water requirements, the tubes supplied with the Model 2008 should be calibrated. Fill all the tubes with the same turbidity standard, preferably one at the higher end of the testing range. Insert each tube into the meter, and record the reading. This data will indicate the correction factor which should be used when comparing results in different tubes.

THE MODEL 2008 TURBIDIMETER

1. Select the AMCO[®] standard closest to the value of the sample.

NOTE: Only use LaMotte specific AMCO[®] turbidity standards with the Model 2008. Contact LaMotte for replacement standards.

2. Switch the selection knob to the proper range (0 - 20 or 0 - 200 NTU).
3. Fill turbidity tube with standard. Cap with paired, marked cap. Wipe tube with a lint-free tissue.
4. Insert tube into chamber. Cap chamber.

NOTE: The green LED will light to indicate tube is fully inserted, and the meter is working.

5. Adjust STANDARDIZE knob until display reads value of standard. The Model 2008 is now calibrated and ready for use.

TESTING

1. Fill a clean container with at least 50 mL of sample water. Set container aside to allow sample to equilibrate to air temperature, and to let gasses escape.

NOTE: Do not let dust or other airborne contaminants contact sample.

2. Rinse an empty turbidity tube with sample. Fill turbidity tube to neck with sample water.

NOTE: Pour sample down the side of tube to avoid creating air bubbles.

3. Cap with paired, marked cap. Wipe tube with a lint free tissue.

4. Insert tube into chamber. Cap chamber. Select appropriate range on selection knob. As soon as reading stabilizes, record reading as NTU.

NOTE: The green LED will light to indicate tube is fully inserted, and the meter is working.

5. If the sample has a turbidity reading of greater than 200 NTU, the sample must be diluted with turbidity-free water before being tested. Multiply result by the appropriate factor.

PREPARING TURBIDITY-FREE WATER

If the sample turbidity is higher than 200 NTU, it must be diluted with turbidity-free water, and retested. It is very important that no foreign matter be introduced into the water. Water prepared using this procedure can be stored in a clean glass jar, with a cap, in a dark area at room temperature, and used as required. Always check the water for particles or other foreign matter before using.

1. Unscrew the filter holder (0598), and place a white membrane filter (1103) on the screen inside. Make sure the membrane is centered on the screen and covers the entire surface. Replace top of filter holder.
2. Remove the plunger from the syringe and attach filter holder to bottom of syringe (0943).
3. Fill syringe with deionized or distilled water. Insert plunger and, exerting pressure, slowly force water through filter. Collect water in a suitable clear, glass storage container.
4. Remove filter holder from syringe, then remove plunger from barrel.
5. Replace filter holder, and repeat Steps 3 and 4 until desired amount of turbidity-free water has been collected.

NOTE: Periodically examine the membrane filter to assure no holes or cracks are present.

DILUTING THE SAMPLE

If the sample has a reading greater than 200 NTU's, it must be diluted with turbidity-free deionized water to bring the reading within the range of the Model 2008.

The following table gives quick reference guidelines on dilutions of various proportions. All dilutions are based on a 25 mL volume. Graduated pipets should be used for all dilutions.

SIZE OF SAMPLE	TURBIDITY-FREE WATER TO BRING VOLUME TO 25 mL	MULTIPLICATION FACTOR
25 mL	0 mL	1
12.5 mL	12.5 mL	2
2.5 mL	22.5 mL	10

EXAMPLE: Measure 12.5 mL of sample water into a graduated cylinder. Add turbidity-free water until the cylinder is filled to the 25 mL line. The sample has been diluted by one-half, and the dilution factor is therefore 2. Perform the test procedure, then multiply the reading from the display by 2 to obtain the test result.

RECHARGING THE BATTERY

The Model 2008 is supplied with Ni-Cad rechargeable batteries. These batteries can be recharged, but can only be replaced by LaMotte personnel. Attempting to replace the batteries yourself will void the warranty. A small indicator will appear on the left side of the display when the batteries need to be recharged.

NOTE: The Model 2008 can continue to make measurements while the battery is recharging. See Testing on page 9 for procedures.

1. Connect AC adapter to the Model 2008.
2. Set selection knob to CHARGE BATTERY. The red LED will light, indicating the batteries are recharging.

NOTE: Measurements can be made while the batteries are recharging.

3. The batteries will be completely recharged in approximately 4.5 hours. The red LED will extinguish when the batteries are recharged.

If there is no display when the selector knob is switched to 0-20 or 0-200, the battery has no charge. Plug in the adapter, switch the selector knob to "OFF", and leave the meter plugged in overnight. The battery can be recharged using the above procedure.

REPLACING THE BATTERIES

When the batteries are no longer able to hold a charge, return the instrument to LaMotte Company for new batteries. Replacing the batteries yourself voids the meter warranty.

REPLACING THE LAMP

The tungsten lamp included with the Model 2008 will last approximately 45,000 hours. If you suspect the lamp is dimming, insert a clean empty sample tube into the chamber. If the display is unstable, the lamp needs to be replaced. Call LaMotte Company for a return authorization number to have the lamp replaced.

The Model 2008 was factory calibrated using AMCO® standards. If formazin or other standards are used, or the front panel calibration procedure does not supply sufficient range, an internal calibration procedure should be used.

NOTE: Adjusting any internal components other than those specified will void the meter warranty.

1. Select two standards to use during the calibration procedure. The lowest and highest NTU standards should be chosen. (Ex. 0.5 and 5.0)
2. Make sure all glassware is clean and scratch-free. Wipe tubes with a lint free tissue to remove all fingerprints.
3. Set the selection knob to OFF.
4. Remove the four screws from the base of the turbidimeter. Holding the meter face down, carefully lift the back off the meter.

NOTE: The back and faceplate are connected by a short ribbon-cable. Do not disconnect this cable.

5. Set the meter in an upright, operating position on a flat surface.
6. Set the STANDARDIZE knob to the 12 o'clock position.
7. Set the selection knob to the proper range for the chosen standards (0 - 20 NTU or 0 - 200 NTU).
8. Insert the tube containing the low standard into the chamber. Place cap on chamber. Use a screwdriver to adjust the zero trim pot until the display reads the proper NTU value.

CAUTION: Only adjust the zero trim pot. Do not adjust other potentiometers. See diagram on following page to determine position of zero trim pot.

NOTE: Rapid hand movements near the circuit board may cause readings to fluctuate. Allow readings to stabilize before continuing.

(continued)

9. Insert the tube containing the high standard into the chamber. Place cap on chamber. Use a screwdriver to adjust the slope trim pot until the display reads the proper NTU value.

CAUTION: Only adjust the slope trim pot. Do not adjust other potentiometers. See diagram below to determine position of slope trim pot.

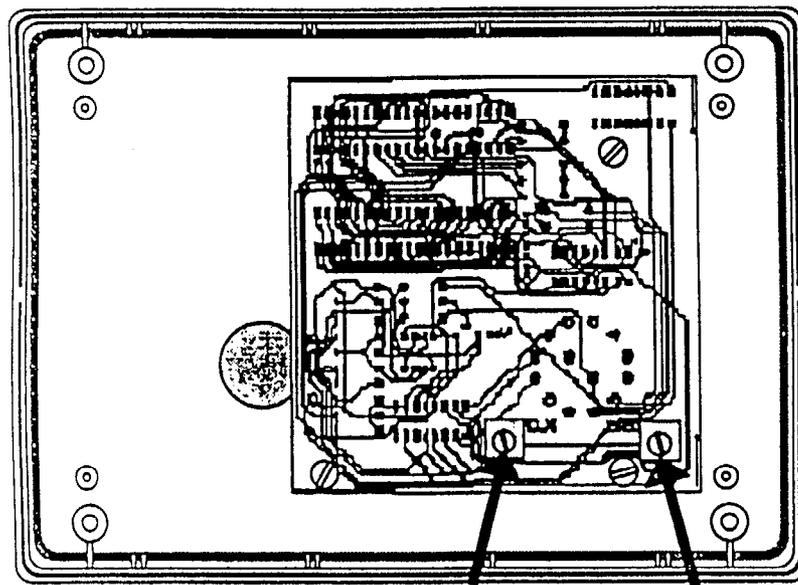
NOTE: Rapid hand movements near the circuit board may cause readings to fluctuate. Allow readings to stabilize before continuing.

10. Repeat Steps 8 and 9 until both the low and high standard values are correctly displayed.

NOTE: Use the orientation mark on the caps to assure the tubes are being placed in the meter the same way each time.

11. Reattach faceplate to back. The Model 2008 is now calibrated and ready to use.

Inside View of Front Panel



Slope Adjust Zero Adjust

REPAIRS

If it is necessary to return the instrument for repair, contact LaMotte Company at 1-800-344-3100 for a return authorization number.

INSTRUMENT GUARANTEE

This instrument is guaranteed to be free of defects in material and workmanship for one year from date of original purchase. If, in that time, it is found to be defective, it will be repaired without charge, except for transportation expenses. This guarantee does not cover the batteries.

This guarantee is void under the following circumstances:

- operator's negligence
- improper application
- unauthorized servicing

LIMITS OF LIABILITY

Under no circumstances shall LaMotte Company be liable for loss of life, profits, or other damages incurred through the use or misuse of their products.

PACKAGING AND DELIVERY

Experienced packaging personnel at LaMotte Company assure adequate protection against normal hazards encountered during shipping. After the product leaves the manufacturer, all responsibility for its safe delivery is assured by the transporter. Damage claims must be filed immediately with the transporter to receive compensation for damaged goods.

APPENDIX G
WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS
AND WELL DEPTH MEASUREMENTS

**WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND
WELL DEPTH MEASUREMENTS
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WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS

1.0 PURPOSE

The purpose of this procedure is to describe the method of determining various down-hole measurements: groundwater levels and product (or non-aqueous phase liquid, NAPL) levels, if present, and total depth of groundwater monitoring wells and piezometers.

2.0 SCOPE

The methods described in this SOP generally are applicable to the measurement of groundwater levels, product or NAPL levels, and well depths in monitoring wells and piezometers.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed.

Field Team Leader - The Field Team Leader is responsible for ensuring that these procedures are implemented in the field, and for ensuring that personnel performing these activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the sampling personnel to follow these procedures or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of down-hole measurements.

5.0 PROCEDURES

Calculations of groundwater elevations and product or NAPL interface level measurements collected from a monitoring well give an indication of:

- The horizontal hydraulic gradient and the direction of groundwater flow.
- The vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane).
- Floating or sinking product thicknesses which are also known as Light Non-Aqueous Phase Liquids (LNAPLS) and Dense Non-Aqueous Phase Liquids (DNAPLS), respectively.

This information, when combined with other site specific information such as hydraulic conductivity or transmissivity, extent of contamination, and product density, may be used to estimate the rate of contaminant movement or source areas, etc.

Well depth is one of the factors used to determine the zone that a well monitors. Well depth also is used in the calculation of purge volumes as discussed in SOP F104, Groundwater Sample Acquisition.

The following sections briefly discuss the procedures for measuring groundwater levels, product or NAPL levels, and well depth. For all of the procedures discussed, it is assumed that the measurement will be taken from the top of the PVC or stainless steel casing (though other measuring points can be used), and that horizontal and vertical control is available for each well through a site survey, such that measurements may be converted to elevations above Mean Sea Level (MSL) or some other consistent datum. A permanent notch, placed on the inner PVC or stainless steel casing by the surveyor will facilitate consistent water level measurements.

The manufacturer's instructions for all equipment referenced herein should be read by the equipment operator(s) and accompany the equipment to the field.

5.1 Water Level Measurement

Water levels in groundwater monitoring wells shall be measured from the permanent point indicated at the top of the inner casing (they surveyed elevation point, as marked by the surveyor), unless otherwise specified in the project plans, using an electronic water level measuring device (water level indicator). The point of measurement will be documented in the field logbook if different from the top of the inner casing. The reason for deviating from the measurement point should also be noted.

Water levels are measured by lowering the probe into the well until the device indicates that water has been encountered, usually with either a constant buzz, or a light, or both. The water level is recorded to the nearest foot (0.01) using the graduated markings on the water level indicator cord. This measurement, when subtracted from the measuring point elevation, yields the groundwater elevation.

Groundwater levels shall always be measured to the nearest 0.01 foot. However, reporting of water level elevations depends on the accuracy of the vertical control (typically either 0.1 or 0.01 foot).

5.2 Product or NAPL Level Measurements

The procedure for product or NAPL level measurement is nearly identical to that for groundwater elevation measurements. The only differences are the use of an interface probe that detects both NAPLs and water, and the indication signal given by the measurement device. Typically, encountering NAPLs in a monitoring well is indicated by a constant sound. When water is encountered, the signal becomes an alternating on/off beeping sound. This allows for the collection of measurements for both the top of the NAPL layer in a well and the water/NAPL interface.

The apparent water table elevation below the product level will be determined by subtracting the "depth to water" from the measuring point elevation. The corrected water table elevation will then be calculated using the following equation:

$$WTE_c = WTE_a + (\text{Free Product Thickness} \times 0.80)$$

Where:

- WTE_c = Corrected water table elevation
- WTE_a = Apparent water table elevation
- 0.80 = Average value for the density of petroleum hydrocarbons. Site-specific data will be used where available.

5.3 Well Depth Measurements

Well depths typically are measured using a weighted measuring tape. A water level meter may also be used. The tape is lowered down the well until resistance is no longer felt, indicating that the weight has touched the bottom of the well. The weight should be moved in an up and down motion a few times so that obstructions, if present, may be bypassed. The slack in the tape then is collected until the tape is taut. The well depth measurement is read directly off of the measuring tape, at the top of the PVC or stainless steel casing, to the nearest 0.01-foot and recorded in the Field Logbook. If a water level indicator is used, add the distance from the bottom of the probe to the point where water levels are measured.

5.4 Decontamination of Measuring Devices

Water level indicators, interface probes and weighted measuring tapes that come in contact with groundwater must be decontaminated using the following steps after use in each well:

- Rinse with potable water
- Rinse with deionized water
- Rinse with:
 - ▶ Methanol or acetone (EPA Region I)
 - ▶ Methanol or acetone (EPA Region II)
 - ▶ Methanol (EPA Region III)
 - ▶ Isopropanol (EPA Region IV)
- Rinse with deionized water

Portions of the water level indicators or other similar equipment that do not come into contact with groundwater, but may encounter incidental contact during use, need only undergo potable water and deionized water rinses.

6.0 QUALITY ASSURANCE RECORDS

The Field Logbook shall serve as the quality assurance record for water, product level or well depth measurements.

7.0 REFERENCE

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

APPENDIX H
PHOTOIONIZATION DETECTOR (PID)
HNU MODELS PI 101 AND DL 101

**PHOTOIONIZATION DETECTOR (PID)
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**PHOTOIONIZATION DETECTOR (PID)
HNU MODELS PI 101 and DL 101**

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the HNU Model PI 101 or DL 101 photoionization detector (PID), or an equivalent or similar instrument, in the field. Calibration and operation, along with field maintenance will be included in this SOP.

2.0 SCOPE

This procedure provides information on the field operation and general maintenance of the HNU (PID). Application of the information contained herein will ensure that this type of field monitoring equipment will be used properly. Review of the manufacturer's instruction manual is necessary for more complete information.

These procedures refer only to monitoring for health and safety. The methods are not directly applicable to surveillance of air quality for analytical purposes.

3.0 DEFINITIONS

Ionization Potential - In this case, a numeric equivalent that expresses the amount of energy needed to replace an electron with a photon. This energy is further defined in terms of electron volts (eV).

PID - Photoionization Detector

ppm - parts per million: parts of vapor or gas per million parts of air (directly proportional to calibration gas).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures

are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in both the Field Logbook and the daily Realtime Air Monitoring Log during each field investigation.

5.0 PROCEDURES

The HNu utilizes the principle of photoionization whereby contaminant molecules enter the ion chamber and electrons are displaced by ultraviolet photons producing positive ions. These displaced positive ions are in turn collected on a special electrode. As the positive ions collect on the electrode, they create an electrical current which is amplified and displayed on the meter as a concentration in parts per million (ppm).

The HNu is only effective for contaminants that have ionization potentials (IP) of less than or equal to the electron volt (eV) capacity of the lamp (i.e., methane, having an IP of 12.98 eV, will not be detected at a lamp potential of 11.7 eV). The standard lamp is 10.2 eV with optional lamps of 9.5 eV and 11.7 eV, respectively. For the PI 101 the span settings should be as

follows: 1.0 for 9.5 eV lamps; 9.8 for 10.2 eV lamps; and 5.0 for 11.7 eV lamps. During calibration, these span settings will be adjusted as necessary, using the span control knob.

The following subsections will discuss HNu calibration, operation, and maintenance. These sections, however, should not be used as a substitute for the manufacturer's instruction manual.

5.1 Calibration

For calibration purposes, the following items will be needed:

- *Gas cylinder containing 95 to 100 parts per million (ppm) of isobutylene, balance in air.
- A 0.30 liters per minute regulator.
- Connector tubing.
- Screwdriver set.
- Calibration Gas Humidifier (for high humidity environments).
- Photoionization Detector (PID) Calibration Form.

*Note: Do not rely on accuracy of rated cylinder concentration when content drops to <200 psi.

Prior to each use, make sure that the battery is fully charged, the ultraviolet lamp is working, and that the fan is operating and drawing air into the probe (fan operates at approximately 100-200 cc/minute for the PI 101 and 225 cc/minute for the DL 101). Procedures for completing these preliminary activities are given in the manufacturer's instruction manual.

PI 101

To calibrate the HNu PI 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 3-5 in the manufacturer's instruction manual. The HNu PI 101 should be calibrated on a daily basis.

- Turn the function control switch to the standby position and zero the instrument by turning the zero adjustment knob to align the indicator needle with zero on the readout meter.
- Set the range on the HNu and allow the instrument to warm up a few minutes before calibrating. Choices for range are 0-20, 0-200, and 0-2,000 ppm, respectively. Range choice must take into account the concentration of the calibration gas. For example, if you are using a concentration of 100 ppm isobutylene as the calibration gas, your

range should be set on the 0-200 scale. If you have to zero the instrument in the desired range, record background if present.

- Attach tubing to the regulator (use the Calibration Gas Humidifier in high humidity environments).
- Attach the free end of the tubing to the probe and turn on the calibration gas.
- Calibrate the PID to benzene equivalents. Using the 10.2 eV (lamp) probe and 100 ppm isobutylene, the meter should read 56 units. Using the 11.7 eV (lamp) probe and 100 ppm isobutylene, the meter should read 65 units. If the reading on the meter is not ± 5 percent of the concentration of the calibration gas, adjust the span setting knob until the meter reads accordingly. If after adjusting the span setting knob the readout meter is still not responding, refer to the manufacturer's instruction manual. Also, when the HNu is calibrated it should respond to a minimum of 90 percent of the concentration of the calibration gas within three seconds after introduction of that gas. If proper calibration cannot be obtained, internal calibration may be required. Note, only qualified personnel should perform internal calibrations.
- Record the calibration on the "Photoionization Detector (PID) Calibration Form".

DL 101

To calibrate the HNu DL 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 4.4 in the manufacturer's instruction manual.

- Press and release the POWER button on the keypad and wait for the screen to stabilize then press the CALIBRATE key until "Calibrate?" appears. At this point press the ENTER key until "Elec_Zero? Yes" appears on the screen in which case you will press the ENTER key, again, to confirm the electronic zero.
- The display will now read "CE/ENT/EXIT Conc = ___ ppm" which requires the concentration of the calibration gas (noted on the side of the calibration gas bottle) to be entered on the keypad. The display will prompt you to "Attach gas to probe and /ENTER/" so attach tubing to probe (use the calibration gas humidifier in high humidity environments), open valve, and press ENTER key. Press ENTER again when "Press ENTER when Ready: xxx ppm" appears on screen. This will cause "Calibrating...Please Wait" to appear on screen.

Note: This calibration is effective when the instrument is in the Survey Mode, which is the default mode. For calibrations other the one described, or if proper calibration cannot be obtained, refer to the manufacturer's instruction manual.

- For calibrations using an alternate gas or span values, refer to Section 4.5 of the manufacturer's instruction manual.
- Record the calibration on the "Photoionization Detector (PID) Calibration Form" which accompanies each HNu.

5.2 Operation

PI 101

Note: IMPORTANT - The HNu should be "zeroed" in a fresh air environment if at all possible. If there is a background concentration, it must be documented and then zeroed out.

- Prior to each use of the HNu, check that the battery is fully charged by turning the dial to BATT and making sure that it is within range. Also make sure that the ultraviolet lamp and the fan are working properly.
- Select your desired range. HNu ranges consists of a 0-20, 0-200, and 0-2,000 ppm, respectively. Consult with the Field Team Leader for more information when choosing the appropriate range, however, in most instances the range will be set initially at 0-20.
- When HNu is used intermittently, turn knob to STANDBY to help in extending the life of the UV lamp when operating in a low humidity environment. Otherwise, leave the knob set to the range desired so that the UV lamp will "burn off" any accumulated moisture.

Note: When using the PI 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

DL 101

The DL 101 is designed to default to the survey mode when initially powered up, therefore once the calibration has been completed, the instrument is ready to go. Within the survey mode several options are available, briefly these options include:

1. The Site Function

The Site function assigns a number to a site that is being analyzed. Press the Site Key on the keypad to enter a specific site number, or press the gray button on the rear of the probe to increment a site number.

2. Logging Data

The Log function stores data in memory. To log data, press the Log key on the keypad or the Log button on the back of the probe. "Log" will appear in the upper right corner of the display when activated and disappears when not activated. To turn logging off, press either the Log key on the keypad or the red Log button on the rear of the probe.

- The DL 101 allows for the interchanging of different voltage lamps, however, refer to the manufacturer's instructions before attempting to change the lamp.
- The DL 101 also offers three other modes of operation, the Hazardous Waste Mode, the Industrial Hygiene Mode, and the Leak Detection Mode. Each of these modes increases the range of capabilities for this instrument which is covered in detail in the manufacturer's instruction manual.

Note: When using the DL 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

5.3 Interferences and Potential Problems

A number of factors can affect the response of the PI 101 HNu and DL 101 HNu.

- High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when monitoring a soil gas well that is accessible to groundwater.
- High concentrations of methane can cause a downscale deflection of the meter.
- High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpenes in wooded areas, will also affect instrument response.

5.4 Maintenance

The best way to keep an HNu operating properly is to keep it as clean as possible. HNu's should be decontaminated and wiped down after each use.

Corrective Maintenance

- The ultraviolet lamp should be periodically cleaned using a special compound supplied by HNu Systems, Inc. for the 10.2 eV lamp, and a chlorinated solvent such as 1,1,1-trichloroethane for the 11.7eV lamp. Consult the manufacturer's instruction manual for specific cleaning instructions.
- The ionization chamber can be periodically cleaned with methyl alcohol and a swab.

Note: UV lamp and ion chamber cleaning is accomplished by following the procedures outlined in Section 5.2, however, this should only be performed by trained personnel.

- Documenting the HNu's observed symptoms and then referring to the manufacturer's instruction manual section on troubleshooting (Section 6.0) also can be employed. If this does not work, the Field Team Leader should be consulted for an appropriate course of action.

Repair and Warranty Repair - HNu's have different warranties for different parts, so documenting the problem and sending it into the manufacturer assists in expediting repair time and obtaining appropriate warranty service.

5.5 SHIPPING AND HANDLING

Following is information regarding the transport of the HNu meter and calibration gas.

- If HNu is to be carried on in aircraft, the calibration gas must be removed from the carrying case as cylinders of compressed gas are not permitted on passenger aircraft. The calibration gas should either be shipped to the site of its intended use, or purchased locally.
- Shipping of the calibration gas requires the completion of a form (specified by the shipping company) that identifies the package as a compressed gas. Compressed gas stickers must be affixed to the package.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc.) serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the HNu meter had wide range fluctuations during air monitoring activities).

7.0 REFERENCES

HNu Systems, Inc. Instruction Manual. Model PI 101, 1986.

HNu Systems, Inc. Operator's Manual. Model DL 101, 1991.

APPENDIX I
BACHARACH COMBUSTIBLE GAS/OXYGEN METER
AND PERSONAL GAS MONITOR

**BACHARACH COMBUSTIBLE GAS/
OXYGEN METER PERSONAL GAS MONITOR
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BACHARACH COMBUSTIBLE GAS/ OXYGEN METER AND PERSONAL GAS MONITOR

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the Bacharach Sentinel 4 and Bacharach Sniffer® 503-A meters in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

2.0 SCOPE

This procedure provides information into the field operation and general maintenance of the Sentinel 4 Sniffer and 503-A. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

3.0 DEFINITIONS

Carbon Monoxide Sensor - Expresses the Carbon Monoxide concentration in parts per million (ppm).

Combustible Gas - Combustible gas is expressed as a percent of the lower explosive limit (LEL).

Hydrogen Sulfide Sensor - Expresses the Hydrogen Sulfide concentration in parts per million (ppm).

Oxygen Sensor - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

Sentinel 4 - Combustible Gas/Oxygen/Hydrogen Sulfide/Carbon Monoxide meter.

Sniffer 503-A - portable Combustible Gas and Oxygen Alarm instrument.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in the Field Logbook during each field investigation.

5.0 PROCEDURES

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A utilize the principle of detecting sensors. The following four paragraphs discuss theory of operation as it applies to each functional sensor.

The combustible gas sensor uses two elements that are wound with a platinum wire. One of the elements is impregnated with a catalyst to oxidize combustible gases. The other element

is impregnated with material that will also oxidize combustible gases, but will respond to temperature and humidity conditions. When the meter is turned on, an electrical current is passed through the elements and wires. As a combustible gas enters the chamber the elements will oxidize the combustible gas, thus increasing the heat and resistance of the element. This change in resistance causes a system imbalance, which produces a measurable signal proportional to the combustible gas concentration.

The percent oxygen is measured utilizing an electrochemical sensor. As atmospheric oxygen enters the meter it diffuses into the sensor which converts the amount of oxygen in the sensor to a voltage signal. This voltage is directly proportional to percent oxygen in the atmosphere.

The concentration of hydrogen sulfide is measured utilizing an electrochemical sensor. As atmospheric hydrogen sulfide enters the meter it diffuses into the sensor which converts the amount of hydrogen sulfide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric hydrogen sulfide concentration.

The concentration of carbon monoxide as measured utilizing an electrochemical sensor. As atmospheric carbon monoxide enters the meter it diffuses into the sensor which converts the amount of carbon monoxide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric carbon monoxide concentration.

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A are intrinsically safe for use in Class I, Division 1, Groups A, B, C and D hazard areas. One fact that needs to be expressed is that this type of monitoring equipment utilizes internal oxidation of combustibles, if the meter is placed in an oxygen deficient atmosphere, the combustible reading may be affected. Review of each of the instruction manuals will aid in determining the percentage of oxygen that affects the combustible gas readings.

The following subsections will discuss Sentinel 4 and Sniffer 503-A calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

5.1 Calibration

Sentinel 4

Due to the numerous steps involved in calibration, it is recommended that you follow the calibration procedures (on a daily basis) as outlined in the instruction manual from pages 5-12 to 5-20.

NOTE: A calibration kit will be provided for each Sentinel 4. This kit contains a cylinder for the combustible gas sensor, one cylinder for the hydrogen sulfide sensor, and one cylinder for the carbon monoxide sensor. The oxygen sensor can be calibrated with (uncontaminated/fresh air environment) atmospheric air and does not need cylinder gas.

Note: When a single sensor doesn't zero, none of the sensors are zeroed.

Sniffer® 503-A

Oxygen Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if battery is in recharge zone instrument will need to be charged.
2. To zero the oxygen detector, turn function switch to "BATTERY TEST" position and press "TEST" switch and observe the O₂ meter indication. If indicator is zero, no further adjustment is necessary. If not, follow procedures in Section 5.4.1 of the Operations Manual.
3. To calibrate the oxygen detector, turn function switch to "BATTERY TEST" position. Unlock the "OXYGEN CALIB" knob and adjust it for an O₂ meter indication of 21 or at the CAL mark. Relock "OXYGEN CALIB" knob. If using zero calibration gas, follow procedures in Section 5.4.2 of the Operator's Manual.
4. Record on Calibration Sheet.

% LEL Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if batter is in recharge zone, instrument will need to be charged. Allow 5 minutes for the instrument to warm up.
2. Turn function switch to the % LEL position.

Note: To eliminate the annoyance of the audible alarm, cover the alarm with a hand or duct tape during calibration. The tape must be removed, prior to operation!!

3. Connect calibration gas (typically 30% of the LEL) and allow gas to flow for 1 minute.

Note: If calibration gas has a concentration value, not a % LEL value, the % LEL can be calculated as follows:

$$\% \text{ calibration gas (i.e., methane)} \times 20\% \text{ LEL (meter alarm setting)} = \% \text{ LEL calibration setting}$$

If meter indication is within $\pm 5\%$ of LEL calibration gas, no further adjustment is required. If not, follow procedures in Section 5.5.4 of Operator's Manual.

Sniffer® 503-A

1. Connect sample probe and tubing to the instrument's sample inlet (refer to Sections 8.4 and 8.5 for the Operator's Manual for available hoses and probes).
2. Check that battery is in Operational Range.
3. Turn instrument to % LEL range and allow to warm up for 1 minute.
4. Check in a fresh air environment that % LEL reads 0% and that O₂ indicator reads 21% (calibration mark).

5. Sample air/gas from area to be tested, allow 30 seconds for readings to stabilize. When finished, allow at least 10 seconds (longer if extension line is used) to purge sample line.
6. If instrument is operating erratically, refer to "TROUBLESHOOTING" Section (Table 5-2) in Operator's Manual.

5.2 Operation

Sentinel 4

Due to the Sentinel 4 having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 6-1 to 6-34.

NOTE: Since the Sentinel 4 is capable of measuring four different parameters, an understanding of the alarm, error, and fault messages must be obtained. This can be done by reviewing the troubleshooting table found on pages 9-2 to 9-9.

5.3 Site Maintenance

After each use, the meters should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

5.4 Scheduled Maintenance

<u>Function</u>	<u>Frequency</u>
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the Sentinel 4 or Sniffer 503-A had wide range fluctuations during air monitoring activities.)

NOTE: The "Toxic Gas Meter Calibration Form" will be completed daily, prior to performing any air monitoring.

7.0 REFERENCES

Bacharach Installation, Operation, Maintenance Manual, Sentinel 4 Personal Gas Monitor, 1990.

Bacharach Installation, Operation, Maintenance Manual, Sniffer® 503-A, Rev. 3 - October 1990.

APPENDIX J
LAND SURVEY

**LAND SURVEYING
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- 6.0 HEALTH AND SAFETY**
- 7.0 QUALITY ASSURANCE RECORDS**

LAND SURVEYING

1.0 PURPOSE

This procedure describes methods and equipment commonly used by a Registered Land Surveyor when compiling by survey the vertical and horizontal locations of on-site monitoring wells and other site structures, and topographic features associated with study areas at various Naval Activity locations.

2.0 SCOPE

The information presented in this SOP is generally applicable to all the various Naval Activity locations, except where state-specific requirements differ concerning certifications, licenses and registrations.

Specific surveying problems encountered by the survey crew may require the adaptation of existing equipment or design of new equipment. Such innovations shall be documented in the survey crew's Field Logbook.

3.0 DEFINITIONS

North American Datum (NAD) - Datum used during the absence of established horizontal and vertical control.

Mean Sea Level (MSL) - Adopted as a datum plane for the measurement of elevations and depths.

Horizontal Control - Horizontal location of an object from surveyed corners or other features on permanent land monuments in the immediate site area. Will be based on North American Datum (NAD).

Vertical Control - Vertical location of an object compared to the adjacent ground surface.

Bench Mark - Precisely determined elevation above or below sea level. May also have horizontal control (northing, easting) determined for location.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with acceptable surveying practices as required by the state in which the work is performed.

Field Team Leader - The Field Team Leader is responsible for ensuring that procedures are implemented in the field and that personnel performing surveying activities have been briefed and trained to execute these procedures.

5.0 PROCEDURES

Baker requires the services of a Registered Land Surveyor to determine by survey the elevations and horizontal locations of monitoring wells and other site structures, and topographic features associated with study areas at various Navy Activity locations. The surveyor will mobilize to the site within seven days upon receiving the notice-to-proceed. All site surveys must be completed in the time frame agreed upon. The site map shall be completed within ten days of completion of the site survey.

5.1

Specifically, Baker requires the following:

Delineate the elevations of groundwater monitoring wells to an accuracy of 0.01 feet, referenced to United States Geological Survey Mean Sea Level (MSL) from the nearest datum bench mark. Each Naval Activity has identified existing bench marks that may be used for control; however, these bench marks may not be directly adjacent to the survey sites.

5.1.1

The elevation point for each well casing and a permanent mark designating the elevation point shall be established on each well. In addition, the ground surface elevation for each well

shall be established. Some of the wells will be flush-mounted level with the pavement; thus the land surface elevation will be above the "top of casing" elevation for those wells.

5.1.2

Determine the elevation of the directly adjacent ground surface to an accuracy of 0.1 feet.

5.2

Delineate the horizontal location of each well from surveyed corners or other features on permanent land monuments in the immediate site area to an accuracy of 0.1 foot, referenced to North American Datum (NAD). Baker will supply an existing Navy property plot plan or CADD file for each site to the subcontractor that will serve as the base map for locating surveyed points. All permanent points established during control traverses shall be shown.

5.3

Locate various drainage trenches/structures and significant topographic features at Baker's request via the survey. A Baker representative may be present during survey activities to identify points and features to be located. If no Baker representative will be present, the subcontractor will be notified in advance as to what features or types of features are to be included in the survey.

5.4

In the absence of Activity-established horizontal and vertical control, all survey points will be based on North American Datum (NAD) for horizontal control and MSL for vertical control.

5.5

The subcontractor shall provide Baker with a letter report containing all relevant survey information along with one legible copy of the field survey notes recorded when determining the surveyed elevations, location of wells, and requested topographic information. The subcontractor shall also provide one reproducible, legible copy of the property map showing the well designation, "top-of-casing" elevation and location at each well, and a table listing the

well designation, "top-of-casing" ground surface elevations, coordinates for each well, and plotted horizontal features. Baker cannot verify the accuracy of Navy-supplied site maps, it is recognized that the subcontractor's responsibility in plotting features is to provide most accurate locations possible on mapping available. Tabulated data provided by the subcontractor, however, must be accurate on an MSL datum specified above. All deliverables must be in ACAD R12.

5.6

The subcontractor shall perform these services in accordance with standard, acceptable surveying practices as required by the state in which the work is performed and all work shall be conducted under the supervision of a Registered Land Surveyor, duly licensed to work in the state.

6.0 HEALTH AND SAFETY

The subcontractor is to provide for and assume responsibility for adequate health and safety protection for on-site personnel. Baker requires contracted land surveyors to provide evidence of having received OSHA-specified training to conduct work on potentially hazardous sites. The specific content of the training requirements are outlined in 29 CFR 1910.120(e). These requirements include:

- Minimum of 24 hours of hazardous waste training
- Eight hours of additional training for supervisors
- Eight hours of hazardous waste refresher training for every year after the initial 24-hour training
- Medical surveillance as specified in the specific OSHA regulations

At least one of the on-site surveying personnel must have the 32 hour supervisor hazardous waste training. The subcontractor is to provide to Baker personnel on-site or in Baker's offices copies of current training and medical certifications, and to assure that this documentation accompanies their personnel onto the job site.

7.0 QUALITY ASSURANCE RECORDS

The Field Logbook shall serve as the quality assurance record for on-site surveying activities.

APPENDIX K
DRUM SAMPLING

**DRUM SAMPLING
TABLE OF CONTENTS**

- 1.0 PURPOSE**
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 - 3.0 DEFINITIONS**
 - 4.0 RESPONSIBILITIES**
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 - 7.1 Bung Wrench
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 - 7.3 Backhoe Spike
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 - 7.5 Pneumatic Devices
 - 8.0 PROCEDURES**
 - 8.1 Preparation
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 - 8.3 Drum Opening
 - 8.4 Drum Sampling
 - 9.0 QUALITY ASSURANCE/QUALITY CONTROL**
 - 10.0 REFERENCES**
- ATTACHMENT A - DRUM WASTE CHARACTERIZATION SHEET**
- ATTACHMENT B - LIST OF FIGURES**

DRUM SAMPLING

1.0 PURPOSE

The purpose of this SOP is intended to provide general information for the sampling of drums by qualified individuals in the field. Due to widely varied (and potentially hazardous) conditions posed by drum sampling, specific SOPs must be determined on a case-by-case basis. This SOP provides information to assist in ensuring that safe procedures are followed as applicable to the inspection, opening, and sampling of drums in the field.

2.0 SCOPE AND APPLICATION

This SOP provides technical guidance on safe and cost-effective response actions at sites containing both known and unknown drum contents. Container contents are sampled and characterized for disposal, bulking, recycling, grouping and/or classification purposes.

3.0 DEFINITIONS

Bung - a threaded metal or plastic plug usually positioned at the top or side of a drum.

Over Pack - a metal or plastic drum-like container that is larger than the container(s) stored therein.

Lab Pack - a drum holding multiple individual containers of laboratory materials normally surrounded by cushioning absorbent material.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the drum sampling activities.

Project Health and Safety Officer (PHSO) - The PHSO is responsible for developing a site-specific Health and Safety Plan (HASP) for drum sampling activities which include personal protection levels, air monitoring requirements, and safe drum sampling procedures.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the proper respiratory and personal protective equipment for each member of the sampling team is selected in compliance with the HASP, and coordinating these efforts with the Field Team Leader.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the drum sampling techniques and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the Field Investigation personnel performing drum sampling activities have been briefed and trained to execute these procedures.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader and Project Manager. The Field Investigation Personnel are responsible for documenting all sampling data on the appropriate Drum Sample Characterization Sheet presented as Attachment A and in the Field Logbook.

5.0 METHOD SUMMARY

Prior to sampling, drums should be inventoried and properly staged in a secure area. An inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization and sometimes consolidation of drums which have similar wastes or characteristics.

6.0 INTERFERENCES

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used if the drums are visually overpressurized (bulging) or if shock-sensitive materials are suspected. Drums that have been overpressurized, to the extent that the head is swollen several inches above the chime (beveled edge of drumtop), should not be moved. A number of devices have been developed for venting critically swollen drums. One method that

has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid hooking device attached to the tube goes over the chime and holds the spear securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum and the gas vents along the grooves. The device can be inexpensively and easily designed and constructed where needed. Once the pressure has been relieved, the bung can be removed and the drum contents sampled.

7.0 EQUIPMENT APPARATUS

The following are standard materials and equipment required for drum sampling:

- Health and Safety Plan
- Air monitoring equipment
- Fire extinguishing equipment
- Personnel protective equipment
- Wide mouth glass jars with teflon cap liner, approximately 500 ml volume
- Uniquely numbered sample identification labels with corresponding data sheets
- One-gallon covered (paint) cans half-filled with absorbent (i.e. kitty litter or vermiculite)
- Chain-of-Custody forms
- Decontamination plan and materials
- Glass thieving tubes or Composite Liquid Waste Sampler (COLIWASA)
- Drum opening devices

7.1 Bung Wrench

A common method for opening drums manually is using a universal bung wrench (see Figure 1, Attachment B). These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast-iron, brass or a bronze-beryllium, nonsparking alloy formulated to reduce the likelihood of sparks. The use of a "NONSPARKING" wrench does not completely eliminate the possibility of a spark being produced, therefore extreme caution should be exercised.

7.2 Drum Deheader

One means by which a drum can be opened manually (when a bung is not removable with a bung wrench) is by using a drum deheader (see Figure 2, Attachment B). This tool is designed to cut the lid of a drum off (or part way off) by means of a scissors-like cutting action. This device is limited in that it can be attached only to closed head drums. Drums with removable heads must be opened by other means.

7.3 Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket (see Figure 3 and 4, Attachment B). In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure to the potentially hazardous nature of the drum's contents.

7.4 Hydraulic Drum Opener

Another remote drum opening procedure is the utilization of remotely operated hydraulic devices. One such device uses hydraulic pressure to pierce through the wall of a drum (see Figure 5, Attachment B). The device consists of a manually operated pump which pressurizes oil through a length of hydraulic line.

7.5 Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed (see Figure 6, Attachment B). It should be noted that this bung removal method does not permit the slow venting of the container, and therefore appropriate precautions must be taken to reduce personnel exposure to pressurized, potentially hazardous drum contents. It also requires the container to be upright and relatively level. Bungs that are rusted shut or are in very poor condition cannot be removed with this device.

8.0 PROCEDURES

It is anticipated that the procedures for drum sampling may include a limited degree of drum handling. Therefore, it will be necessary to inspect the drum(s) for certain conditions prior to sampling.

8.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies will be needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that the equipment is in good working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific Health and Safety Plan.
6. Use marking devices to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

8.2 Inspection

Prior to sampling, drums will be visually inspected to gain as much information as possible about their contents. Items to consider during inspection include:

- Symbols, wording, labels, or other marks indicating that drum contents are hazardous, e.g., radioactive, explosive, corrosive, toxic, or flammable.

- Symbols, wording, labels, or other marks indicating that the drum contains discarded laboratory chemicals, reagents, or other potentially dangerous materials in small-volume individual containers.
- Signs of deterioration such as corrosion, rust, and leaks.
- Signs of the chemical nature of the contents, such as residue, crystal buildup, etc. at bung opening.
- Signs that the drum is under pressure such as swelling and bulging.
- Special drum types (refer to Table 1).
- Configuration of the drumhead (ringtop or bung).
- Orientation such as whether the drum is standing upright, tilted, or lying on its side.
- Accessibility of the drum.

Monitoring will be conducted around the drums using instruments such as a gamma radiation survey instrument, organic vapor monitor (OVA or HNu), colorimetric tubes (Dräger tubes), and/or a combustible gas meter. The results can be used to classify the drums into categories such as radioactive, leaking/deteriorating, bulging, explosive/shock-sensitive, or laboratory packs.

Personnel will not handle, move, open, sample or in anyway disturb a drum containing radioactive waste, explosive or shock-sensitive waste, laboratory packs, or biohazardous waste until specific direction and safe procedures are received from the Project Manager, PHSO and the Field Team Leader.

TABLE 1
SPECIAL DRUM TYPES

Polyethylene or PVC-lined Drums	Often contain strong acids or bases. If the lining is punctured, the substance will usually corrode the steel, resulting in a significant leak or spill.
Exotic Metal Drums (e.g., aluminum, nickel, stainless steel, or other unusual metal)	Very expensive drums that usually contain an extremely dangerous and/or corrosive/reactive material.
Single-Walled Drums used as a Pressure Vessel	These drums have fittings for both product filling and placement of an inert gas, such as nitrogen. May contain reactive, flammable, or explosive substances.
Laboratory Packs	Used for disposal of expired chemicals and process samples from university laboratories, hospitals, and similar institutions. Individual containers within the lab pack are often not packed in absorbent material. They may contain incompatible materials, radioisotopes, shock-sensitive, highly volatile, highly corrosive, or extremely toxic exotic chemicals. Laboratory packs can be an ignition source for fires at hazardous waste sites.

When drums exhibit the characteristics of the aforementioned categories, the following procedures will be followed:

- **Radioactive Wastes** - If the drum exhibits radiation levels above background, normally 0.01-0.02 mrem/hr (milliroentgen equivalent in man per hour), that are less than or equal to 2 mrem/hr, there is a possible radiation source present. Continue the investigation with caution, and inform the SHSO. If the radiation levels are greater than 2 mrem/hr there is a potential radiation hazard. Work will stop, and the Field Team Leader and Project Manager will be notified so that new procedures can be developed and implemented.
- **Explosive or Shock-Sensitive Waste** - If handling is necessary, exercise extreme caution, have nonessential personnel move to a safe distance, and use a grappler unit for initial handling which is constructed for explosive containment. Use nonsparking equipment and/or remote control devices.
- **Bulging Drums** - Do not move drums under internal pressure unless proper equipment is used, such as a grappler unit constructed for explosive containment.
- **Packaged Laboratory Wastes (Lab Packs)** - Lab Packs can be an ignition source for fires and sometimes contain shock-sensitive materials. Once a lab pack has been opened, a chemist or other qualified individual should inspect, classify and segregate the bottles (without opening), according to the hazards of the wastes. The objective of such a classification system is to ensure safe segregation of the lab packs' contents (refer to Table 2 for an example of a lab pack classification). If crystalline material is noted at the neck of any bottle, handle it as a shock-sensitive waste (due to the potential presence of picric acid, potassium permanganate or explosive mixtures resulting when the aqueous solution crystallizes), or other inimical (harmful) materials, and obtain advice from qualified personnel prior to handling.

Until drum contents are characterized, sampling personnel will assume that unlabeled drums contain hazardous materials. Personnel also should be aware that drums are frequently mislabeled and may not contain the material identified.

TABLE 2
LAB PACK CLASSIFICATION EXAMPLES

Classification	Examples
Inorganic acids	Hydrochloric Acid Sulfuric Acid
Inorganic bases	Sodium hydroxide Potassium hydroxide
Strong oxidizing agents	Ammonium nitrate Barium nitrate Sodium chlorate Sodium peroxide
Strong reducing agents	Sodium thiosulfate Oxalic acid Sodium sulphite
Anhydrous organics and organometallics	Tetraethyl lead Phenylmercuric chloride
Anhydrous inorganics and metal hydrides	Potassium hydride Sodium hydride Sodium metal Potassium
Toxic organics	PCBs Insecticides
Flammable organics	Hexane Toluene Acetone
Inorganics	Sodium carbonate Potassium chloride
Inorganic cyanides	Potassium cyanide Sodium cyanide Copper cyanide
Organic cyanides	Cyanoacetamide
Toxic metals	Arsenic Cadmium Lead Mercury

8.3 Drum Opening

Drums are to be opened and sampled in place. For opening drums manually, equipment such as a nonsparking metal (brass, bronze/manganese, aluminum, molybdenum) bung/plug wrench and a drum deheading device will be used for waste contents that are known to be nonreactive and nonexplosive, within a structurally sound drum.

While opening drums manually with a bung wrench, the following procedures will be used:

- Drums will be positioned bung up, or, for drums with bungs on the side, laid on their sides with the bung plug up. Note that care should be taken when moving a drum into position for opening.
- Use a wrenching motion that is a slow and steady pull across the drum, using a "cheater bar" if the leverage for unscrewing the bung is poor.
- If there is evidence of incompatible chemical reactions, a sudden pressure buildup, or a release of potentially toxic fumes while the bung is being loosened, field personnel will immediately leave the area and arrange for remote drum opening equipment to be used.
- If the drum cannot be opened successfully using a nonsparking hand wrench, then other methods of drum opening (deheading or puncturing) must be considered. If deheading or puncturing a drum, it will be necessary to overpack the drum to minimize the potential for spilling the drum's contents.
- If the drum shows signs of swelling or bulging, perform all steps slowly. From a remote location, relieve excess pressure prior to drum opening using the devices listed below, if possible. If performing drum opening activities manually, place a barrier such as an explosion-resistant plastic shield between the worker and bung to deflect any gas, liquid, or solids which may be expelled as the bung is loosened.

Whenever possible, use the following remote-controlled devices for opening drums:

- A pneumatically operated impact wrench to remove drum bungs.

- A hydraulically or pneumatically operated drum piercer.
- A backhoe equipped with bronze spikes for penetrating drum tops (typical in large-scale operations).

Additional general procedures for drum opening are as follows:

- If a supplied-air respiratory protection system is used, the bank of air cylinders must be maintained outside of the work area.
- If personnel must be located near the drums being opened, place explosion-resistant plastic shields between them and the drums, in case of detonation. Locate controls for drum opening equipment, monitoring equipment, and fire suppression equipment behind the explosion-resistant plastic shield. Nonessential personnel must be positioned upwind from the drum opening and sampling operations.
- When feasible, monitor air quality continuously during drum opening, and as close as possible to the potential source of contaminants, (i.e., placing probes as close as practical without hindering drum opening operations), and hang or balance the drum opening equipment to minimize exertion.
- Do not use picks, chisels, etc. to open drums manually.
- Open exotic metal drums and polyethylene or polyvinylchloride-lined (PVC-lined) drums by removing or manually drilling the bung, while exercising extreme caution.
- Do not open or sample individual containers within laboratory packs.
- Reseal open bungs and/or drill openings as soon as possible, with new bungs or plugs to avoid explosions and/or vapor generation. If an open drum cannot be resealed, place the drum into an overpack.
- Plug any openings in pressurized drums with pressure venting caps set to a 5-psi release to allow venting of vapor pressure.

- Decontaminate and/or properly dispose of sampling equipment after each use to avoid mixing incompatible wastes and contaminating subsequent samples.

8.4 Drum Sampling

When sampling a previously sealed vessel, check for the presence of bottom sludge. Since some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel.

The most widely used instrument for sampling is a glass tube commonly referred to as a glass thief (Figure 7, Attachment B). This tool is simple, cost effective, quick and collects a sample without having to decontaminate. Glass thieves are typically 6 mm to 16 mm I.D. and 48 inches long.

Drum sampling can be a very hazardous activity because it often involves direct contact with unidentified wastes. Prior to collecting any sample, field team personnel will become familiar with the procedures identified in the Sampling Plan and in this SOP.

Certain information can be construed from the drumhead configuration prior to sampling, such as:

- Removable "Whole" Lid = designed to contain solid material
- Bung opening = designed to contain liquids
- Drum Liner = may contain a highly corrosive or otherwise hazardous material

When manually sampling from a drum, use the following techniques:

- Keep sampling personnel at a safe distance while drums are being opened. Sample only after opening procedures are complete.
- Do not lean over or between other drums to reach the drum being sampled.
- Cover drum tops with plastic sheeting or other suitable uncontaminated materials to avoid excessive contact with the drum tops.

- Never stand on drums. Use mobile steps or another platform to achieve the height necessary to safely sample from the drums.
- After the drum has been opened, monitor headspace gases with no less than an explosimeter and an organic vapor analyzer. In most cases it is impossible to observe the contents of these sealed or partially sealed vessels.
- Obtain samples with either glass rods (thiefs) or with a vacuum pump and tubing. Do not use contaminated items such as discarded rags during sampling. Glass rods will be removed prior to pumping to minimize damage to pumps.
- Identify each drum with a sample number. Record the number on the Drum Waste Characterization Sheet and permanently on the drum (mark lid and side) using either a label, permanent marker, or spray paint. Cover drums with plastic sheeting and secure to minimize degradation of labeling from variable weather conditions.

8.4.1 Procedures for using a glass thief are as follows:

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About one foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper.
5. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.
6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.

7. Remove tube from the sample container.
8. Cap the sample container tightly and place prelabeled sample container in a carrier.
9. Replace bung or lid securely on drum.
10. Break the thief into pieces inside a drum which has been designated for solid hazardous waste disposal. Previously, drum thieves were broken and disposed inside the drum being sampled. However, this activity hinders the future disposal of liquid drum contents by introducing solid material.
11. Log all samples in the site logbook and on field data sheets.
12. Package samples and complete necessary paperwork.
13. Transport sample to decontamination zone in preparation for transport to analytical laboratory.

8.4.2 COLIWASA Sampler

The Composite Liquid Waste Sampler (COLIWASA) is designed to collect a sample from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. The COLIWASA (Figure 8, Attachment B) is a much cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized materials. One configuration consists of a 152 cm x 4 cm inside diameter (I.D.) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

9.0 QUALITY ASSURANCES/QUALITY CONTROL

The following quality assurance procedures apply:

- Document all data on standard chain of custody forms, field data sheets and/or within site logbooks.

- Operate all instrumentation in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the Work Plan and Sampling Plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and must be documented in the field logbook.

Quality assurance records shall consist of completed Drum Waste Characterization Sheets and data entered into the Field Logbook. A sample Drum Waste Characterization Sheet is presented as Attachment A. Attachment B contains example figures of drum sampling equipment.

10.0 REFERENCES

NIOSH/OSHA/USCG/EPA, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. Publication No. 85-115.

U.S. EPA, 1986. Drum Handling Practices at Hazardous Waste Sites. Wetzel, Furman, Wickline, and Hodge, JRB Associates, McLean, Virginia. Publication No. 86-165362.

NIOSH, 1990. NIOSH Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio. Publication No. 90-117.

U.S. EPA, 1991 Compendium of ERT Waste Sampling Procedures. OSWER Directive 9360.4-07. EPA/540/P-91/008

ATTACHMENT A

DRUM WASTE CHARACTERIZATION SHEET

Project Location _____ Project No. _____
 Project Manager _____ Telephone _____
 Logger _____ Sampler _____
 Weather _____ Date _____ Time _____

Drum Type: Fiber Steel Poly Stainless Steel Nickel
 Poly-Lined Ring Top Closed Top Overpacked
 Drum Size: 85 55 42 30 16 10 5 Other _____
 Drum Contents: Amount Full 3/4 1/2 1/4 <1/4 MT
 Drum Condition: Good Fair Poor

	Physical State				Color	Clarity			Layer Thickness (Inches)
	Liquid	Solid	Gel	Sludge	Use Std. Colors	Clear	Cloudy	Opaque	
Top									
Middle									
Bottom									

pH _____ PID _____ ppm
 Rad Meter _____ mr/hr
 Other _____
 MFG Name _____
 Chemical Name _____

Additional Information: _____

LABORATORY COMPATIBILITY ANALYSES

	Physical State				Color	Clarity			Water Sol. Sor I Density	React. A - Air W - Water	pH Std. Unit	Hex. Sol. Sor I	Per. + or -	Oxid. + or -	CN + or -	Sul. + or -	Biel-Stein + or -	Flash Point °C or °F
	Liquid	Solid	Gel	Sludge	Use Std. Colors	Clear	Cloudy	Opaque										
Top																		
Middle																		
Bottom																		

Comments: _____

PCB Conc. _____ ppm Flash Point _____ °C

Data Reviewer _____ Compatibility Comp. Bulk No. _____

Field Reviewer _____

ATTACHMENT B

LIST OF FIGURES

Figure 1: Universal Bung Wrench

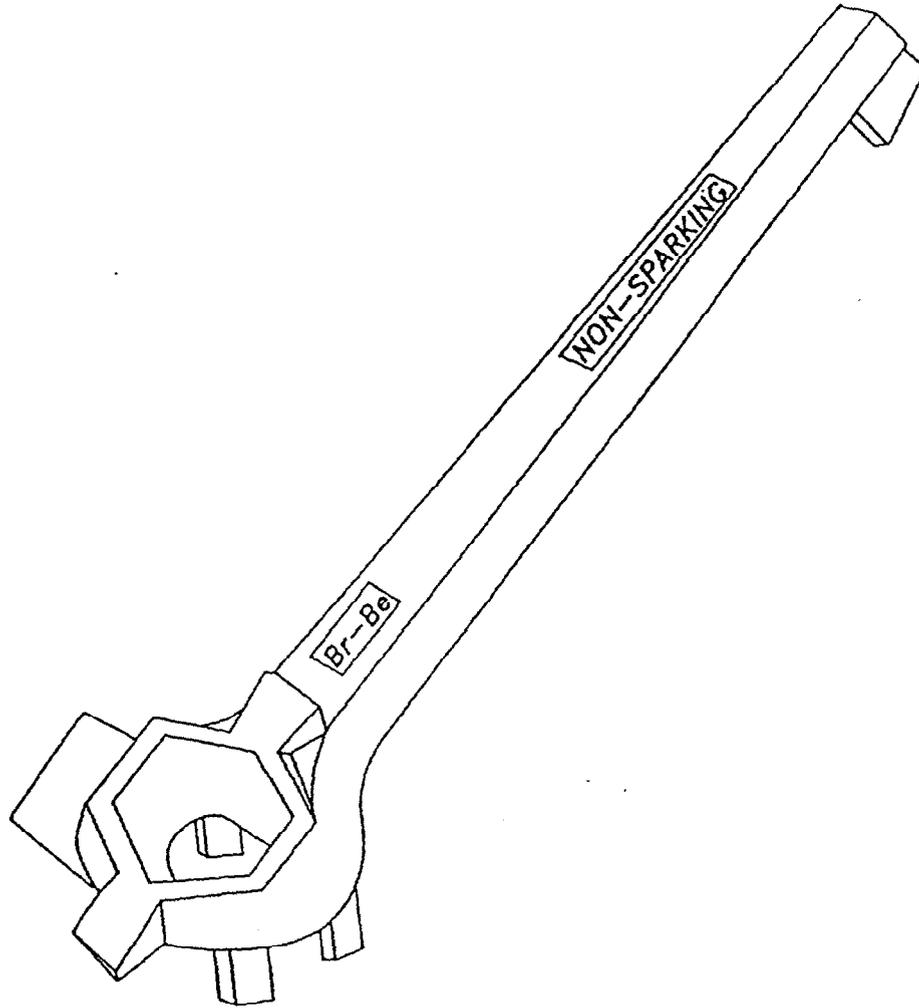


Figure 2: Drum Deheader

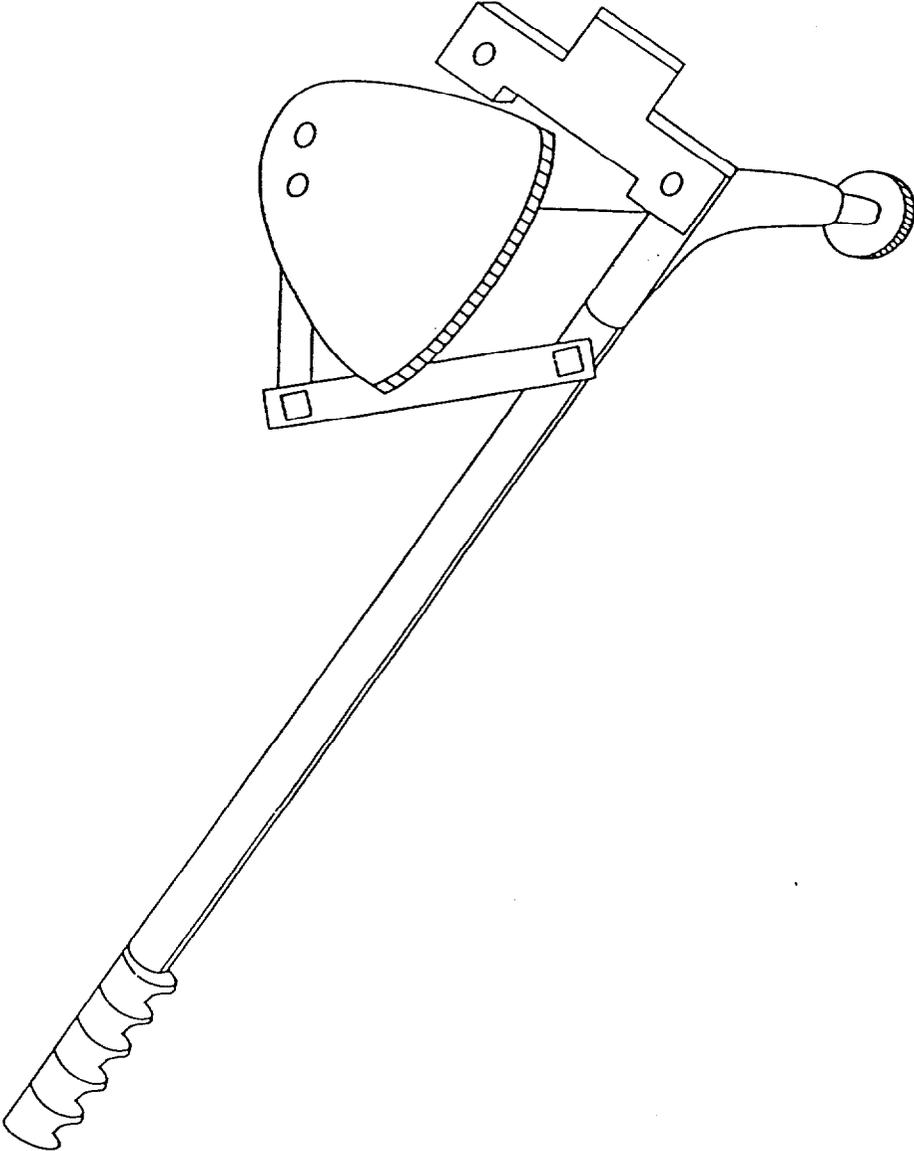


Figure 3: Hand Pick, Pickaxe, and Hand Spike

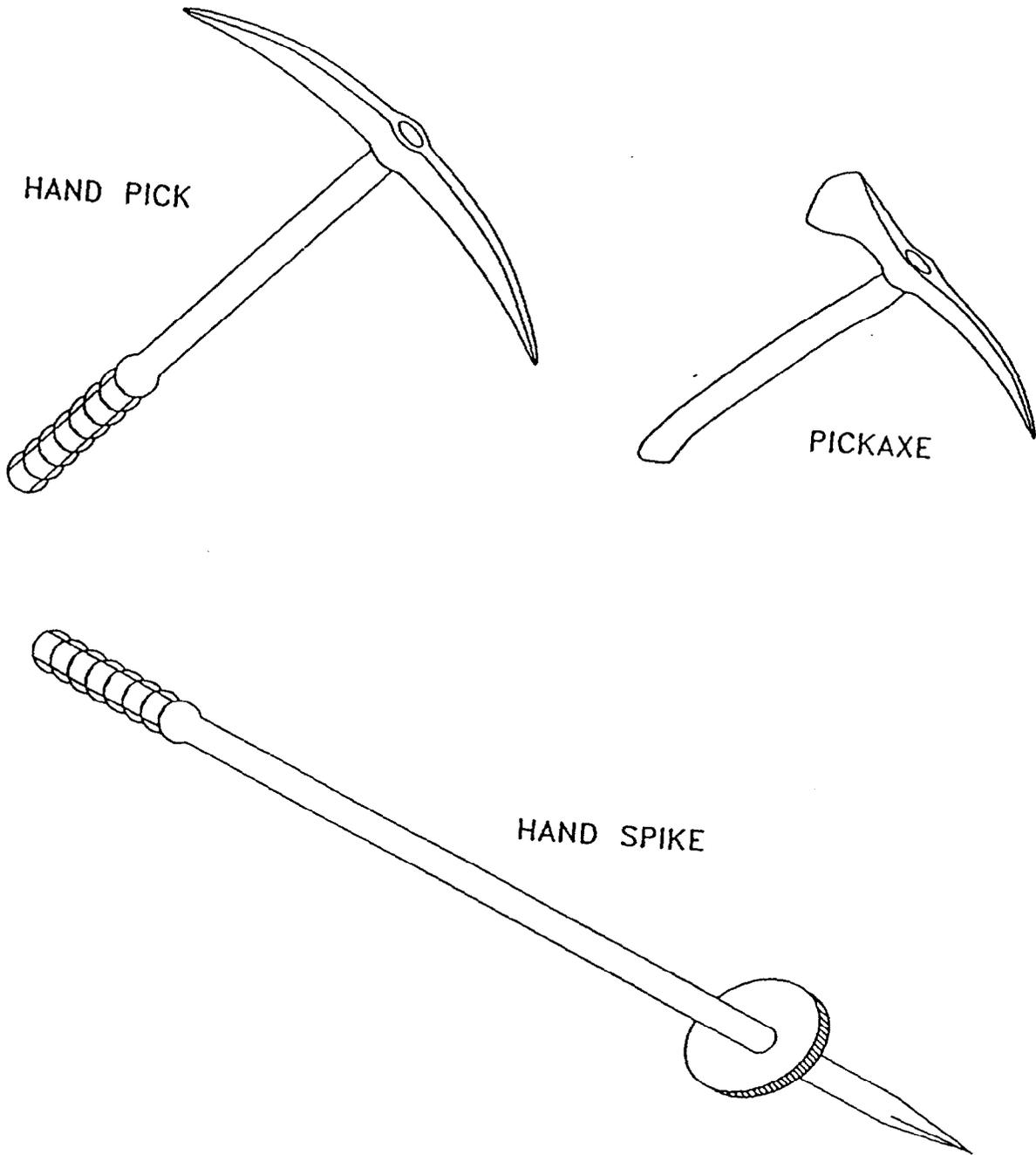


Figure 4: Backhoe Spike

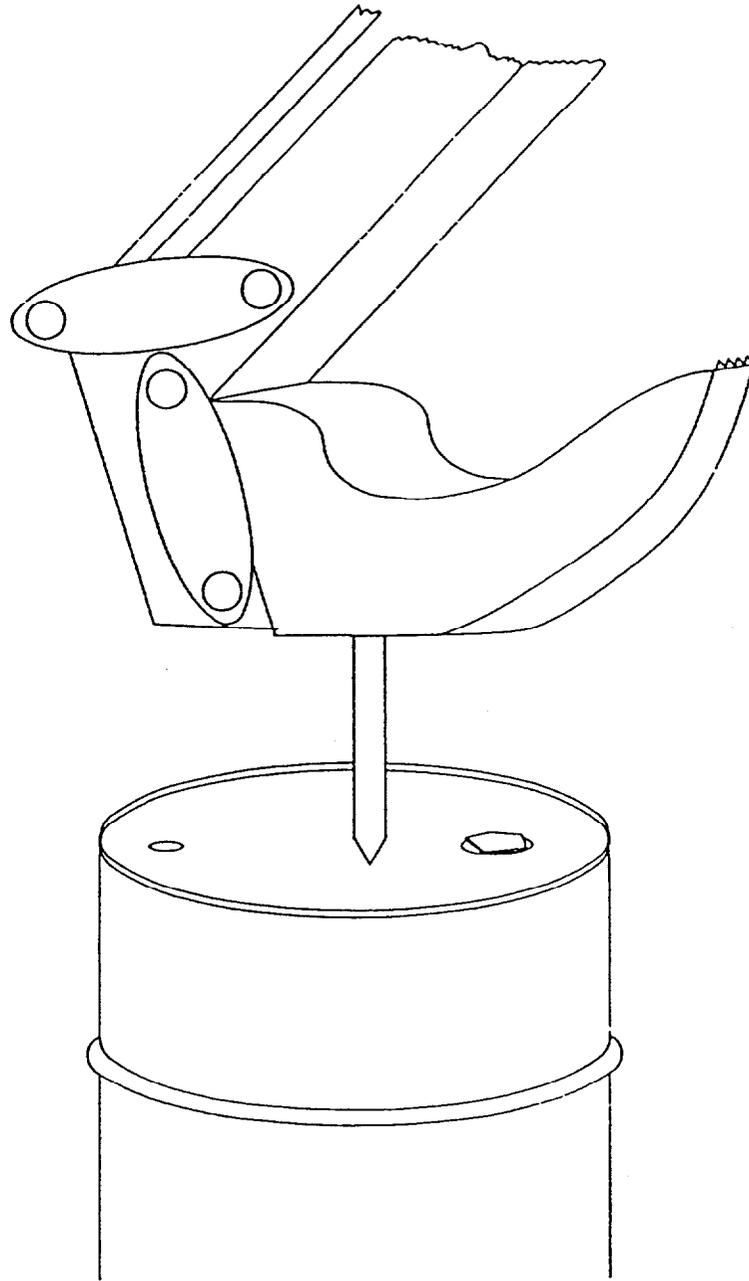


Figure 5: Hydraulic Drum Opener

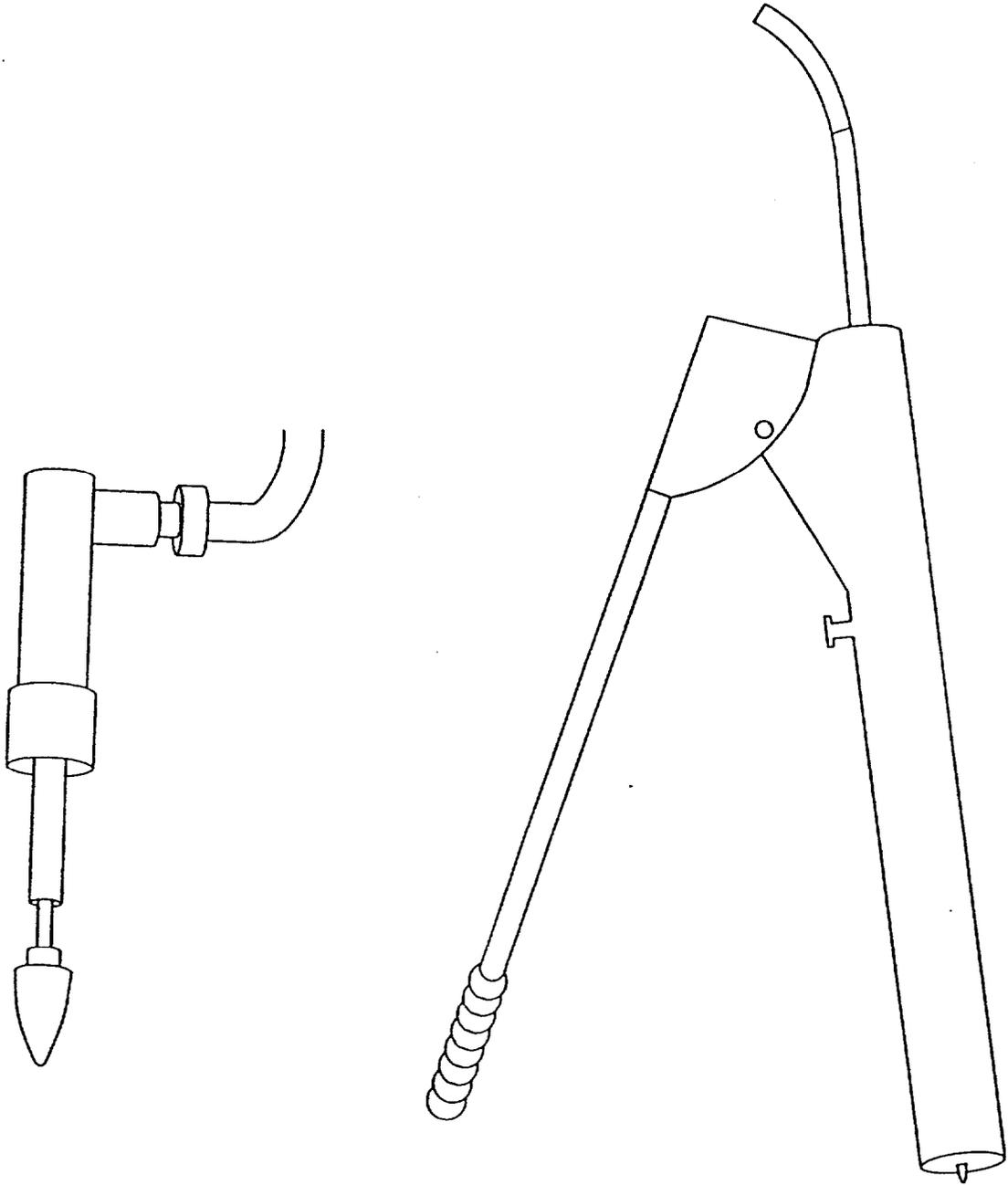


Figure 6: Pneumatic Bung Remover

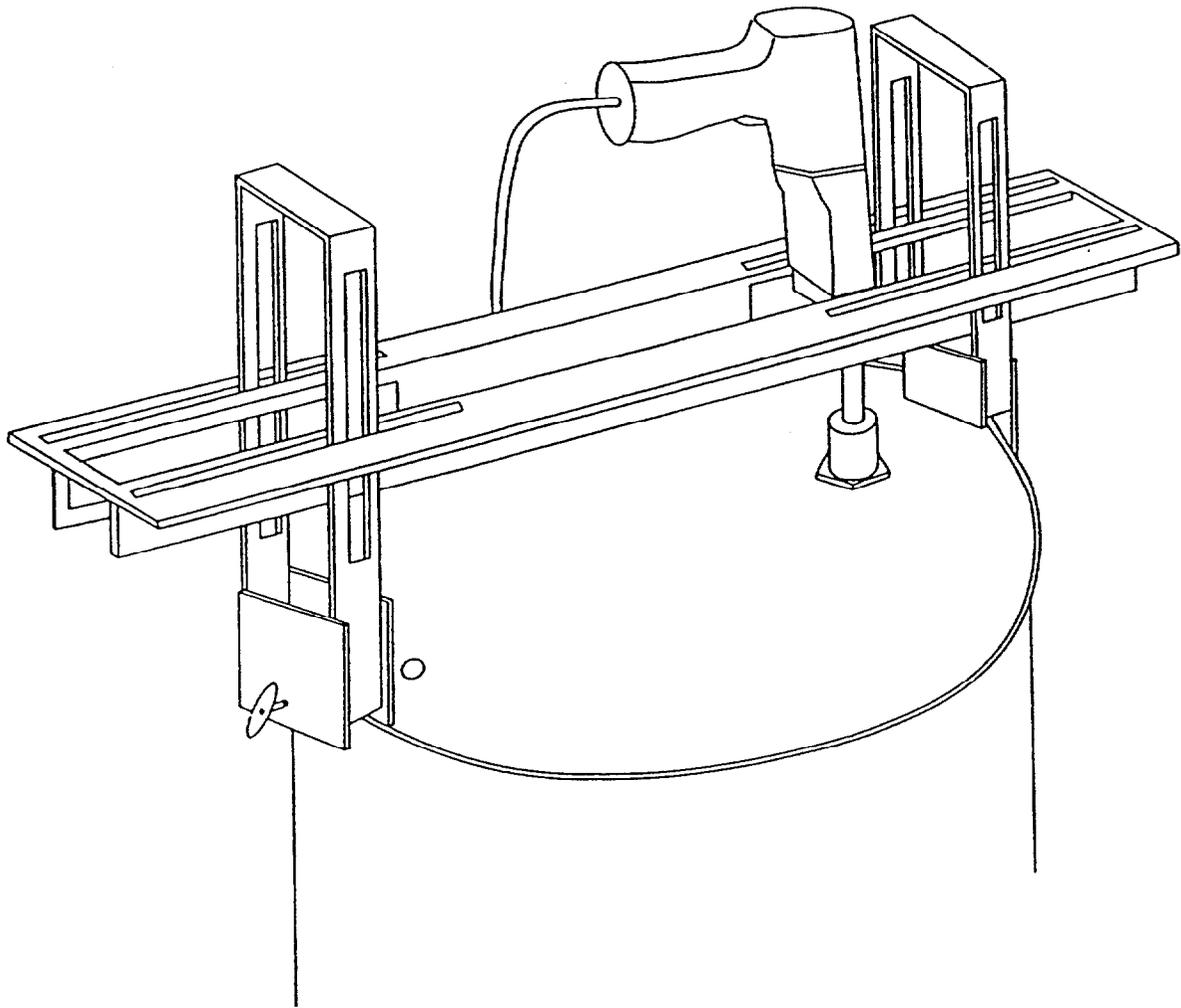
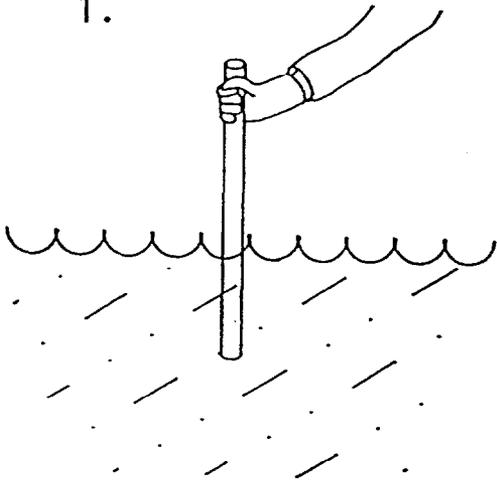


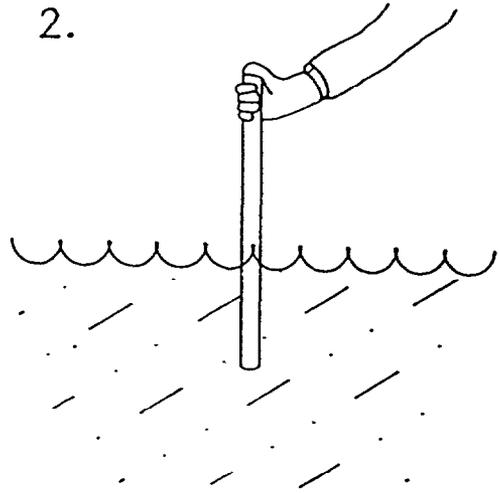
Figure 7: Glass Thief

1.



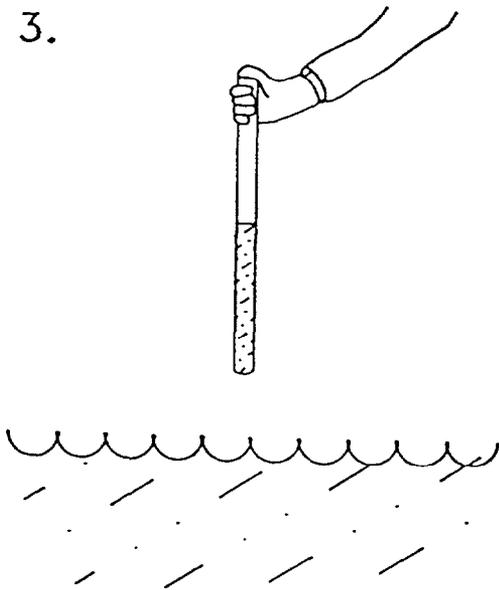
Insert open tube (thief) sampler in containerized liquid.

2.



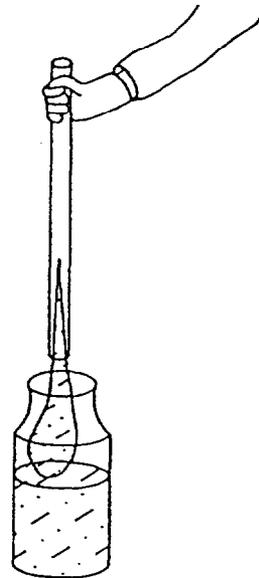
Cover top of sampler with gloved thumb.

3.



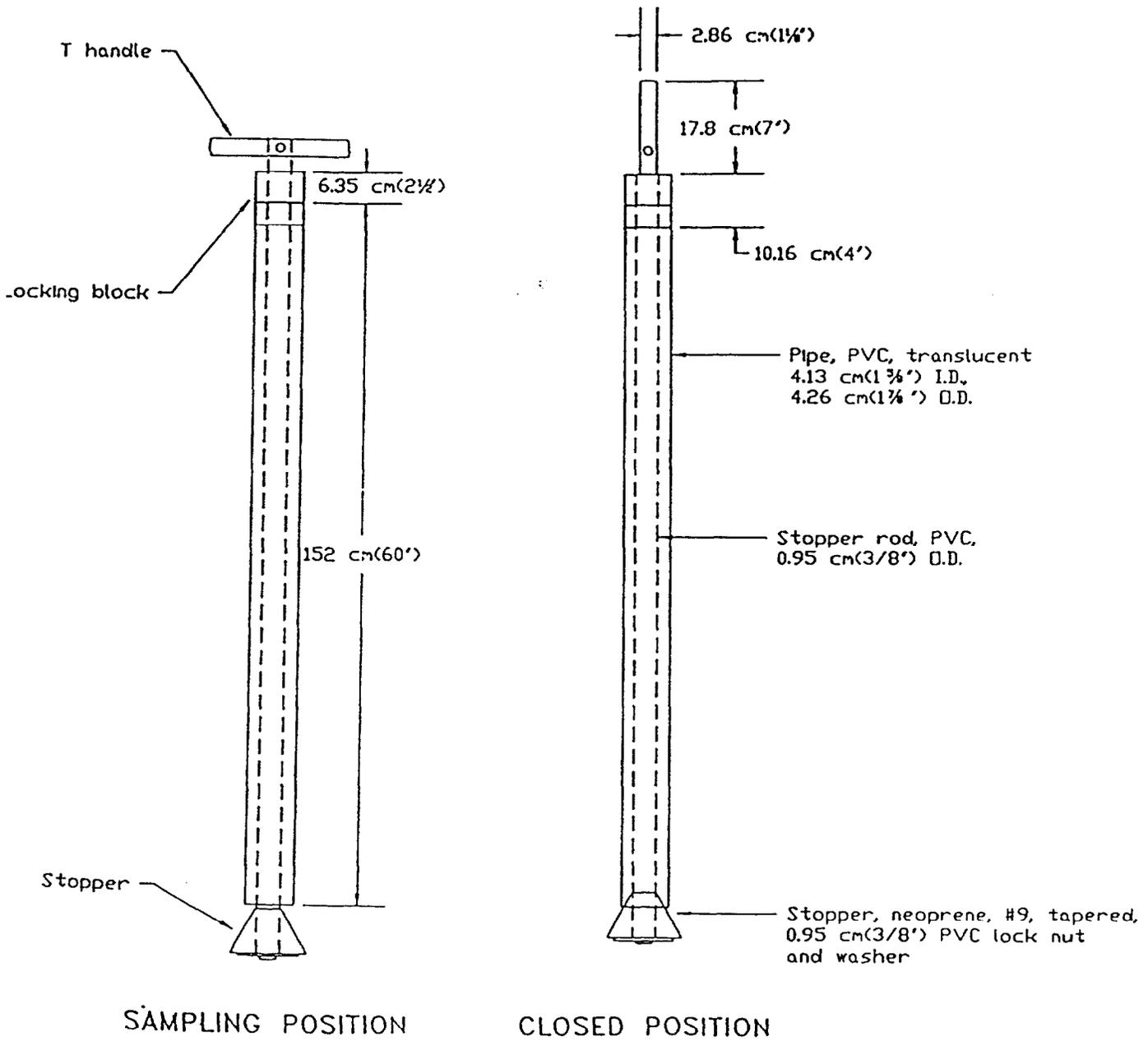
Remove open tube (thief) sampler from containerized liquid.

4.



Place open tube sampler over appropriate sample bottle and remove gloved thumb.

Figure 8: COLIWASA



APPENDIX L
WASTEWATER SAMPLE ACQUISITION

**WASTEWATER SAMPLE ACQUISITION
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 - 5.1 On-Shore
 - 5.2 Off-Shore
- 6.0 QUALITY ASSURANCE RECORDS**
- 7.0 REFERENCES**

WASTEWATER SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for collecting wastewater samples.

2.0 SCOPE

This procedure provides information for the acquisition of waste water samples. Review of the information contained herein will ensure that sample acquisition is properly conducted.

3.0 DEFINITIONS

Sampling Plan - A "plan of action" that guides the implementation of methods that will lead to achieving the plans objective(s).

Grab Sample - An entire sample which is collected at one specific sample location at a specific point in time.

Composite Sample - A sample which is collected at several different locations and/or at different points in time.

Environmental Sample - Samples of naturally occurring materials; soil, sediment, air, water.

Waste Sample - Samples which are comprised of process wastes or other manmade waste material(s).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project specific plans are in accordance with procedures where applicable, or that other approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the waste water sample acquisition techniques and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the Field Investigation personnel performing the sample acquisition activities have been briefed and trained to execute these procedures.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project specific procedures as outlined in the Work Plan and as directed by the Field Team Leader and Project Manager. The Field Investigation Personnel are responsible for documenting all wastewater sampling activities and ambient air monitoring results in the field log book.

5.0 PROCEDURES

This protocol outlines procedures and equipment for the collection of representative liquid samples and sediment/sludge samples from standing lakes, ponds and lagoons, and flowing streams, rivers, channels, sewers and leachate seeps.

The collection of samples from these sources presents a unique challenge. Often sampling can be quite easy and routine (e.g., collecting a surface water sample from a two foot deep stream). Other times, the nature of site specific conditions may dictate that: 1) special equipment is needed to access the sample, 2) appropriate health and safety measures are critical, 3) proper timing is essential due to waste release times or tidal fluctuations, and/or 4) wastewater flow rate is a factor for consideration.

Prior to sample collection, impoundment characteristics (size, depth, flow) should be recorded in the field log book. Sampling should proceed from downstream locations to upstream locations so that sediment disturbance (turbidity) caused by sampling does not affect sample quality. Additionally, if a sediment sample will be collected at the same location as a liquid sample, the liquid sample must be collected first to minimize sample turbidity.

If the Sampling Plan requires that samples are to be collected from the shore of an impoundment, specific health and safety considerations must be addressed. The person collecting the sample should be fitted with a safety harness and rope secured to a sturdy, immobile object on shore. Backup personnel should be available to assist in sample collection

and should be prepared and able to pull the sampler to safety if unstable banks are encountered.

To more adequately characterize the content and/or quality of an impoundment, samples may be collected away from the shoreline, often at various depths. If the content of the impoundment is suspected to be highly hazardous, the risk to sampling personnel must be weighed against the need to collect the sample. If a barge or boat is used, each person on the vessel must be equipped with a life preserver and/or lifeline.

The sampling of liquids in lakes, ponds, lagoons, streams, rivers, channels, sewers and leachate seeps is generally accomplished through the use of one of the following samplers:

- Laboratory cleaned sample bottle
- Pond sampler
- Weighted bottle sampler
- Wheaton dip sampler
- Kemmerer Depth Sampler
- Bacon Bomb Sampler

The factors that will contribute to the selection of a sampler include the width, depth and flow of the location being sampled, and whether the sample will be collected from the shore or a vessel.

For flowing liquids, tidal influence on the collected sample is an additional concern and should be addressed in the Sampling Plan. At a minimum, the stage of the tide at the time of sample collection should be recorded. Consideration should be given to sampling at varied tidal stages as well as seasonally. Tidal information can be obtained from local bait shops, newspaper listings and/or local radio or television news reports.

Samplers may encounter situations where rate of flow affects their ability to collect a sample. For fast flowing rivers and streams it may be nearly impossible to collect a mid-channel sample at a specific point. Low flowing streams and leachate seeps present the opposite problem. In these cases the sampler should attempt to locate an area where flow is obstructed and a pool is created. If this is not possible, sediment may be dug with a decontaminated trowel to create a pooled area where sufficient liquid will accumulate for sampling.

5.1 On-Shore

If the banks are not sloped, sampling personnel may be able to collect the liquid directly into the sample bottle. In some instances where access is limited, a pond sampler, by virtue of its extension capabilities, may be necessary. For a stream, channel or river, collect the sample at mid-depth. For standing liquid, collect the sample from just below the surface or at mid-depth. Once the sample is obtained by sample vessel, transfer it directly into the sample bottle. If volatile organic compounds (VOCs) are to be analyzed, fill the appropriate sample containers for VOCs first, then fill sample containers for other chemical analyses. Decontaminate the sampling device following procedures outlined in the Sampling Plan and/or SOP F502 before obtaining the next sample.

5.2 Off-Shore

Collect a liquid sample using the sample bottle or decontaminated pond sampler, if necessary. If the liquid has stratified, a sample of each strata should be collected. One of the depth samplers listed above will allow collection of discrete representative liquid samples at various depths. Proper use of the chosen sampling device includes slowly lowering and careful retrieval of the sample, immediate transfer of the liquid into the appropriate sampling container, and logbook notation of the depth at which the sample was collected. After collection, the sampling device must be decontaminated prior to obtaining the next sample.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records shall consist of recording sample date and acquisition time(s), sample number, sample location(s), sample depth(s), name of the Field Investigation Personnel collecting the sample(s), and Service Order Number in the field logbook. The type of container used to hold the sample and preservative agent, if needed, also will be documented, as will the method of sampling equipment decontamination. In addition, if photographs are taken of the sample site, the photograph number and direction of view shall be recorded as well.

7.0 REFERENCES

Field Sampling Procedures Manual. Chapter 8. New Jersey Department of Environmental Protection, Trenton, New Jersey. February 1988.

Sampling and Analysis Methods. Compilation of EPA's Sampling and Analysis Methods, USEPA, Washington, D.C. 1991.

Characterization of Hazardous Waste Sites. USEPA, Washington, D. C. 1990.

APPENDIX M
SAMPLE PRESERVATION AND HANDLING

**SAMPLE PRESERVATION AND HANDLING
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- 1.0 PURPOSE**
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 - 5.1 Sample Containers
 - 5.2 Preservation Techniques
 - 5.3 Sample Holding Times
- 6.0 SAMPLE HANDLING AND TRANSPORTATION**
- 7.0 REFERENCES**

samples for analysis is regulated by Code of Federal Regulations Title 40 (Protection of the Environment), along with 49 CFR Part 172 Subpart H. The transportation of chemicals used as preservatives and samples identified as hazardous (as defined by 49 CFR Part 171.8) are regulated by 49 CFR Part 172.

3.0 DEFINITIONS

HCl - Hydrochloric Acid

H₂SO₄ - Sulfuric Acid

HNO₃ - Nitric Acid

NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalents per liter, where an equivalent is the amount of a substance containing one mole of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one mole of H, is "one-normal," while a one molar solution of H₂SO₄ containing two moles of H, is "two-normal."

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is also responsible for proper certification of individuals responsible for transportation of samples of hazardous substances.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures. The Field Team Leader is responsible to ensure all samples and/or hazardous substances are properly identified, labeled, and packaged prior to transportation.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate sample preservation and handling. It is also the responsibility of the field sampling personnel to understand and adhere to the requirements for proper transportation of samples and/or hazardous substances.

laboratory prior to their shipment to the field or added in the field using laboratory supplied preservatives. Some of the more commonly used sample preservation techniques include storage of sample at a temperature of 4°C, acidification of water samples, and storage of samples in dark (i.e. amber) containers to prevent the samples from being exposed to light.

All samples shall be stored at a temperature of 4°C. Additional preservation techniques shall be applied to water samples as follows:

- Water samples to be analyzed for volatile organics shall be acidified.
- Water samples to be analyzed for semivolatile organics shall be stored in dark containers.
- Water samples to be analyzed for pesticides/PCBs shall be stored in dark containers.
- Water samples to be analyzed for inorganic compounds shall be acidified.

These preservation techniques generally apply to samples of low-level contamination. The preservation techniques utilized for samples may vary. However, unless documented otherwise in the project plans, all samples shall be considered low concentration. All samples preserved with chemicals shall be clearly identified by indicating on the sample label that the sample is preserved.

5.3 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses is considered the holding time and must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for routine sample collection are provided in Attachment A.

6.0 **SAMPLE HANDLING AND TRANSPORTATION**

After collection, the outside of all sample containers will be wiped clean with a damp paper towel; however sample handling should be minimized. Personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination and loss of sample labels. Sealable plastic bags, (zipper-type bags), should be used when glass sample containers are placed in ice chests to prevent cross-contamination, if breakage should occur.

ATTACHMENT A

**REQUIRED CONTAINER, PRESERVATION TECHNIQUES
AND HOLDING TIMES**

ATTACHMENT A

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time (1)	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C 1:1 HCl pH <2	10 days	CLP	2 x 40 ml
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
PCB/Pesticides	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
Cyanide	plastic/glass	NaOH to pH >12 Cool to 4°C	14 days	CLP EPA 335.2	1 x 1 liter
Metals (TAL)	plastic/glass	HNO ₃ to pH <2	180 days except Mercury is 26 days	CLP	1 x 1 liter
Total Organic Carbon	glass, teflon lined cap	Cool to 4°C H ₂ SO ₄ to pH <2	28 days	EPA 415.1	2 x 40 ml
Total Organic Halogen	plastic/glass	Cool to 4°C H ₂ SO ₄ to pH <2	28 days	EPA 450.1	250 ml
Chloride	plastic/glass	none required	28 days	EPA 325.2/325.3	250 ml
Sulfate	plastic/glass	Cool to 4°C	28 days	EPA 375.4	250 ml
Alkalinity	plastic/glass	Cool to 4°C	14 days	EPA 310.1/310.2	250 ml
Gross alpha/gross beta	plastic/glass	HNO ₃ to pH <2	6 months	9310	1 gallon
Chlorinated herbicides	glass, teflon lined cap	Cool to 4°C	14/28 days	EPA 515.1	1000 ml
Hardness	plastic/glass	HNO ₃ to pH <2	6 months	EPA 130.2	150 ml

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991. Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

ATTACHMENT B
SAMPLE SHIPPING PROCEDURES

Introduction

Samples collected during field investigations or in response to a hazardous materials incident must be classified by the project leader, prior to shipping by air, as either environmental or hazardous substances. The guidance for complying with U.S. DOT regulations in shipping environmental laboratory samples is given in the "National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Pertinent regulations for the shipping of environmental samples is given in 40 CFR 261.4(d). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods/hazardous substance. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the United Nations International Civil Aviation Organization (UN/ICAO), which is equivalent to IATA.

Individuals responsible for transportation of environmental samples or dangerous goods/hazardous substances must be tested and certified by their employer. This is required by 49 CFR Part 172 Subpart H Docket HM-126 to assure the required qualifications for individuals offering materials for transportation.

Environmental samples shall be packed prior to shipment by commercial air carrier using the following procedures:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug (inside and outside) with fiber or duct tape. Line the cooler with a large heavy duty plastic bag. This practice keeps the inside of the cooler clean and minimizes cleanup at the laboratory after samples are removed.
2. Allow sufficient headspace (ullage) in all bottles (except VOAs) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

APPENDIX N
CHAIN-OF-CUSTODY

**CHAIN-OF-CUSTODY
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- 5.0 PROCEDURES**
 - 5.1 Sample Identification
 - 5.2 Chain-of-Custody Procedures
- 6.0 QUALITY ASSURANCE RECORDS**
- 7.0 REFERENCES**

CHAIN-OF-CUSTODY

1.0 PURPOSE

The purpose of this SOP is to provide information on chain-of-custody procedures to be used to document sample handling.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters, SOP F101). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 DEFINITIONS

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

5.0 PROCEDURES

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.1 Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s);
- CTO Number;
- Project Sample Number;
- Sample location or sampling station number;
- Date and time of sample collection and/or measurement;
- Field observations;
- Equipment used to collect samples and measurements; and,
- Calibration data for equipment used.

Measurements and observations shall be recorded using waterproof ink.

5.1.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project or Contract Task Order (CTO) Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 12/21/85).
- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 am., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.

- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2 Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

5.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.
- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.
- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.
- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.

5.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below.

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method, grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).
- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample shipping package. Retain the copy with field records.
- Sign and date the custody seal; a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening so that it would be broken if the container was to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other

documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

6.0 QUALITY ASSURANCE RECORDS

Once samples have been packaged and shipped, the COC copy and airbill receipt becomes part of the Quality Assurance Record.

7.0 REFERENCES

1. USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

ATTACHMENT A

EXAMPLE SAMPLE LABEL

ATTACHMENT A

EXAMPLE SAMPLE LABEL

Baker	Baker Environmental Inc. Airport Office Park, Bldg. 3 420 Rouser Road Coraopolis, PA 15108
Project: <u>19026-SRN</u>	CTO No.: <u>0026</u>
Sample Description: <u>Groundwater</u>	
Date: <u>09/17/92</u>	Sampler: <u>ABC</u>
Time: <u>0944</u>	
Analysis: <u>TAL Metals (CAP)</u>	Preservation: <u>HNO₃</u>
Project Sample No.: <u>CAX-GW-04</u>	

Note: Typically, sample labels are provided by the analytical laboratory and may be used instead of the above. However, samplers should make sure all pertinent information can be affixed to the label used.

ATTACHMENT B

EXAMPLE CHAIN-OF-CUSTODY RECORD

ATTACHMENT C

EXAMPLE CUSTODY SEAL

ATTACHMENT C

EXAMPLE CUSTODY SEAL

Baker	____/____/____ Date	Baker	____/____/____ Date
	_____ Signature		_____ Signature
	CUSTODY SEAL		CUSTODY SEAL

APPENDIX O
FIELD LOGBOOK

**FIELD LOGBOOK
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- 4.0 RESPONSIBILITIES**
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 - 5.1 Cover
 - 5.2 Daily Entries
 - 5.3 Photographs
- 6.0 QUALITY ASSURANCE RECORDS**
- 7.0 REFERENCES**

FIELD LOGBOOK

1.0 PURPOSE

This SOP describes the process for maintaining a field logbook.

2.0 SCOPE

The field logbook is a document which records all major on-site activities conducted during a field investigation. At a minimum, the following activities/events shall be recorded in the field logbook by each member of the field crew.

- Arrival/departure of site workers and visitors
- Arrival/departure of equipment
- Sample pickup (sample numbers, carrier, time)
- Sampling activities
- Start or completion of boreholes, monitoring wells, or sampling activities
- Health and safety issues

The field logbook is initiated upon arrival at the site for the start of the first on-site activity. Entries are made every day that on-site activities take place. At least one field logbook shall be maintained per site.

The field logbook becomes part of the permanent site file. Because information contained in the field logbook may be admitted as evidence in legal proceedings, it is critical that this document is properly maintained.

3.0 DEFINITIONS

Field logbook - The field logbook is a bound notebook with consecutively numbered pages. Upon entry of data, the logbook requires the signature of the responsible data/information recorder.

4.0 RESPONSIBILITIES

The Field Team Leader is responsible for maintaining a master field logbook for the duration of on-site activities. Each member of the sampling crew is responsible for maintaining a complete and accurate record of site activities for the duration of the project.

5.0 PROCEDURES

The following sections discuss some of the information which must be recorded in the field logbook. In general, a record of all events and activities, as well as other potentially important information shall be recorded by each member of the field team.

5.1 Cover

The inside cover or title page of each field logbook shall contain the following information:

- Contract Task Order Number
- Project name and location
- Name of Field Team Leader
- Baker's address and telephone number
- Start date
- If several logbooks are required, a sequential field logbook number

It is good practice to list important phone numbers and points of contact here.

5.2 Daily Entries

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded by each team member.

- Date
- Start time
- Weather
- All field personnel present
- All visitors present
- Other pertinent information (i.e., planned activities, schedule changes, expected visitors, and equipment changes)

During the day, an ongoing record of all site activities should be written in the logbook. The master logbook kept by the field team leader need not duplicate that recorded in other field logbooks, but should summarize the information in other books and, where appropriate, reference the page numbers of other logbooks where detailed information pertaining to a subject may be found.

Some specific information which must be recorded in the logbook includes:

- Equipment used, equipment numbers, calibration, field servicing
- Field measurements
- Sample numbers, media, bottle size, preservatives, collection methods, and time
- Test boring and monitoring well construction information, including boring/well number and location
- Sketches for each sample location including appropriate measurements if required.
- Photograph log
- Drum log
- Other pertinent information

All entries should be made in indelible ink; all pages numbered consecutively; and all pages must be signed or initialed and dated by the responsible field personnel completing the log. No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single line, initialed, and dated.

5.3 Photographs

If photographs are permitted at a site, the record shall be maintained in the field logbook. When movies, slides or photographs are taken of any site location, they are numbered or cross-referenced to correspond to logbook entries. The name of the photographer, date, time, site location, site description, direction of view and weather conditions are entered in the logbook as the photographs are taken. Special lenses, film, or other image-enhancement techniques also must be noted in the field logbook. Once processed, photographs shall be serially numbered and labeled corresponding to the field logbook entries. Note that it may not be permitted to take photographs at all Activities; permission must be obtained from the LANTDIV EIC and the Activity responsible individual.

6.0 QUALITY ASSURANCE RECORDS

Once on-site activities have been completed, the field logbook shall be considered a quality assurance record.

7.0 REFERENCES

None.

FINAL

**SITE INVESTIGATION
QUALITY ASSURANCE PROJECT PLAN
FOR
SITE 10 - ORIGINAL BASE LANDFILL**

MCB, CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0369

JANUARY 20, 1998

Prepared for:

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1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been developed for the field investigation of the following site at Marine Corps Base, Camp Lejeune, North Carolina:

- Site 10 - Original Base Landfill

The preparation of this QAPP, and other related project plans, is being performed under the Navy CLEAN Contract No. N62470-89-D-4814, Contract Task Order 0369. Baker Environmental, Inc., (Baker) is the prime contractor for the implementation of this project.

This QAPP addresses the quality assurance and quality control steps and procedures that will be administered for the sample collection and analysis for this Site Investigation (SI). Detailed information regarding sample handling and analytical methods are provided in Sections 6.0 and 9.0, respectively. Sample collection procedures are provided in the Field Sampling and Analysis Plan (FSAP).

2.0 SCOPE OF QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) addresses sample collection and analysis to be conducted for the field investigation of Site 10 of Camp Lejeune, North Carolina. The QAPP has been developed for the Department of Navy (DON) in accordance with U.S. Environmental Protection Agency (USEPA) guidelines. Contractors will follow QA/QC practices and procedures, including chain-of-custody procedures, while conducting all sample collection and analysis activities.

In order to provide adequate QA/QC, this investigation will require:

1. The use of a NFESC-certified analytical laboratories;
2. The use of accepted analytical methods for the samples discussed in the FSAP. Analysis of samples for hazardous constituents parameters will be performed using the following documents:
 - "Statement of Work for Organic Analysis," USEPA, OLM01.9, August 1991
 - "Statement of Work for Inorganic Analysis," USEPA, ILM03.0, March 1990
 - "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
 - "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
 - "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition
 - "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886
3. The conducting of field audit(s) during initial sampling activities to verify that sampling is being performed according to the Plan.

The structure of this QAPP and the QA elements addressed are:

- Title Page
- Table of Contents
- Introduction
- QAPP Scope
- Project Description
- Project Organization
- QA Objectives for Data Measurement
- Sampling Procedures

- QA Objectives for Data Measurement
- Sampling Procedures
- Sample and Document Custody
- Calibration Procedures and Frequency
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal QC Checks
- Performance and System Audits
- Preventive Maintenance
- Data Measurement Assessment Procedures
- Corrective Action
- QA Reports to Management

3.0 PROJECT DESCRIPTION

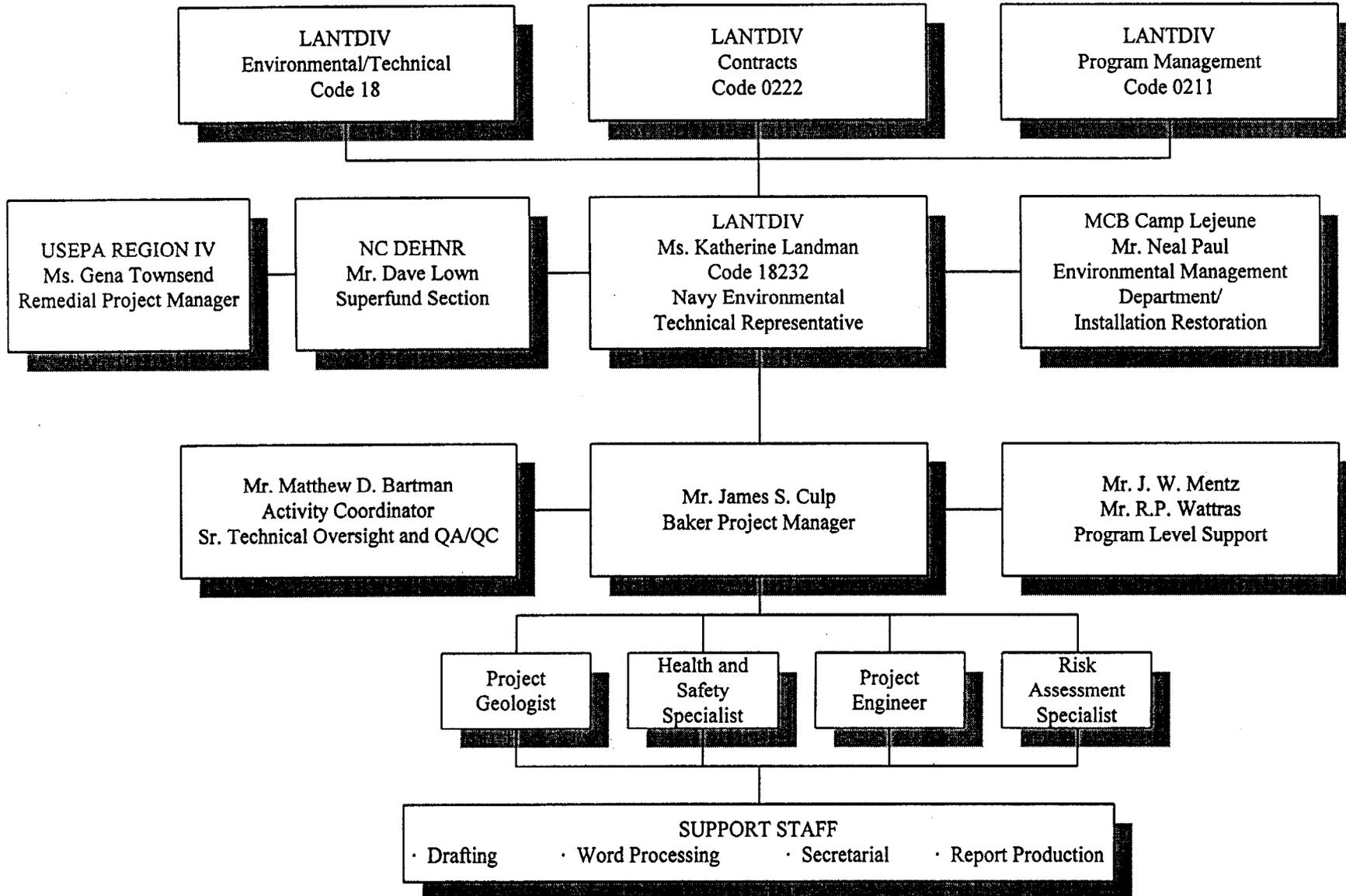
An introduction to the field investigation of Site 10 describing the project objectives and scope are given in Sections 4.0 and 5.0 of the SI Work Plan. These sections discuss the objectives of the SI, and the various field sampling and analytical programs. A detailed description of the field investigations, including sample location and designation and sampling procedures and frequency, is presented in Sections 3.0, 4.0, and 5.0 of the FSAP.

4.0 PROJECT ORGANIZATION

Technical performance of the investigation of Site 10 at Camp Lejeune and key personnel responsible for quality assurance throughout its duration are described in Section 5.0 of the SI Work Plan. The contractor will utilize subcontractors to perform laboratory analysis, data validation, drilling and monitoring well installation, geophysical investigation, and surveying. Specific subcontractors have not yet been identified. Figure 4-1 shows the project organization, lines of authority, and support personnel/organizations.

FIGURE 4-1

PROJECT ORGANIZATION



5.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

The purpose of a QA Program is to establish policies for the implementation of regulatory requirements and to provide an internal means for control and review so that the work performed is of the highest professional standards.

5.1 Project Quality Assurance Objectives

The following is a list of QA objectives which will be implemented at Camp Lejeune Site 10.

- Obtain scientific data of a quality sufficient to meet scientific and legal scrutiny.
- Gather/develop data in accordance with procedures appropriate for its intended use.
- Ensure that data is of acceptable precision, accuracy, completeness, representativeness, and comparability as required by the project.

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

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of skilled, qualified personnel.
- Assessment of all quality assurance sampling reports furnished by the contract laboratory.
- Assessment of data through data validation, and of procedures through laboratory and field audits.
- Correction for prevention of reoccurrence of conditions adverse to quality.

This QAPP, prepared in direct response to these goals, describes the QA Program to be implemented and the quality control (QC) procedures to be followed by field and laboratory personnel during the course of the project.

This QAPP presents the project organization and specifies or references technical procedures, documentation requirements, sample custody requirements, audit, and corrective action provisions to be applied to provide confidence that all activities meet the intent of the QA program. This QAPP has been prepared in accordance with USEPA guidance as presented in "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80.

The procedures contained or referred to herein have been taken from:

- "Statement of Work for Organic Analysis," USEPA, OLM01.9, August 1991
- "Statement of Work for Inorganic Analysis," USEPA, ILM03.0, March 1990
- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised

- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
- "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
- "Test Methods for Evaluating Solid Waste," USEPA SW846, November 1986, 3rd Edition
- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886
- "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," USEPA, (QAMS 005/80).

5.2 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 to support a specific decision. The DQOs are expressed in terms of precision, accuracy, representativeness, completeness, and comparability. Definitions for these terms, as well as for the more general term uncertainty, are given in Table 5-1. The Project Manager, in conjunction with the Navy Environmental Technical Representative (NTR), is responsible for defining the DQOs. The intended use of the data, analytical measurements, and the availability of resources are integral in development of DQOs. DQOs define the level of uncertainty in the data that is acceptable for each specific activity during the investigation. This uncertainty includes both field sampling error and analytical instrument error. Ideally, zero uncertainty is the goal; however, the variables associated with sampling and analysis contribute to a degree of uncertainty in any data generated. It is an overall program objective to keep the total uncertainty within an acceptable range, so as not to hinder the intended use of the data. To achieve this objective, specific data quality requirements such as detection limits, criteria for accuracy and precision, sample representativeness, data comparability, and data completeness have been specified.

The data collected will be used:

- To evaluate the presence or absence of contamination resulting from previous disposal activities.
- To assess potential contaminant migration and exposure pathways.
- To monitor health and safety conditions during field activities.
- To identify releases or suspected releases of hazardous waste and/or constituents.
- To screen from further investigation those areas which do not pose a threat to human health or environment.

All samples for characterizing the site or qualitatively assessing human health and environmental risks will be analyzed and reported by the laboratory as Level IV data (NFESC Level D). Field parameters including temperature (aqueous only) and specific conductance will be Level I (NFESC Level A) data quality.

TABLE 5-1

DEFINITIONS OF DATA QUALITY INDICATORS

PRECISION - A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is expressed in terms of the standard deviation. Comparison of replicate values is best expressed as the relative percent difference (RPD). Various measures of precision exist depending upon the "prescribed similar conditions".

ACCURACY - The degree of agreement of a measurement (or an average of replicate 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.

6.0 SAMPLE AND DOCUMENT CUSTODY PROCEDURES

Descriptions of the procedures to be used for sampling the groundwater and soil at the site are provided in the FSAP. The number of samples, sampling locations, and sampling rationale by media also are presented in Section 5.0 of the FSAP.

Sample custody procedures outlined in this section have been developed from "User's Guide to the Contract Laboratory Program," December 1988, OSWER Directive No. 9240.0-01. These procedures are in accordance with "EPA NEIC Policies and Procedure Manual," May 1978, revised November 1984, EPA 330-78-001-R and "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," December 1980, QAMS-005/80.

The purpose of this section is to outline the sample handling and sample documentation procedures to be used during implementation of the FSAP. The objective of the sample handling procedures is to deliver representative samples to the laboratories for analysis. The objectives of the sample documentation procedures are to: (1) ensure complete analysis of the requested parameters within the required turnaround times; and (2) document the sample from the point of collection to the final data report.

6.1 Sampling Handling

New polyethylene or glass bottles containing the proper preservatives will be provided by the laboratory for sample collection. In addition to the chemical preservatives, samples will be stored on ice at 4°C in a waterproof metal or sturdy plastic cooler, if required (see Tables 6-1 through 6-2 for summaries of containers, preservation, and holding times for water and solids, respectively).

6.2 Chain-of-Custody Procedures

A sample is considered to be in an individual's possession if:

- It is in the sampler's possession or it is in the sampler's view after being in his or her possession.
- It was in the sampler's possession and then locked or sealed to prevent tampering.
- It is in a secure area.

Five kinds of documentation will be used in tracking and shipping the analytical samples:

- Field log book
- Sample labels
- Chain-of-Custody (COC) records
- Custody seals
- Commercial carrier airbills

TABLE 6-1

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES

Parameter	Container	Preservation	Holding Time
TCL Volatiles	Two 40-ml vials with teflon septum caps	Cool, 4°C HCl pH <2	14 days (7 days if unpreserved)
TCL Semivolatiles	1-liter amber glass bottle with teflon caps	Cool, 4°C	7 days to extraction; 40 days from extraction to analysis
TCL Pesticides/PCBs	1-liter amber glass bottle with teflon caps	Cool, 4°C	7 days to extraction; 40 days after extraction for analysis
TAL Metals	1-500 ml polyethylene bottle	HNO ₃ pH<2	6 months; Mercury 28 days

Notes:

TAL - Target Analyte List

TCL - Target Contaminant List

TABLE 6-2

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOLID SAMPLES

Parameter	Container	Preservation	Holding Time
TCL Volatiles	One 4-ounce wide-mouth glass jars	Cool, 4°C	10 days
TCL Semivolatiles	One 8-ounce wide-mouth glass jar	Cool, 4°C	7 days to extraction; 40 days from extraction to analysis
TCL Pesticides/PCBs	One 8-ounce wide-mouth glass jar	Cool, 4°C	7 days to extraction; 40 days after extraction for analysis
TAL Metals	One 8-ounce wide-mouth glass jar	Cool, 4°C	6 months; Mercury, 28 days
TCLP Metals	Two 8-ounce wide-mouth glass jar	Cool, 4°C	14 days
Corrosivity	One 4-ounce wide-mouth glass jar	Cool, 4°C	10 days
Ignitability	One 4-ounce wide-mouth glass jar	Cool, 4°C	14 days
Reactivity	One 4-ounce wide-mouth glass jar	Cool, 4°C	10 days

Notes:

TAL - Target Analyte List

TCL - Target Contaminant List

TCLP - Toxicity Characteristic Leaching Procedure

At a minimum, the label for each sample bottle will contain the following information:

- Site name
- Sample number
- Date and time of collection
- Sample type (grab or composite)
- Matrix
- Sampler's initials

The sample information, as well as the analysis to be performed on the sample, will be entered in the field log book for each sampling point. Additionally, the following items will be entered:

- Dates and times of entry
- Names of field personnel on site
- Names of visitors on site
- Field conditions
- Description of activities
- Sampling remarks and observations
- QA/QC samples collected
- List of photographs taken
- Sketch of site conditions

Custody of the samples will be maintained by field personnel from the time of sampling until the time they are forwarded to the analytical laboratory.

The sample custody is documented using Chain-of-Custody (COC) records. Field personnel will complete a COC record, in waterproof ink, to accompany each cooler forwarded from the site to the laboratory. Chemical reagents used to preserve the samples will be recorded on the COC record. Any errors on the COC records will not be erased; instead, a line will be drawn through the error and initialed by the person completing the form. The original copy will be placed in a sealable plastic bag and put inside the appropriate cooler, secured to the cooler's lid.

If the sample cooler is to be shipped by commercial air carrier, the cooler must be secured with custody seals so that the seals would be broken if the cooler was opened. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill.

If the sample shipment is hand delivered to the laboratory by field personnel or retrieved by laboratory personnel at the site, then the custody seals are not necessary. The laboratory sample custodian, or his/her designee accepting the sample shipment, whether it is from the air carrier or the field personnel, signs and dates the COC record upon sample receipt. The original COC record will be returned along with the final data report. The laboratory will be responsible for maintaining internal log books and records that provide a custody record during sample preparation and analysis.

Laboratory Chain-of-Custody Procedures

Upon sample receipt the steps below will be performed.

- Samples will be received and unpacked in the laboratory where the staff checks for bottle integrity (loose caps, broken bottles, etc.).
- Samples will be verified with incoming paperwork (packing slip, etc.) by type of bottle and stabilizer. The paperwork must be either signed or initialed.
- Information concerning the sample (from the sampling record, Chain-of-Custody, and observation) will be recorded along with parameters to be analyzed, date of sampling, and date the sample is received in the laboratory.
- Samples will be placed in an appropriate secured storage area until analysis.
- When analysis is complete, samples will be stored for a 30-day period unless otherwise specified.

If collected samples arrive without Chain-of-Custody or incorrect Chain-of-Custody records, the following steps will be taken:

- The laboratory will prepare a nonconformance form stating the problem.
- The site supervisor and Project Manager will be notified.
- If the missing information cannot be provided by the field staff, the samples affected will not be analyzed.

Primary considerations for sample storage are:

- Secured storage.
- Maintain prescribed temperature, if required, which is typically four degrees Celsius.
- Extract and/or analyze samples within the prescribed holding time for the parameters of interest.

6.3 Document Custody Procedures

Project records are necessary to support the validity of the work and to furnish documentary evidence of quality. The evidentiary value of data is dependent upon the proper maintenance and retrieval of quality assurance records. Therefore, procedures will be established to assure that all documents attesting to the validity of work can be accounted for when the work is completed.

Records must be legible, filled out completely, and adequately identified as to the item or activity involved. Records will be considered valid only if initialed, signed, or otherwise authenticated and dated by authorized personnel. These records may either be originals or reproduced copies. Records submitted to the files, with the exception of correspondence, will be bound, placed in folders or binders, or otherwise secured for filing.

Following receipt of information from external sources, completion of analyses, and issuance of reports or other transmittals, associated records will be submitted to the proper file. In addition, transmitted records must be adequately protected from damage and loss during transfer (e.g. hand carrying or making copies prior to shipment).

The following documents will be transferred to the proper files during the course of the project: calculations and checkprints; reports and other data transmittals; copies of proposals, purchase orders for project services, and contracts; correspondence including incoming and outgoing letters, memoranda, and telephone records; and reference material.

All individuals on the project staff will be responsible for reporting obsolete or superseded project-related information to the Project Manager. In turn, the Project Manager will notify the project and laboratory staffs of the resulting status change in project documents, such as drawings and project procedures.

In general, outdated drawings and other documents will be marked "void." However, the Project Manager may request the copies be destroyed. One copy of void documents is maintained in the project files with the reasons, and date of voiding clearly indicated.

Documents will be marked "preliminary" to denote calculations and other material which have not been formally checked, or based on information which has not been checked, or do not contribute to final project information.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

The following section describes calibration procedures and frequency.

7.1 Field Instruments

Two field instruments will be used for health and safety monitoring: the O₂/LEL meter, and the HNu System portable photoionizer. These instruments will be calibrated on site daily according to the manufacturer's instructions in addition to the factory calibration it will receive prior to the start of site sampling. The calibration standards will be recorded in the field log book.

A pH meter and a conductivity meter will be used to analyze groundwater and surface water samples. Procedures from "Test Methods for Evaluating Solid Waste," USEPA, SW846, November 1986, 3rd Edition will be used to calibrate these meters. Specific procedures for the calibration of water quality instruments are presented in the FSAP.

7.2 Laboratory Instruments

The laboratory's procedures for calibration and related quality control measures will be conducted according to the protocols presented in the following documents:

- "Statement of Work for Organic Analysis," USEPA, OLM01.9, August 1991
- "Statement of Work for Inorganic Analysis," USEPA, ILM03.0, March 1990
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," USEPA, July 1982
- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
- "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
- "Test Methods for Evaluating Solid Waste," USEPA SW848, November 1986, 3rd Edition
- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

Formal calibration procedures will be established to ensure that instrumentation and equipment used for sample analysis are accurately calibrated and properly functioning. These procedures will apply to all instruments and equipment quantities. All calibrations will be performed by laboratory personnel or external agencies using standard reference materials.

All calibrations will be recorded on in-house calibration forms or instrument vendor forms or in dedicated bound notebooks. The following data will be recorded for all calibrations: the date, target

readings, actual readings, instrument identification number, and the analyst's initials. Other data may be recorded depending upon the calibration performed.

Only properly calibrated and operating equipment and instrumentation will be used. Equipment and instrumentation not meeting the specified calibration criteria will be segregated from active equipment whenever possible. Such equipment will be repaired and recalibrated before reuse.

All equipment will be uniquely identified, either by serial number or internal calibration number, to allow traceability between equipment and calibration records. Recognized procedures (ASTM, USEPA, or manufacturer's procedures) will be used for calibration whenever available.

7.2.1 Method Calibration

Method calibration will be performed as part of the laboratory analytical procedure (calibration curves, tuning). Calibration curves will be prepared using five standards in graduated amounts across the appropriate range of analysis. New calibration curves will be prepared whenever new reagents or standards are prepared or yearly, whichever is more frequent.

7.2.2 GC/MS System Calibration Procedure

This section outlines the requirements for the calibration of GC/MS systems for the determination of organic compounds. The following operations will be performed in support of these requirements:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time monitoring

Tuning and Mass Calibration

It will be necessary to establish that a given GC/MS system meets the standard mass spectral abundance criteria prior to initiating data collection. This will be accomplished through the analysis of p-bromofluorobenzene (BFB) for volatile compounds or decafluorotri-phenylphosphine (DFTPP) for semivolatile compounds. The BFB or DFTPP criteria must be met before any blanks, standards, or samples are analyzed.

A GC/MS system used for organic compound analysis will be tuned to meet the criteria specified for BFB analysis (volatile compounds) or DFTPP (semivolatile compounds) for an injection of 50 nanograms (ng) of BFB or DFTPP. The analysis must be performed separately from standard or blank analysis. These criteria will be demonstrated every 12 hours of operation. Professional judgment must be used to determine whether background subtraction is required to eliminate column bleed or instrument background (i.e., noise). Calibration documentation will be in the form of a bar graph spectrum and a mass listing.

GC/MS System Calibration

After tuning criteria have been met and prior to sample analysis, the GC/MS system is initially calibrated at five concentrations utilizing the compounds to be analyzed to determine the linearity of response. Internal and surrogate standards will be used with each calibration standard. Standards will be analyzed under the same conditions as the samples.

- **Relative Response Factor (RRF) Calculation** - The USEPA specifies the internal standard to be used on a compound-by-compound basis for quantification. The relative response factor (RRF) will be calculated for each compound at each concentration level.
- **Continuing Calibration** - A calibration check standard containing all semivolatile or volatile compounds and surrogates will be run every 12 hours of analysis. A system performance check will also be performed. The criteria will be the same as for the initial calibration system performance check. A calibration check will also be performed. The percent difference will be determined for each Calibration Check Compound (CCC).

The percent Difference for each CCC must be less than or equal to 25.0 percent. The system performance check and calibration check criteria must be met before sample analysis can be performed. The continuing calibration will be recorded on the continuing calibration forms.

7.2.3 GC System Calibration Procedure for Pesticides/PCBs

This section outlines the requirements for the calibration of GC systems for the determination of pesticides/PCBs. The following operations are performed in support of these requirements:

Three types of analyses will be used to verify the calibration and evaluate instrument performance. The analyses of instrument blanks, Performance Evaluation mixtures (PEMs), and the mid-point concentration of the individual standard mixtures A and B constitute the continuing calibration.

For pesticide/PCB analysis it is necessary to establish resolution criteria by performing a Resolution Check Mixture where the depth of the valley of two adjacent peaks must be greater than or equal to 60.0 percent of the height of the shorter peak.

The breakdown of DDT and Endrin in both of the PEMs must be less than 20.0 percent and the combined breakdown of DDT and Endrin must be less than 30.0 percent. All peaks in both the Performance Evaluation Mixtures must be 100 percent resolved on both columns.

The absolute retention times of each of the single component pesticides and surrogates in both of the PEMs must be within the retention time windows determined from the three point initial calibration.

The relative percent difference of the calculated amount and the true amount for each of the single component pesticides and surrogates in both of the PEMs must be less than or equivalent to 25 percent.

At least one chromatogram between any two adjacent peaks in the midpoint concentrations of Individual Standard Mixtures A and B in the initial calibration must be greater than or equal to 90 percent.

7.2.4 System Calibration Procedure for Metals Analysis

This section outlines the requirements for the calibration of atomic absorption (AA) and Inductively Coupled Plasma (ICP) systems for the determination of metals. The following will be performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The AA system utilized for direct aspiration technique analysis will be initially calibrated with a calibration blank and five calibration standards. The standard concentrations will be determined as follows. One standard will be at a concentration near, but above, the MDL. The other concentrations will correspond to the expected range of concentrations found in the actual samples. This five-point calibration must be performed daily.

The AA system utilized for graphite furnace technique analysis will be initially calibrated with a calibration blank and three calibration standards. The standard concentrations will be determined as follows. One standard will be at a concentration at the Contract Required Detection Limit (CRDL). The other concentrations will correspond to the expected range of concentrations found in the actual samples. This three-point calibration must be performed daily.

For AA systems, the calibration standards will be prepared fresh each time an analysis is to be performed and discarded after use. The standards contain the same reagents at the same concentrations as will result in the samples following preparation.

The ICP system will be calibrated initially with a calibration blank and one calibration standard. This calibration must be performed daily. In addition, ICP systems must undergo quarterly linearity checks.

Correlation Coefficient Calculation

The data points of the blank and the five calibration standards will be utilized to calculate the slope, the intercept, and the correlation coefficient of the best fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient will be >0.995 for AA analyses and >0.995 for ICP analysis.

Calibration Verification

The initial calibration curve will be verified on each working day by the measurement of one mid-range calibration standard. The calibration verification acceptance criterion will be as follows:

- ICEP/GFAA - 90 to 110 percent of true value
- Cold Vapor AA - 80 to 120 percent of true value

When measurements exceed the control limits, the analysis will be terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.

7.2.5 System Calibration Procedure for Inorganic Analyses

This section outlines the requirements that will be used for calibration of calorimetric systems for analyses of inorganic parameters. The following will be performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The system will be initially calibrated with a blank and five calibration standards. Standard concentrations will be at a concentration near, but above, the MDL with additional concentrations corresponding to the expected range of concentrations found in actual samples. Standards contain the same reagents at the same concentrations as will be present in samples following preparation.

Correlation Coefficient Calculation

Data points of the blank and five calibration standards will be utilized to calculate slope, intercept, and correlation coefficient of a best fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient will be >0.995 for all systems.

Calibration Verification

The initial calibration curve will be verified on each working day by the measurement of two calibration standards.

- ICEP/GFAA - 90 to 110 percent of true value
- Cold Vapor AA - 80 - 120 percent of true value

When measurements exceed control limits, analysis will be terminated, the problem will be corrected, the instrument will be recalibrated, and calibration will be reverified.

7.2.6 Periodic Calibration

Periodic calibration must be performed on equipment required in analyses but not routinely calibrated as part of the analytical methodology. Equipment that falls within this category includes ovens, refrigerators, and balances. The calibration will be recorded either on specified forms or in bound notebooks. Discussed below are the equipment, the calibration performed, and the frequency at which the calibration must be performed.

- Balances will be calibrated weekly with class S weights.
- The pH meter will be calibrated daily with pH 4 and 7 buffer solutions and checked with pH 10 buffer solution.

- The temperatures of the refrigerators will be recorded daily.
- All liquid in glass thermometers will be calibrated annually with the N.B.S. certified thermometer. Dial thermometers will be calibrated quarterly.
- The N.B.S. Certified Thermometer will be checked annually at the ice point.

The following equipment must maintain the following temperatures:

- Sample Storage and Refrigerators - within 2 degrees of 4 degrees Celsius
- Water Bath, Mercury - within 2 degrees of 95 degrees Celsius

8.0 ANALYTICAL PROCEDURES

This next section discusses analytical procedures.

8.1 Field Analysis

A O₂/LEL and HNu PI-101 meters will be used to analyze ambient air for health and safety monitoring, as well as to screen soil during the soil sampling. The O₂/LEL meter detects explosive gases that may be present (i.e., methane). The HNu PI-101 detects total organic vapor. These instruments will be operated in accordance with the manufacturer's instructions.

The pH, temperature, and specific conductivity of aqueous samples also will be measured in the field. These analyses will be obtained in accordance with "Handbook for Sampling and Sample Preservation of Water and Wastewater," September 1982, EPA/600/4-82-029.

8.2 Laboratory Analysis

The samples that will be collected during the investigation will be analyzed for constituents listed in Tables 8-1 through 8-4. Parameters will be analyzed using USEPA methods as noted in Tables 8-1 through 8-4. Compounds and the corresponding method performance limits also are listed in Tables 8-1 through 8-4.

TABLE 8-1

ORGANIC METHOD PERFORMANCE LIMITS

Compound	Water CRQL ⁽¹⁾ (µg/L)	Soil/Sediment CRQL ⁽¹⁾ (µg/kg)	Method
Volatiles:			CLP/SOW ⁽²⁾
Chloromethane	10	10	
Bromomethane	10	10	
Vinyl Chloride	10	10	
Chloroethane	10	10	
Methylene Chloride	10	10	
Acetone	10	10	
Carbon Disulfide	10	10	
1,1-Dichloroethene	10	10	
1,1-Dichloroethane	10	10	
1,2-Dichloroethene (total)	10	10	
Chloroform	10	10	
1,2-Dichloroethane	10	10	
2-Butanone	10	10	
1,1,1-Trichloroethane	10	10	
Carbon Tetrachloride	10	10	
Bromodichloromethane	10	10	
1,2-Dichloropropane	10	10	
cis-1,3-Dichloropropene	10	10	
Trichloroethene	10	10	
Dibromochloromethane	10	10	
1,1,2-Trichloroethane	10	10	
Benzene	10	10	
trans-1,3-Dichloropropene	10	10	
Bromoform	10	10	
4-Methyl-2-pentanone	10	10	
2-Hexanone	10	10	
Tetrachloroethene	10	10	
Toluene	10	10	
1,1,2,2-Tetrachloroethane	10	10	
Chlorobenzene	10	10	
Ethylbenzene	10	10	
Styrene	10	10	
Xylenes (total)	10	10	

TABLE 8-1 (Continued)

ORGANIC METHOD PERFORMANCE LIMITS

Compound	Water CRQL ⁽¹⁾ (µg/L)	Soil/Sediment CRQL ⁽¹⁾ (µg/kg)	Method
Semivolatiles:			CLP/SOW ⁽²⁾
Phenol	10	330	
bis(2-Chloroethyl) ether	10	330	
2-Chlorophenol	10	330	
1,3-Dichlorobenzene	10	330	
1,4-Dichlorobenzene	10	330	
Benzyl alcohol	10	330	
1,2-Dichlorobenzene	10	330	
2-Methylphenol	10	330	
bis(2-Chloroisopropyl)ether	10	330	
4-Methylphenol	10	330	
N-Nitroso-di-n-dipropylamine	10	330	
Hexachloroethane	10	330	
Nitrobenzene	10	330	
Isophorone	10	330	
2-Nitrophenol	10	330	
2,4-Dimethylphenol	10	330	
Benzoic acid	25	1600	
bis(2-Chloroethoxy)methane	10	330	
2,4-Dichlorophenol	10	330	
1,2,4-Trichlorobenzene	10	330	
Naphthalene	10	330	
4-Chloroaniline	10	330	
Hexachlorobutadiene	10	330	
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	10	330	
2-Methylnaphthalene	10	330	
Hexachlorocyclopentadiene	10	330	
2,4,6-Trichlorophenol	10	330	
2,4,5-Trichlorophenol	25	1600	
2-Chloronaphthalene	10	330	
2-Nitroaniline	25	1600	
Dimethylphthalate	10	330	
Acenaphthylene	10	330	

TABLE 8-1 (Continued)

ORGANIC METHOD PERFORMANCE LIMITS

Compound	Water CRQL ⁽¹⁾ (µg/L)	Soil/Sediment CRQL ⁽¹⁾ (µg/kg)	Method
2,6-Dinitrotoluene	10	330	CLP/SOW ⁽²⁾
3-Nitroaniline	25	1600	
Acenaphthene	10	330	
2,4-Dinitrophenol	25	1600	
4-Nitrophenol	25	1600	
Dibenzofuran	10	330	
2,4-Dinitrotoluene	10	330	
Diethylphthalate	10	330	
4-Chlorophenyl-phenyl ether	10	330	
Fluorene	10	330	
4-Nitroaniline	25	1600	
4,6-Dinitro-2-methylphenol	25	1600	
N-nitrosodiphenylamine	10	330	
4-Bromophenyl-phenylether	10	330	
Hexachlorobenzene	10	330	
Pentachlorophenol	25	1600	
Phenanthrene	10	330	
Anthracene	10	330	
Di-n-butylphthalate	10	330	
Fluoranthene	10	330	
Pyrene	10	330	
Butylbenzylphthalate	10	330	
3,3'-Dichlorobenzidine	10	660	
Benzo(a)anthracene	10	330	
Chrysene	10	330	
bis(2-Ethylhexyl)phthalate	10	330	
Di-n-octylphthalate	10	330	
Benzo(b)fluoranthene	10	330	
Benzo(k)fluoranthene	10	330	
Benzo(a)pyrene	10	330	
Indeno(1,2,3-cd)pyrene	10	330	
Dibenz(a,h)anthracene	10	330	
Benzo(g,h,i)perylene	10	330	

TABLE 8-1

ORGANIC METHOD PERFORMANCE LIMITS

Compound	Water CRQL ⁽¹⁾ (µg/L)	Soil/Sediment CRQL ⁽¹⁾ (µg/kg)	Method
Volatiles:			CLP/SOW
Chloromethane	10	10	
Bromomethane	10	10	
Vinyl Chloride	10	10	
Chloroethane	10	10	
Methylene Chloride	5	5	
Acetone	10	10	
Carbon Disulfide	5	5	
1,1-Dichloroethene	5	5	
1,1-Dichloroethane	5	5	
1,2-Dichloroethene (total)	5	5	
Chloroform	5	5	
1,2-Dichloroethane	5	5	
2-Butanone	10	10	
1,1,1-Trichloroethane	5	5	
Carbon Tetrachloride	5	5	
Bromodichloromethane	5	5	
1,2-Dichloropropane	5	5	
trans-1,3-Dichloropropene	5	5	
Trichloroethene	5	5	
Dibromochloromethane	5	5	
1,1,2-Trichloroethane	5	5	
Benzene	5	5	
trans-1,3-Dichloropropene	5	5	
Bromoform	5	5	
4-Methyl-2-pentanone	10	10	
2-Hexanone	10	10	
Tetrachloroethene	5	5	
Toluene	5	5	
1,1,2,2-Tetrachloroethane	10	10	
Chlorobenzene	5	5	
Ethylbenzene	5	5	
Styrene	5	5	
Xylenes (total)	5	5	

TABLE 8-2

INORGANIC METHOD PERFORMANCE LIMITS

Analyte	Method Number ⁽¹⁾	CRDL ⁽²⁾ (µg/L)	Method Description
Metals: Aluminum	200.7	200	Inductively Coupled Plasma
Antimony	200.7 204.2	60	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Arsenic	200.7 206.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Barium	200.7	200	Inductively Coupled Plasma
Beryllium	200.7 210.2	5	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Cadmium	200.7 213.2	5	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Calcium	200.7 215.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Chromium	200.7 218.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Cobalt	200.7	50	Inductively Coupled Plasma
Copper	200.7	25	Inductively Coupled Plasma
Iron	200.7	100	Inductively Coupled Plasma
Lead	200.7 239.2	3	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Magnesium	200.7 242.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Manganese	200.7	15	Inductively Coupled Plasma
Mercury	245.1 245.2 245.5	0.2	Water by manual cold vapor technique Water by automated cold vapor technique Soil/sediment by manual cold vapor technique

TABLE 8-2 (Continued)

INORGANIC METHOD PERFORMANCE LIMITS

Analyte	Method Number ⁽¹⁾	CRDL ⁽²⁾ (µg/L)	Method Description
Nickel	200.7	40	Inductively Coupled Plasma
Potassium	200.7 258.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Selenium	200.7 270.2	5	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Silver	200.7 272.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Sodium	200.7 273.1	5000	Inductively Coupled Plasma Atomic Absorption, Direct Aspiration
Thallium	200.7 279.2	10	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Vanadium	200.7	50	Inductively Coupled Plasma
Zinc	200.7	20	Inductively Coupled Plasma

Notes:

- ⁽¹⁾ Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM03.0, March 1990.
- ⁽²⁾ Contract Required Detection Limit.

TABLE 8-3

TCLP METHOD PERFORMANCE LIMITS

Parameter	Aqueous PQL ⁽¹⁾ (µg/L)	Solid PQL ⁽¹⁾ (µg/kg)	Method
TCLP Volatiles:			EPA Method 3550A/ EPA Method 8240B
Benzene	5	10	
Carbon Tetrachloride	5	5	
Chloroform	5	5	
1,2-Dichloroethane	5	5	
1,1-Dichloroethylene	5	5	
Methyl ethyl ketone	NA	NA	
Tetrachloroethylene	5	5	
Trichloroethylene	5	5	
Vinyl Chloride	10	10	
TCLP Semivolatiles:			EPA Method 3550A/ EPA Method 8270B
o-Cresol	10		
m-Cresol	10	660	
p-Cresol	10	660	
Cresol	10	660	
1,4-Dichlorobenzene	10	660	
2,4-Dinitrotoluene	10	660	
Hexachlorobenzene	10	660	
Hexachlorobutadiene	10	660	
Hexachloroethane	10	660	
Nitrobenzene	10	660	
Pentachlorophenol	50	3300	
Pyridine	50	3300	
2,4,5-Trichlorophenol	10	660	
2,4,6-Trichlorophenol	10	660	
TCLP Pesticides:			EPA Method 3550A/ EPA Method 8080A
Chlordane	0.14	9.4	
Endrin	0.06	4.0	
Heptachlor (and its hydroxide)	0.03	2.0	
Lindane	0.04	2.7	
Methoxychlor	1.8	120	
Toxaphene	2.4	160	
TCLP Herbicides:			EPA Method 8105
2,4-D	12	240	
2,4,5-TP Silvex	1.7	34	

TABLE 8-3 (Continued)

TCLP METHOD PERFORMANCE LIMITS

Analyte	Water PQL ⁽¹⁾ (µg/L)	Soil PQL ⁽¹⁾ (µg/kg)	Method	Method Description
TCLP Metals:				
Arsenic	10	30	6010A 7060A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Barium	20	1	6010A	Inductively Coupled Plasma
Cadmium	1	2	6010A 7131A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Chromium	20	4	6010A 7191	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Lead	10	2	6010A 7421	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Mercury	2	0.002	7470A	Water by manual cold vapor technique Water by automated cold vapor technique
Selenium	20	40	6010A 7740	Inductively Coupled Plasma Atomic Absorption, Furnace Technique
Silver	2	4	6010A 7760A	Inductively Coupled Plasma Atomic Absorption, Furnace Technique

Notes:

⁽¹⁾ Practical Quantitation Limit, taken from "Test Methods for Evaluating Solid Waste," USEPA, November 1986. Most recent updates include: 60101A, 7760A-July 1992; 3550A, 8240B, 8270B, 8080A, 7060A, 7131A, 7470A-September 1994.

These methods will be used to analyze the Toxicity Characteristic Leading Procedure (TCLP) extract. The extract will be prepared using Method 1311, described in "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52FR 26886.

TABLE 8-4

RCRA METHOD PERFORMANCE LIMITS

Parameter	Aqueous Performance Limit	Solid Performance Limit	Method
RCRA:			
pH/Corrosivity	NA ⁽¹⁾	NA ⁽¹⁾	SW-846 9010A
Ignitability	NA ⁽¹⁾	NA ⁽¹⁾	SW-846 1010
Reactive Cyanide	10 mg/L ⁽¹⁾	10 mg/L ⁽¹⁾	SW-846 9012
Reactive Sulfide	50 mg/L ⁽¹⁾	50 mg/kg ⁽¹⁾	SW-846 9030A

Notes:

⁽¹⁾ Practical Quantitation Limit taken from "Test Methods for Evaluating Solid Waste," USEPA, November 1986. Most recent updates include 9010A, 9030A - July 1992.

NA = Not applicable

9.0 DATA REDUCTION, VALIDATION AND REPORTING

The following section presents data reduction, validation, and reporting procedures.

9.1 Field Data Procedures

Data validation practices as described by "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses," USEPA, June 1988, and "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses - Draft," USEPA, June 1991 will be followed to insure that raw data are not altered and that an audit trail is developed for those data which require reduction. The documentation of sample collection will include the use of bound field log books in which all information on sample collection will be entered in indelible ink. Appropriate information will be entered to reconstruct the sampling event, including site name (top of each page), sample identification, brief description of sample, date and time of collection, sampling methodology, field measurements and observations, and sampler's initials (bottom of each page, and dated).

A rigorous data control program will insure that all documents for the investigations are accounted for when they are completed. Accountable documents include items such as log books, field data records, correspondence, chain-of-custody records, analytical reports, data packages, photographs, computer disks, and reports. The project manager will be responsible for maintaining a project file in which all accountable documents will be inventoried. The project records will be retained for a period of three years after project close-out; then the files will be forwarded to the Navy.

All the field data, such as those generated during field measurements, observations and field instrument calibrations, will be entered directly into a bound field notebook. Each project team member will be responsible for proofing all data transfers made, and the Project Manager or his designee will proof at least ten percent of all data transfers.

9.2 Laboratory Data Procedures

The following procedures summarize the practices routinely used by laboratory staff for data reduction, validation, and reporting. Numerical analyses, including manual calculations, will be documented and subjected to quality control review. Records of numerical analyses must be legible and complete enough to permit reconstruction of the work by a qualified individual other than the originator.

9.2.1 Laboratory Data Validation

Data validation begins with data reduction and continues through to the reporting of data.

Data processing will be checked by an individual other than the analyst who performed the data processing. The checker will review the data for the following:

- Utilization of the proper equations
- Correctness of numerical input
- Correctness of computations

- Correct interpretation of raw data (chromatographs, strip charts, etc.)

The checking process will be sufficient thorough enough to verify the results.

All entries made in benchbooks, data sheets, computation sheets, input sheets, etc. will be made in ink. No entry will be rendered unreadable.

9.2.2 Analytical Reports

The items listed below will be required of analytical reports.

- Data will be presented in a tabular format.
- Analytical reports will be approved by appropriate laboratory personnel.
- The following information will be included on the report: client name and address, report date, sample date, analysis dates, number of samples, purchase order number, project number, and project type. All pages must be numbered.
- The sample numbers and corresponding laboratory numbers will be identified.
- The parameters analyzed, report units, and values will be identified.
- Method, trip, and field blank results will be reported.
- Matrix spike, matrix spike duplicate, and replicate recoveries will be reported.
- Calibration summaries will be reported.
- Surrogate recoveries will be reported.
- Holding times and sample analysis dates will be reported.
- The detection limit of the procedure will be identified.
- Consistent significant figures will be used.
- Referenced footnotes will be used when applicable.
- A letter of transmittal will accompany the report if any anomalies are associated with the data.

9.3 Independent (Third Party) Data Validation

Review of all pertinent analytical data will be performed by Baker personnel and an independent third party data validator.

A preliminary review will be performed by the Project Manager or designee to verify that all necessary paperwork (e.g., chain-of-custodies, traffic reports, analytical reports, and laboratory personnel signatures) and deliverables are present. A detailed and independent data validation will be performed by a data validation subcontractor to verify the qualitative and quantitative reliability of the data presented and adherence to stated analytical protocols. This review will include a detailed review and interpretation of all data generated by the laboratory for Level III or IV deliverables. The primary tools which will be used by experienced data validation personnel will be analytical method operating practices, statements of work (for CLP), guidance documents, established criteria, and professional judgment.

During the data review, a data support documentation package will be prepared which will provide the back-up information that will accompany all qualifying statements present in the quality assurance review.

10.0 INTERNAL QUALITY CONTROL CHECKS

The following section describes internal quality control checks.

10.1 Field Quality Control Checks

Four types of field quality assurance/quality control samples will be submitted to the laboratory: trip blanks, equipment rinsates, field blanks, and field duplicates. The results from the field quality control samples will be used by the data validator to determine the overall quality of the data. A breakdown by type of sample with which the QA/QC samples will be submitted to the laboratories is given in Table 10-1. A summary of the number of environmental and QA/QC samples to be submitted for analysis will be given in the FSAP.

Field Blanks

Field blanks consist of the source water used in decontamination, steam cleaning, and drilling. At a minimum, one field blank from each vent and each source of water must be collected and analyzed for the same parameters as the related samples. Organic-free deionized water is taken to the field in sealed containers and poured into the appropriate sample containers at predesignated locations. This will be done to determine if any contaminants present in the area may have an affect on the sample integrity.

Trip Blank

Analysis of trip blanks will be performed to monitor possible contamination during shipment and collection of samples. Trip blanks are initiated in the laboratory prior to the shipping of sample packs. A corresponding trip blank will be prepared for each set of samples to be analyzed for volatile organic compounds.

Trip blank samples will be prepared by adding four drops of concentrated hydrochloric acid and then filling the container with organic-free deionized water (ASTM Type II). The trip blanks accompany the samples through shipment to the sample site, sample collection, shipment to the laboratory, and storage of the samples.

If the analyses indicate contamination of the trip blank, the sample sources may be resampled. If the extent and nature of the contamination does not warrant such actions, the data will be accepted as valid.

Field Duplicates

Duplicates for soil samples are collected, homogenized, and split. All samples except VOCs are homogenized, and split. Volatiles are not mixed, but select segments of the soil are taken from the length of the core and placed in 4-ounce glass jars. Cores may be sealed and shipped to the laboratory for subsampling if the project deems this appropriate. The duplicate for water samples should be collected simultaneously. Field duplicates should be collected at a frequency of 10% per sample matrix for Levels III and IV. All the duplicates should be sent to the primary laboratory responsible for analysis. The same samples used for field duplicates shall be split by the laboratory

TABLE 10-1
QA/QC SAMPLE FREQUENCY

Type of Sample	Metal	Organic
Trip Blank (for volatiles only)	NA ⁽¹⁾	One per cooler or one per shipping day
Equipment Rinsate ⁽²⁾	One per day	One per day
Field Blank	One per source per event ⁽³⁾	
Field Duplicate ⁽⁴⁾	10%	10%

Notes:

- (1) Not applicable
- (2) Samples are collected daily; however, only samples from every other day are analyzed.
- (3) Other samples are held and analyzed only if evidence of contamination exists.
- (4) Source water includes water used in decontamination, steam cleaning, and drilling.
The duplicate must be taken from the sample which will become the laboratory matrix spike/matrix duplicate for organics or for the sample used as a duplicate in inorganic analysis.

and used by the laboratory as the laboratory duplicate or matrix spike. This means that for the duplicate sample, there will be analyses of the normal sample, the field duplicate, and the laboratory matrix spike/duplicate.

Equipment Rinsates

Equipment rinsates are the final organic-free deionized water rinse from equipment cleaning collected daily during a sampling event. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are found in the rinsate, the remaining samples must be analyzed. The results of the blanks will be used to flag or assess levels of analytes in the samples. This comparison is made during validation. The rinsates are analyzed for the same parameters as the related samples.

10.2 Laboratory Quality Control Checks

This section provides descriptions of the laboratory quality control checks.

Method Blank

Analysis of method blanks will be performed to verify that method interferences caused by contamination in reagents, glassware, solvents, etc. are minimized and known.

Method blanks will be initiated by the analyst prior to the preparation and/or analysis of the sample set. A method blank consists of a volume of organic-free deionized water equal to the sample volume which is carried through the entire analytical procedure. For solid samples to be analyzed by GC/MS, the method blank consists of a purified solid matrix approximately equal to the sample weight. A method blank will be analyzed with each set of samples or at the very least, daily. If the analytical data of the method blank indicates excessive contamination, the source of contaminant will be determined. The samples may be re-analyzed or the data may be processed "as is" depending upon the nature and extent of the contamination.

Replicate Sample Analysis

Replicate sample analysis will be performed to demonstrate the precision of an analysis. An interlaboratory replicate sample is initiated by the analyst prior to sample preparation and carried through the entire analytical procedure. The frequency of interlaboratory replicate analysis for each analyte is summarized in Table 10-2.

Spike Analysis

Spike analysis will be performed to demonstrate the accuracy of an analysis. The analyst initiates the spike prior to sample preparation and analysis by adding a known amount of analyte(s) to a sample. The spike sample is carried through the entire analytical procedure. The frequency of spike analysis for each analyte(s) is summarized in Table 10-2.

TABLE 10-2
QA/QC ANALYSIS FREQUENCY

Parameter	Replicate	Spike
Organics:		
All analyses by GC/MS	5%	5%
All analyses by GC	5%	5%
Metals:		
Liquids by flame AA or ICP	5%	5%
Solids by flame AA or ICP	5%	10%
All analyses by furnace AA	5%	10%

Surrogate Standards

Surrogate standard analysis will be performed to monitor the preparation and analyses of samples. All samples and blanks analyzed by GC/MS and GC are fortified with a surrogate spiking solution prior to extraction or purging.

Internal Standards

Internal standard analyses will be performed to monitor system stability. Prior to injection or purging, internal standards are added to all blanks and samples analyzed by GC/MS (refer to Section 5.1.1.).

Matrix Spikes and Matrix Spike Duplicates

A matrix spike is an aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery. A matrix spike duplicate is a second aliquot of the same matrix as the matrix spike that is spiked in order to determine the precision of the method. A matrix spike and matrix spike duplicate will be performed at a frequency of 1 per 20 samples for organics.

10.3 Laboratory Control Limits

Control limits will be established for QC checks (spikes, duplicates, blanks, etc.). CLP control limits for surrogate standards spikes, and duplicates associated with GC/MS analyses and pesticides/PCB analyses. Control limits for spikes, duplicates, and reference samples will be determined internally through statistical analysis.

Whenever an out-of-control situation occurs, the cause is determined. Any needed corrective actions must be taken.

Method Blanks

For metals analyses, the criteria below are used for method blank analysis.

- If the concentration of the method blank is less than or equal to the detection level, no correction of sample results is performed.
- If the concentration of the blank is above the detection level for any group of samples associated with a particular blank, the concentration of the sample with the least concentrated analyte must be ten times the blank concentration. Otherwise, all samples associated with the blank and less than ten times the blank concentration must be redigested (reprepared) and reanalyzed, if possible. If the affected samples cannot be reprepared and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.

For GC/MS, GC analyses, the criteria below are used for method blank analysis:

- A method blank for volatiles analysis must contain no greater than five times the detection limit of common laboratory solvents (common laboratory solvents are: methylene chloride, acetone, toluene, 2-butanone, and chloroform).
- A method blank for semivolatiles analysis must contain no greater than five times the detection limit of common phthalate esters.
- For all other compounds not listed above, the method blank must contain less than the detection limit of any single compound. If a method blank exceeds the criteria, the analytical system is considered to be out of control. The source of the contamination is investigated and appropriate corrective measures are taken and documented before sample analysis proceeds. All samples processed with a method blank that is out of control (i.e., contaminated), are reextracted/repurged and reanalyzed, when possible. If the affected samples cannot be reextracted/repurged and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.
- No positive result for pesticides/PCBs should be reported unless the concentration of the compound exceeds five times the amount in the blank.
- A method blank for pesticides/PCBs must contain no greater than five times the detection limit for any pesticides/PCBs.

Surrogate Standards

For method blank surrogate standard analysis, corrective action will be taken if any one of the conditions below exist.

- Recovery of any one surrogate compound in the volatile fraction is outside the required surrogate standard recovery limit.
- Recovery of any one surrogate compound in the semivolatile fraction is outside surrogate standard recovery limits.

Corrective action will include steps listed below:

- A check of: the calculations for errors; the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and instrument performance.
- Recalculation or reinjection/repurging of the blank or extract if the above corrective actions fail to solve the problem.
- Reextraction and reanalysis of the blank. For sample surrogate standard analysis, corrective action will be taken if any one of the following conditions exist:

- ▶ Recovery of any one surrogate compounds in the volatile fraction is outside the surrogate spike recovery limits;
- ▶ Recovery of any one surrogate compound in either semivolatile fraction is below ten percent; or
- ▶ Recoveries of two or more surrogate compounds in either semivolatile fraction are outside surrogate spike recovery limits.

Corrective action will include the steps listed below.

- A check of: the calculations for errors; of the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and of instrument performance.
- Recalculating or reanalysis the sample or extract if the above corrective action fails to solve the problem.
- Reextraction and reanalysis of the sample if none of the above are a problem.

11.0 PERFORMANCE AND SYSTEM AUDITS

A field audit will be conducted during the field investigation to verify that sampling is being performed according to the plan. A report will be submitted within 30 calendar days of completion of the audit. Serious deficiencies will be reported within 24 hours of the time of discovery of the deficiency, including actions taken or to be taken to correct such deficiencies.

The following table (Table 11-1) is used for audits. At the appropriate time, the Project Manager or Program QA/QC designee will conduct field audits. Additionally, personnel adhere to Baker's Standard Operating Procedures which cover procedures, reporting and quality.

FIELD SITE AUDIT INSPECTION FORM

LEGEND

X = YES

O = NO

NA = NOT APPLICABLE

1. SITE NAME _____
2. LOCATION _____

CTO# _____
INSPECTOR _____
DATE _____

CERTIFICATION OF PERSONNEL

1. ALL BEI, RFW AND FW PERSONNEL ON SITE ARE CURRENTLY ACTIVE ON CERTIFICATION LIST? _____
2. SITE SAFETY OFFICER AND SITE SUPERVISOR ARE QUALIFIED? _____

COMMENTS: _____

MEDICAL AND FIRST AID

1. FIRST AID KITS ACCESSIBLE AND IDENTIFIED? _____
2. EMERGENCY EYE/SAFETY WASHES AVAILABLE? _____
3. AT LEAST TWO FIRST AID AND CPR TRAINED PERSONS ON SITE AT ALL TIMES WHEN WORKING? _____

COMMENTS: _____

SITE SAFETY/EMERGENCY PLANS

1. SAFETY PLAN POSTED ON SITE AND AVAILABLE FOR REVIEW BY EACH PERSON? _____
2. INITIAL SITE SAFETY MEETING HELD AND DOCUMENTED BEFORE WORK BEGINS? _____
3. HAZARDOUS MATERIALS INFORMATION AVAILABLE FOR ALL SITE HAZARDS? _____
4. EMERGENCY TELEPHONE NUMBERS POSTED? _____
5. EMERGENCY ROUTES DESIGNATED? _____
6. EMERGENCY CONTINGENCY PLAN AND SIGNAL REVIEWED WITH ALL PERSONS. _____
7. DIRECTIONS TO THE HOSPITAL CLEARLY DEFINED AND POSTED? _____
8. DIRECTIONS AND MILEAGE TO HOSPITAL VERIFIED AND DOCUMENTED? _____

COMMENTS: _____

FIELD SITE AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

TRAINING

1. NEW PERSONNEL TO SITE RECEIVE:
 - COPY OF SITE SAFETY PLAN? _____
 - SITE ORIENTATION? _____
 - DISCUSSION ON LEVEL OF PROTECTION? _____
 - DISCUSSION ON DECON PROCEDURES? _____
 - DISCUSSION ON WORK ZONES? _____
 - BRIEFING ON SITE SPECIFIC HAZARDS? _____
2. ALL EMPLOYEES INSTRUCTED IN HAZARDOUS MATERIALS HANDLING PRACTICES? _____

COMMENTS: _____

PERSONAL PROTECTION/EQUIPMENT

1. ALL EQUIPMENT MEETS ANSI/OSHA/EPA CRITERIA? _____
2. LEVELS OF PROTECTION ESTABLISHED? _____
3. SITE CONTROL ZONES CLEARLY DESIGNATED? _____
4. PERSONNEL FAMILIAR WITH PPE PROTOCOLS? _____
5. EMPLOYEES FIT TESTED FOR RESPIRATORS? _____
6. BREATHING AIR GRADE "D" CERTIFIED? _____
7. SUFFICIENT QUANTITIES OF EQUIPMENT? _____
8. INSTRUMENTS PROPERLY CALIBRATED? _____
9. CALIBRATION LOGS UP TO DATE? _____
10. DEFECTIVE EQUIPMENT TAGGED OUT? _____

COMMENTS: _____

DECONTAMINATION

1. DECON SYSTEM SET UP ON SITE? _____
2. DECON SYSTEM UTILIZED? _____
3. CONTAMINATION ZONE CLEARLY DELINEATED? _____
4. APPROPRIATE WASTE RECEPTICALS AVAILABLE FOR ALL WASTES? _____
5. RECEPTICALS PROPERLY CLOSED AT THE END OF EACH DAY? _____
6. ALL DECON LIQUIDS PROPERLY CONTAINED AND DISPOSED OF? _____
7. ALL WASTE DISPOSED OF ACCORDING TO APPROVED PLAN? _____
8. ALL REUSABLE PPE DECONNED AND DISINFECTED DAILY? _____

COMMENTS: _____

FIELD SITE AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

FIRE PREVENTION/PROTECTION

1. HOT WORK PERMITS REQUIRED? _____
2. SMOKING RESTRICTED TO DESIGNATED AREA? _____
3. FLAMMABLE/COMBUSTIBLE LIQUID DISPENSING
TRANSFER SYSTEMS GROUNDED AND BONDED? _____
4. PROPER FLAMMABLE MATERIALS STORAGE? _____
5. LOCATION AND USE OF FIRE EXTINGUISHERS
KNOWN BY ALL PERSONNEL? _____
6. FIRE EXTINGUISHERS APPROPRIATE FOR FIRE
HAZARD POTENTIAL? _____
7. COMBUSTIBLE MATERIALS SEGREGATED FROM
IGNITION SOURCES? _____

COMMENTS: _____

WALKING AND WORKING SURFACES

1. ACCESS WAYS, STAIRS AND RAMPS FREE OF
DEBRIS, MUD, SNOW AND/OR ICE? _____
2. STAIRWAYS, FLOOR AND WALL OPENINGS
GUARDED? _____
3. ELEVATED WORK AREAS GUARDRAILED OR
SAFETY CHAINED? _____
4. FLOTATION DEVICES WORN WHEN WORKING ON
OR OVER DANGEROUS WATERS? _____
5. TOE BOARDS ON OVERHEAD WORK SURFACES? _____
6. MOBILE OFFICES HAVE FIXED STAIRS AND
HANDRAILS? _____
7. WORK AREAS KEPT FREE OF DEBRIS AND
EQUIPMENT NOT BEING USED? _____
8. LADDERS APPROPRIATE FOR TYPE OF WORK
(I.E. DO NOT EXCEED MAXIMUM LENGTH)
BEING PERFORMED? _____
9. SAFETY FEET ON STRAIGHT AND EXTENSION
LADDERS? _____
10. METAL LADDERS PROHIBITED IN ELECTRICAL
SERVICE? _____

COMMENTS: _____

EXCAVATIONS AND CONFINED SPACES

1. UTILITY CHECK PERFORMED AND DOCUMENTED
PRIOR TO DRILLING OR EXCAVATION? _____
2. EXCAVATIONS SLOPED OR SHORED TO PREVENT
CAVE-INS? _____
3. SHORING APPROVED BY AN ENGINEER? _____
4. GUARDRAILS OR FENCES PLACED AROUND
EXCAVATIONS NEAR WALKWAYS OR ROADS? _____
5. EXCAVATION LOCATIONS VISIBLE AT NIGHT? _____
6. LADDERS AVAILABLE IN TRENCHES MORE THAN _____

FIELD SITE AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

- FOUR FEET DEEP AND AT A MINIMUM, TWENTY-FIVE FOOT INTERVALS ALONG A FENCE? _____
7. EXCAVATED MATERIAL IS AT LEAST TWENTY-FOUR INCHES FROM THE EDGE OF ALL TRENCHES? _____
 8. CONFINED SPACE ENTRY PERMIT PROCEDURE IN PLACE AND COMMUNICATED TO ALL PERSONNEL? _____
 9. EMPLOYEE TRAINING INCLUDES CONFINED SPACE ENTRY HAZARDS? _____
 10. CONFINED SPACES TESTED AND DOCUMENTED FOR:
 OXYGEN _____
 CARBON MONOXIDE _____
 COMBUSTIBLE GASES _____
 TOXICITY (HCN- OR H₂S) _____
 11. CONTINUOUS MONITORING FOR OXYGEN, CARBON MONOXIDE AND COMBUSTIBLE GASES? _____
 12. PERSONNEL ENTERING CONFINED SPACE ARE AT A MINIMUM IN LEVEL "B" OR CONSTANT VENTILATION AND MONITORING IS PROVIDED? _____
 13. SAFETY WATCH ASSISTING CONFINED SPACE ENTRY PERSONNEL? _____
 14. SAFETY WATCH PROTECTED SAME AS FIELD TEAM? _____
 15. COMMUNICATION AVAILABLE FROM INSIDE TO OUTSIDE PERSONNEL? _____
 16. WORK IS NOT CONDUCTED IN ANY TANK, VESSEL OR OTHER CONTAINER UNTIL THERE IS NO POSSIBILITY THAT LINES OR ELECTRICAL EQUIPMENT CAN BE ACTIVATED? _____

COMMENTS: _____

MINOR VEHICLES/HEAVY EQUIPMENT

1. INSPECTED BEFORE EACH USE? _____
2. OPERATORS LICENSE FOR EQUIPMENT USED? _____
3. UNSAFE EQUIPMENT TAGGED OUT AND REPORTED? _____
4. EQUIPMENT SHUTDOWN FOR FUELING? _____
5. EQUIPPED WITH BACKUP ALARMS OR SPOTTER USED IF 360° VISIBILITY IS RESTRICTED? _____
6. LOADS ARE SECURE BEFORE TRANSPORT? _____

COMMENTS: _____

SLINGS AND CHAINS

1. SLINGS, CHAINS AND RIGGING INSPECTED PER OSHA? _____
2. DAMAGED SLINGS, CHAINS AND RIGGING TAGGED OUT AND REPORTED? _____
3. EMPLOYEES ARE INSTRUCTED AND KEEP CLEAR OF SUSPENDED LOADS? _____

FIELD SITE AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

COMMENTS: _____

ELECTRICAL

1. WARNING SIGNS INDICATE HIGH VOLTAGE (250 V OR GREATER) PRESENT AND LOCATION? _____
2. ELECTRICAL EQUIPMENT AND WIRING PROPERLY GUARDED? _____
3. ELECTRICAL LINES, EXTENSION CORDS AND CABLES GUARDED AND PROPERLY MAINTAINED? _____
4. EXTENSION CORDS ARE KEPT AWAY FROM DAMP AREAS? _____
5. DAMAGED EQUIPMENT TAGGED OUT? _____
6. UNDERGROUND ELECTRICAL LINES LOCATED AND INDICATED? _____
7. OVERHEAD ELECTRICAL LINES DE-ENERGIZED OR ELEVATED WORK PLATFORMS, WORK AREAS, BOOMS OR LADDERS ERECTED SO NO CONTACT CAN OCCUR WITH ELECTRICAL LINES? _____
8. A POSITIVE ELECTRICAL LOCK-OUT SYSTEM IS USED WHENEVER WORK IS PERFORMED ON OR IN ELECTRIC EQUIPMENT OR ELECTRICALLY ACTIVATED EQUIPMENT? _____

COMMENTS: _____

HAND AND POWER TOOLS

1. GUARDS AND SAFETY DEVICES IN PLACE AND USED? _____
2. TOOLS ARE INSPECTED BEFORE EACH USE? _____
3. EYE PROTECTION AREAS IDENTIFIED AND PROTECTION WORN? _____
4. NON-SPARKING TOOLS AVAILABLE? _____
5. EQUIPMENT TAGGED OUT IF DEFECTIVE? _____

COMMENTS: _____

COMPRESSED GAS CYLINDERS/PRESSURIZED LINES

1. BREATHING AIR CYLINDERS CHARGED ONLY TO PRESCRIBED PRESSURE? _____
2. NO OTHER GAS SYSTEM CAN BE MISTAKEN FOR BREATHING AIR? _____
3. FITTINGS PROHIBIT CROSS CONNECTION? _____
4. CYLINDERS SEGREGATED APPROPRIATELY IN CONTROLLED, PROTECTED BUT WELL VENTILATED AREAS? _____
5. CYLINDERS STORED UPRIGHT AND SECURED? _____

FIELD AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

COMMENTS: _____

MISCELLANEOUS

- 1. TOOLS AND OTHER EQUIPMENT (PORTABLE) ARE STORED AWAY FROM WALKWAYS, ROADS OR DRIVEWAYS WHERE THEY CANNOT FALL ON OR BE FALLEN OVER BY SITE PERSONNEL? _____
- 2. OVERHEAD HAZARDS ARE NOTED, COMMUNICATED TO ALL EMPLOYEES AND LABELED AS NEEDED? _____
- 3. HARD HAT, EYE AND HEARING PROTECTION AREAS ARE DEFINED AND/OR SIGNS IN PLACE? _____
- 4. HARD HATS, EYE AND HEAD PROTECTION IS USED WHERE APPROPRIATE? _____
- 5. COPIES OF CONTRACTS WITH CLIENT AND SUBCONTRACTORS ARE ON SITE? _____
- 6. BAKER'S ROLE REGARDING SITE HEALTH AND SAFETY RESPONSIBILITIES HAS BEEN ESTABLISHED IN SITE PLANS? _____
- 7. SITE MANAGER(S) UNDERSTANDS RESPONSIBILITIES? _____
- 8. SUBCONTRACTORS HAVE RECEIVED APPROVED COPIES OF THEIR SAFETY PLANS OR HAVE SIGNIFIED THEIR INTENT TO CONFORM WITH BAKER'S SAFETY PLAN? _____
- 9. THIS INTENT HAS BEEN SIGNED BY ALL SITE PERSONNEL AND A SUBCONTRACTOR MANAGER? _____
- 10. SITE MANAGERS UNDERSTAND THEIR RESPONSIBILITIES FOR SUBCONTRACTORS' CONFORMANCE WITH ALL OSHA AND OTHER HEALTH AND SAFETY REQUIREMENTS? _____

COMMENTS: _____

ADMINISTRATIVE AUDIT ITEMS

PROJECT LOG BOOKS

- 1. ALL ENTRIES IN SITE LOG MADE IN INK? _____
- 2. DATES AND MILITARY TIMES RECORDED FOR ALL OBSERVATIONS? _____
- 3. ENTRIES SIGNED AT THE END OF THE DAY OR BEFORE A NEW AUTHOR MAKES AN ENTRY? _____
- 4. BLANK SPACES ARE CROSSED OUT AND INITIALED? _____
- 5. CORRECTIONS ARE CROSSED OUT WITH A SINGLE LINE AND INITIALED? _____
- 6. LOG BOOK ENTRIES ARE LEGIBLE? _____
- 7. ENTRIES ARE OBJECTIVE AND NOT SUBJECTIVE? _____
- 8. ENTRIES INCLUDE DETAIL OR PROVIDE A CLEAR SEQUENCE OF EVENTS? _____
- 9. UNUSUAL OCCURRENCES ARE RECORDED (E.G., BREAKDOWNS, MEETINGS, TASKING)? _____
- 10. DIRECTIVES FROM MANAGEMENT ARE RECORDED? _____

FIELD AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

- 11. SITE ENTRY AND EXIT TIMES ARE RECORDED? _____
- 12. WEATHER CONDITIONS ARE RECORDED? _____
- 13. REFERENCE TO INDIVIDUAL LOG BOOKS IS PROVIDED? _____

COMMENTS: _____

FIELD LOGS

- 1. BOREHOLE LOG COMPLETED FOR EACH WELL CONSTRUCTED? _____
- 2. SKETCHES OF WELL CONSTRUCTION AND WELL CONSTRUCTION LOGS COMPLETED? _____
- 3. INFORMATION ON WELL DEVELOPMENT RECORDED? _____
- 4. ~~CHAIN OF CUSTODY FORMS COMPLETED AND PROPERLY FILED?~~ _____
- 5. PROJECT LOG BOOK UP-TO-DATE? _____
- 6. SAMPLE IDENTIFICATION DOCUMENTS AVAILABLE AND ARE BEING UTILIZED? _____

COMMENTS: _____

SITE FILE SYSTEM (TECHNICAL)

- 1. CHAIN-OF-CUSTODY FORMS COMPLETED AND PROPERLY FILED? _____
- 2. DRUM INVENTORY FORMS COMPLETED AND UP-TO-DATE? _____
- 3. MANIFESTS AND DISPOSAL REPORTS COMPLETED AND FILED? _____
- 4. PRODUCT DATA SHEETS AVAILABLE (MSDS)? _____
- 5. SAMPLING LOGS COMPLETED AND UP-TO-DATE? _____
- 6. AIR MONITORING LOGS COMPLETED AND UP-TO-DATE? _____

COMMENTS: _____

SITE FILE SYSTEM (OPERATIONAL)

- 1. BUSINESS CARDS FILED OR POSTED (I.E., VENDORS, EPA, STATE PERSONNEL WHOM HAVE BEEN ON SITE) _____
- 2. CHRONOLOGY OR NARRATIVE OF EVENTS COMPILED OF SITE ACTIVITIES TO DATE? _____
- 3. INVENTORY OF EQUIPMENT COMPILED AND AVAILABLE FOR REVIEW? _____
- 4. SITE ENTRY/EXIT LOGS COMPLETED AND UP-TO-DATE? _____
- 5. HOT ZONE ENTRY/EXIT LOGS COMPLETED AND UP-TO-DATE? _____

FIELD AUDIT INSPECTION FORM

X = YES
O = NO
NA = NOT APPLICABLE

- 6. OPERATIONAL REPORTS AVAILABLE FOR REVIEW AND ARE BEING ADHERED TO? _____
- 7. ORGANIZATIONAL CHART AVAILABLE IDENTIFYING KEY PERSONNEL? _____

COMMENTS: _____

SITE FILE SYSTEM (FINANCIAL)

- 1. DELIVERY ORDERS COMPLETED AND PROPERLY FILED? _____
- 2. SHIPPING INVOICES ARE PROPERLY FILED (I.E., EQUIPMENT, SAMPLES, ETC.)? _____
- 3. ESTIMATED DISPOSAL COSTS AVAILABLE? _____
- 4. JOB COST SUMMARY FILED AND AVAILABLE? _____
- 5. MODIFICATIONS ARE COMPLETE AND FILED? _____
- 6. RECEIPTS ARE BEING TRACKED AND DOCUMENTED? _____

COMMENTS: _____

SITE FILE SYSTEM (COMMUNITY RELATIONS)

- 1. COMMUNITY RELATIONS PLAN IS COMPLETE AND AVAILABLE FOR REVIEW? _____
- 2. ALL SITE PERSONNEL ARE AWARE OF PLAN AND ARE FAMILIAR WITH PROTOCOLS? _____

COMMENTS: _____

12.0 PREVENTIVE MAINTENANCE

The following section outlines preventative maintenance.

12.1 Field Maintenance

The O₂/LEL meter and the HNu PI-101 are to be used in site characterization and will be maintained as described by the manufacturer's instructions. The pH and specific conductance meters to be used during sampling will be maintained according to Baker's Standard Operating Procedure (SOP) F201. A full set of SOPs will be maintained in the field trailer.

12.2 Laboratory Maintenance

Preventive maintenance is an organized program of actions to prevent instruments and equipment from failing during use and to maintain proper performance of equipment and instruments. A comprehensive preventive maintenance program is implemented to increase the reliability of the measurement system. The preventive maintenance program will address the following:

- Schedules of important preventive maintenance tasks that are carried out to minimize downtime.
- Lists of critical spare parts that are available to minimize downtime.

The laboratory maintains histories, in instrument/equipment logs, of all major equipment. Trouble shooting, maintenance, and spare parts inventory will be recorded in the logs. Instruments and equipment will be maintained periodically in accordance with procedures described in individual analytical methods, manufacturer's recommendation, and/or service contracts.

The modern analytical laboratory depends heavily upon instrumentation and equipment; therefore, cleaning and preventive maintenance are primary considerations in the sustained production of satisfactory data. Specific requirements for proper care of laboratory instrumentation and equipment are contained in the manufacturer's instructions; however, some general guidelines are considered, and are listed below.

- Special precautions must be taken to avoid spillage of corrosive chemicals on or around equipment and instrumentation not only to extend the life of the item, but also to eliminate contamination.
- Where available, covers must be placed on instrumentation when not in use.
- Instrument parts must be cleaned as required (i.e., mirrors, probes, detector cells).

13.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

The following section outlines data measurement assessment procedures.

13.1 Overall Project Assessment

Overall data quality will be assessed by a thorough understanding of the data quality objectives. By maintaining thorough documentation of all decisions made during each phase of sampling, performing field and laboratory audits, thoroughly reviewing the analytical data as they are generated by the laboratory, and providing appropriate feedback as problems arise in the field or at the laboratory, data accuracy, precision, and completeness will be closely monitored.

13.2 Field Quality Assessment

To assure that all field data are collected accurately and correctly, specific written instructions will be issued to all personnel involved in field data acquisition by the Project Manager. The Project Manager will perform field audit(s) during the investigation to document that the appropriate procedures are being followed with respect to sample (and blank) collection. These audits will include a thorough review of the field books used by the project personnel to insure that all tasks were performed as specified in the instructions. The field audits will necessarily enable the data quality to be assessed with regard to the field operations.

The evaluation (data review) of field blanks, and other field QC samples will provide definitive indications of the data quality. If a problem that can be isolated arises, corrective actions can be instituted for future field efforts.

13.3 Laboratory Data Quality Assessment

As part of the analytical QA/QC program, the laboratory applies precision and accuracy criteria for each parameter that is analyzed. When analysis of a sample set is completed, QC data generated will be reviewed and evaluated to ensure acceptance criteria are met. These criteria will be method and matrix specific.

QA/QC data review is based on the following criteria:

- Method Blank Evaluation - The method blank results will be evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents are checked for contamination and the analysis of future samples halted until the system can be brought under control. A high background is defined as a background value sufficient to result in a difference in the sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid. A method blank must contain no greater than two times the parameter detection limit for most parameters.
- Trip Blank Evaluation - Trip blank results will be evaluated for high readings similar to the method blanks described above. If high trip blank readings are encountered (i.e. a value sufficient to result in a difference in sample values, if not

corrected, greater than or equal to the smallest significant digit known to be valid), procedures for sample collection, shipment, and laboratory analysis are reviewed. If both the method and the trip blanks exhibit significant background contamination, the source of contamination is probably within the laboratory. Ambient air in the laboratory and reagents will be checked as possible sources of contamination.

- **Standard Calibration Curve Verification** - The calibration curve or midpoint calibration standard (check standard) will be evaluated daily to determine curve linearity through its full range and that sample values are within the range defined by the low and high standards. If the curve is not linear, sample values are corrected. If average response factors are used to calculate sample concentrations, these factors are verified on a daily basis. Verification of calibration curves and response factors will be accomplished when the evaluated response for any parameter varies from the calibrated response by less than ranges specified in Section 7.0.
- **Duplicate Sample Analyses** - Duplicate sample analyses will be used to determine the precision of the analytical method for the sample matrix. Two types of duplicate samples will be analyzed for this project, field, and laboratory. Duplicate results will be used to calculate precision as defined by the relative percent difference (RPD). If laboratory duplicate values exceeds the control limit, the sample set may be reanalyzed for the parameter in question. Precision limits will be updated periodically following review of data.
- **Reference Sample Analyses** - The results of reference sample analysis will be compared with true values, and the percent recovery of the reference sample will be calculated. If correction is required (excessive or inadequate percent recovery), the reference sample must be reanalyzed to demonstrate that the corrective action has been successful.
- **Surrogate Standard Analyses** - Surrogate standard determinations will be performed on all samples and blanks for GC/MS analyses. All samples and blanks are fortified with surrogate spiking compounds before purging or extraction to monitor preparation and analysis of samples. Recoveries must meet specific criteria. If acceptance criteria are not met, corrective action must be taken to correct the problem and the affected sample must be reanalyzed.
- **Matrix Spike Analyses** - The observed recovery of spike versus theoretical spike recovery will be used to calculate accuracy as defined by the percent recovery. If the accuracy value exceeds the control limit for the given parameter, the appropriate laboratory personnel notified and corrective action will be taken before the sample set is reanalyzed for the parameter in question.

For completeness, it is expected that the methodology proposed for chemical characterization of the samples will meet QC acceptance criteria for at least 95 percent of all sample data. To ensure this

completeness goal, data that does not meet the acceptance criteria will be recollected, reextracted, or reanalyzed, if necessary.

Data representativeness will be ensured through the use of appropriate analytical procedures, and analysis of samples performed within the allowed holding times.

Comparability is a qualitative characteristic of the data. By using standard methods for sampling and analyses, data generated in past or future investigations will be comparable with this investigation data.

14.0 CORRECTIVE ACTION

Corrective action will be taken whenever a nonconformance occurs. A nonconformance will be defined as an event which is beyond the limits established for a particular operation by the plan. Nonconformances can occur in a number of activities. Such activities include sampling procedures, sample receipt, sample storage, sample analysis, data reporting, and computations.

The following personnel will be responsible for detecting and reporting nonconformances:

- Project Staff - during testing and preparation and verification of numerical analyses.
- Laboratory Staff - during the preparation for analyses, performance of analytical procedures, calibration of equipment, and quality control activities.

14.1 Limits of Operation

The limits of operation that are used to identify nonconformances will be established by the contents of the Work Plan, QAPP, and FSAP. Interlaboratory control limits produced by statistical analyses will also be considered as limits of operation.

14.2 Corrective Action

Nonconformances will be identified and communicated to Baker to avoid delays with respect to project schedules and prevent the submission of non-valid data. Documentation will include the following:

- Personnel identifying the nonconformance(s) will be identified.
- The nonconformance(s) will be described and communicated to the Baker Project Manager.
- For serious nonconformances, the site supervisor will have the authority to initiate corrective action.
- For less serious nonconformances, corrective action will be decided upon and signatures will be obtained prior to implementation of corrective action.
- All nonconformances and corrective actions will be documented and reside with the Baker Activity Coordinator. This documentation will be available to LANTDIV.

The Baker Project Manager and Activity Coordinator will be notified of laboratory or field nonconformances and corrective actions taken if:

- A nonconformance causes a delay in work beyond the schedule completion date.
- A nonconformance affects information already reported.
- A nonconformance affects the validity of the data.

If the nonconformance(s) are serious and corrective action cannot resolve the problem(s), NFESC Contract Representatives (NCRs) and the LANTDIV NTR may be notified by Baker.

15.0 QUALITY ASSURANCE REPORTING PROCEDURES

The Project Manager will be responsible for assessing the performance of measurement systems and data quality related to the field investigation. A written record will be maintained of: the results of laboratory QC reports and other periodic assessments of measurement, data accuracy, precision, and completeness; performance and system audits; and any significant QA problems and recommended solutions. Each deliverable will contain a QA/QC assessment section. Also, a QA/QC assessment will be performed any time a significant problem is identified.

The Project Manager will keep in contact with the LANTDIV NTR through informal, verbal reports during the project as well as through monthly progress reports.